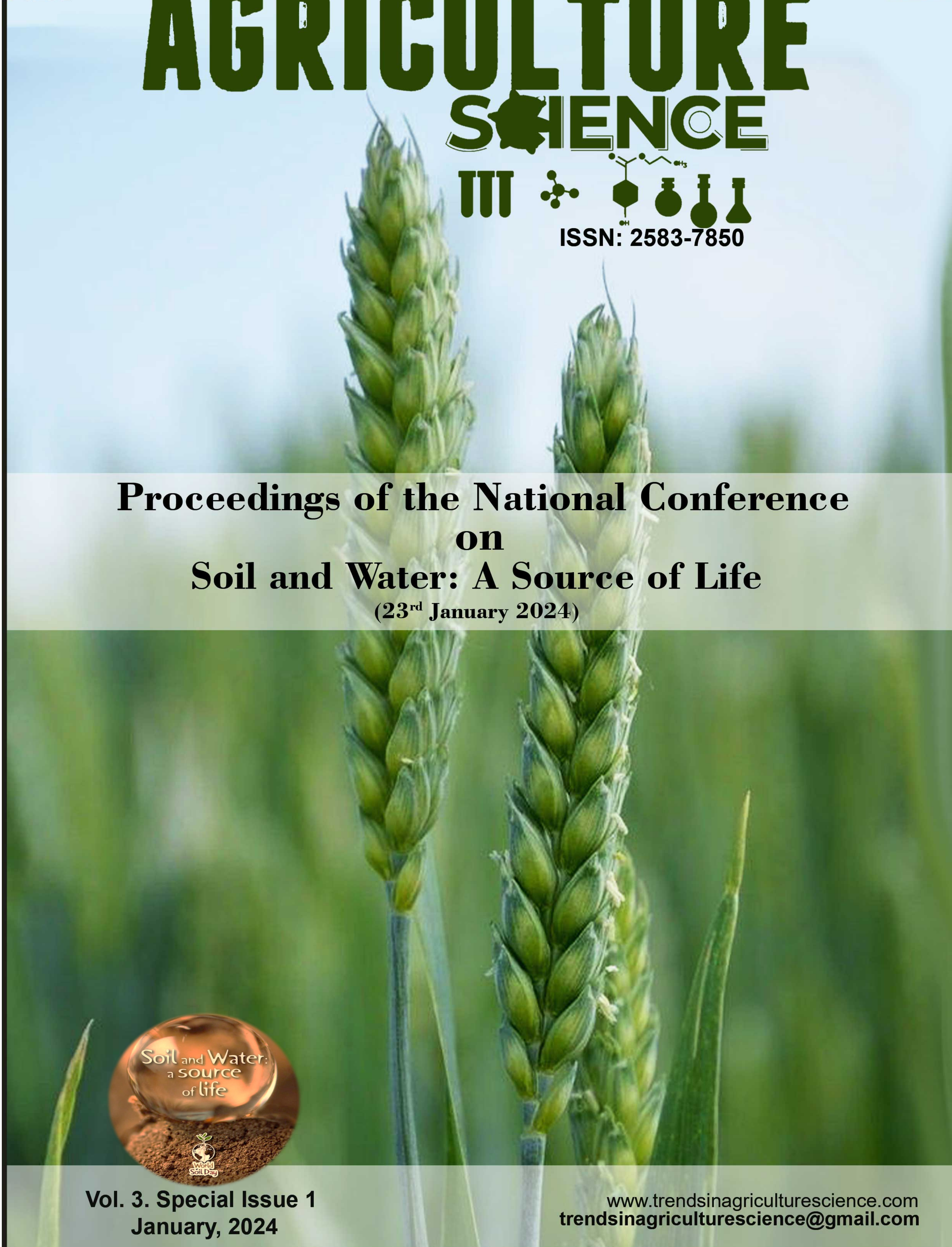
# TRENDS IN AGRICULTURE SCIENCE

ISSN: 2583-7850




## Proceedings of the National Conference on Soil and Water: A Source of Life

(23rd January 2024)

Vol. 3. Special Issue 1
January, 2024

www.trendsinagriculturescience.com
trendsinagriculturescience@gmail.com

# About Trends in Agriculture Sciences

Trends in Agriculture Science (ISSN: 2583-7850) stands as a venerable bastion of scholarly inquiry within the expansive domain of agricultural sciences. As an open-access, peer-reviewed journal, it serves as an indispensable conduit for the dissemination of cutting-edge research findings, scholarly discourse, and practical insights pertaining to the multifaceted realms of agriculture and its allied fields.

With an unwavering commitment to scholarly excellence, Trends in Agriculture Science provides a hospitable platform for a diverse spectrum of scholarly contributions, including original research articles, comprehensive reviews, concise communications, illuminating success stories, and engaging popular articles. Encompassing a wide gamut of disciplines such as agronomy, plant breeding and genetics, soil science and management, agricultural biotechnology, horticulture, animal husbandry and veterinary science, food science and technology, as well as agricultural economics and rural development, the journal embodies a holistic approach to advancing agricultural knowledge.

Central to the scholarly ethos of Trends in Agriculture Science is its robust peer-review process, characterized by meticulous scrutiny and rigorous evaluation. Through this discerning editorial mechanism, the journal upholds a steadfast commitment to quality assurance, ensuring that only the most innovative, original, and scientifically meritorious contributions garner a coveted place within its esteemed pages.

Embodying a spirit of scholarly immediacy, Trends in Agriculture Science espouses a fervent dedication to expeditiously disseminating research findings to the global scientific community. By fostering a dynamic exchange of ideas, insights, and innovations, the journal catalyzes transformative progress within the realm of agricultural sciences, thereby contributing to the collective pursuit of knowledge and the advancement of human welfare.

In sum, Trends in Agriculture Science stands as a venerable bastion of scholarly inquiry, providing a scholarly sanctuary wherein researchers, practitioners, and enthusiasts converge to explore, discover, and shape the future trajectory of agriculture and allied disciplines.

TRENDS IN AGRICULTURE SCIENCES
(ISSN: 2583-7850)

# About Editors

Guiding the editorial vision of Trends in Agriculture Science is Dr. V Kasthuri Thilagam, Ph.D.,a distinguished luminary whose tenure as Editor-in-Chief underscores a profound commitment to scholarly rigor and editorial integrity. Dr. Thilagam's stewardship ensures the maintenance of the highest standards of academic excellence and scholarly discourse within the journal,thereby fostering an environment conducive to intellectual exploration and academic advancement.

Assisting in navigating the intricate editorial terrain is Dr. Shaikh Nasrul Islam, the esteemed Managing Editor, whose astute leadership and editorial acumen facilitate the seamless orchestration of the journal's operations.

## Patron cum Editor in Chief

**Dr V Kasthuri Thilagam Ph.D**

Senior Scientist (Soil Science)
ICAR - Sugarcane Breeding Institute,
Coimbatore- 641 007, Tamil Nadu
Institutional Email: kasthuri.v@icar.org.in
Contact No: +91 9976120719

## Managing Editor

Dr. Shaikh Nasrul Islam PhD
shaikhnasrulislam@gmail.com
+91 8264935634

# Special Issue Editors

**Dr. S. Sivagnanam**
**Dr. S. Anandhi Lavanya**

## PROGRAMME SCHEDULE

| | |
|---|---|
| **DATE** | 23-01-2024 |
| **TOPIC** | NATIONAL CONFERENCE ON **"SOIL AND WATER: A SOURCE OF LIFE"** |

| **TIME** | **PROGRAM** |
|---|---|
| 10.00 AM | Invocation song |
| 10.05AM | Lighting of the lamp |
| 10. 10AM | Welcome Address : **Dr. N. S .Venkataraman,** Director and HOD, SOA, BIHER |
| 10.20 AM | Presidential Address : **Dr. M. Sundararajan,** Vice Chancellor, BIHER |
| 10.30-10.40AM | Inaugural Address & Release of Souvenir : **Dr. A. Sadasakthi,** Dean, SOA, BIHER |
| 10.50AM | **Lead speakers**<br>1. **Dr. S. Neduncheliyan,** Dean, School of Computer Science, SOA ,BIHER<br>2. **L. Jeyanthi Rebecca**, Dean,School of Bio-Engineering, SOA, BIHER<br>3. **Dr. C. Gurumoorthy,** Dean, Centre of Excellence in Applied Nuclear Research, School of Civil and Infrastructure Engineering. BIHER<br>4. **Dr. P. Vasuki,** Professor, School of Computer Science BIHER<br>5. **Dr. S. Suganya,** Senior Scientist , Tamil nadu Agricultural University, Coimbatore<br>6. **Dr. V. Kasthuri Thilagam, Ph. D.,** Senior Scientist (Soil Science), ICAR-Scgarcane Breeding Institute, Coimbatore. |
| 11.50-12.00AM | Tea Break |
| 12.00-1.00PM | Oral Presentations: Online & Offline Mode |
| 1.00-1.15PM | Group Photo |
| 1.15-1.20PM | Valedictory Address: **Dr. T. GeethaJebarathnam,** Professor, SoA, BIHER |
| 1.20-1.45PM | Certificate Distribution: **Dr. A. Sadasakthi,** Dean, SoA, BIHER |
| 1.45-2.00PM | Vote of Thanks: **Dr. S. Sivagnanam, Ph.D.,** Associate Professor, SoA |

TRENDS IN AGRICULTURE SCIENCES

Bharath INSTITUTE OF HIGHER EDUCATION AND RESEARCH
(Declared as Deemed - to - be - University under section 3 of UGC Act 1956)
ACCREDITED WITH 'A' GRADE BY NAAC

TRENDS IN AGRICULTURE SCIENCES

Bharath INSTITUTE OF HIGHER EDUCATION AND RESEARCH
(Declared as Deemed - to - be - University under section 3 of UGC Act 1956)
ACCREDITED WITH 'A' GRADE BY NAAC

TRENDS IN AGRICULTURE SCIENCE

Vol.3 Special Issue 01 January 2024, Page: 01-24

# Impact of Root Zone Temperature (RZT) on Nutrient Uptake of Crops

[1] S. Sivagnanam, [2]Jagadeeswaran. R and [2]V. P. Duraisami
[1]School of Agriculture, Bharath institute of Higher Education and Research, Selaiyur, Chennai – 600 073.
[2]Natural Resource Management, Tamil Nadu Agricultural University, Coimbatore.
https://doi.org/10.5281/zenodo.10550893

Growth and development of a plant are influenced mainly by solar radiation, temperature, soil moisture, soil aeration and mineral nutrients. In addition, other factors also influence crop growth at different stages. Stress is any change in environmental conditions that might reduce or adversely change plant's growth and development and biological strain is the reduced or changed function of the plants in response to stress (Levitt, 1980). The pant growths are affected by two different types of stress biotic (living organisms) and abiotic (temperature, water, chemicals, radiation, wind, sound, magnetic, electrical etc.,). A major challenge of successful crop management today is coping with oxidative stress associated with plant abiotic and biotic stresses (Harsco Corporation, 2013).

Soil temperature is one of the primary factors affecting plant growth (pregitzer and King, 2005). Soil temperature affects plant growth, nutrient/water uptake, Organic matter decomposition etc. Different authors have reported improved growth and photosynthesis rate by raising soil RZT (Day *et al*., 1991; Landhausser *et al*., 1996 and Schwarz *et al*., 1997). The role of RZT on plant growth is to control the root zone layer more directly. There is evidence that nutrient / water uptake is affected by nutrient solution temperature (Borowski, 1995). The relative translocation of nutrients from roots to shoots seemed to be controlled by Root Zone Temperature (Mozafar *et al*., 1993). Temperature directly and indirectly regulates DOM (decomposition of organic matter) production through its influence on biological activities and physico-chemical processes (Stutter, 2007). Increases RZT and reduced allocation of N supply to roots and leaves, and increased allocation to stem, although an effect on carbon assimilation rate was not observed (Gavito *et al*., 2001). In a study of *Lactuca sativa* L. cv. (baby butter fruit) Palma under aeroponical conditions, Tan *et al*., (2002) found that plants grow at optimum cool RZT had higher leaf P concentration compared to the plants grown at hot A-RZT.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

Tomato (Solanum lycopersicum L.) plant growing at $36^0$C RZT for 20 d exhibited decreased shoot growth and P uptake compare with plants growing at $25^0$C RZT (Klock *et al.*, 1997). Chilling decreases root hydraulic conductance and slows down water absorption on the one hand, and on the other hand, impairs stomatal control which leads to excessive water loss and leaf wilting (Capell and Dorffling, 1993; Bloom *et al.*, 2004).

**What is soil temperature and root zone temperature?**

The ideal plant growth temperature is 4.5°C to 35°C. Plant needs different temperature for different stages of growth likewise, seed germination (10 – 30°C), optimum root growth temperature (20-25°C) and optimum microorganism growth (25-35°C) and some plants tolerate to develop under high and low temperature less than 4°C and more than 35°C.

The main source of soil temperature is sunlight. The heat energy transfer in to the soil in three basic process **convection, conduction and radiation**. The flow of heat as a result of mixing or turbulence (heat flow liquid or gasses) known as convection. Heat flow through a body by the transference of the momentum of individual molecules without mixing, the process is known as molecular conduction or simply conduction (flow of heat tack place: one molecule to another). The process of transference of heat energy through space by means of electromagnetic waves called radiation (black body absorbs most of the radiation than body).

**Important Soil Temperature Cycle**

Diurnal cycle, during day time soil gets heated and expressed maximum in after noon and minimum during morning. The soil is a poor conductor of heat and therefore this cycle is effective up to **30cm depth**. Annual cycle**,** soil temperatures during the whole year include summer and winter seasons. This cycle is operative upto **15-20 meters depth** and Seasonal cycle**,** manifests variation of soil temperature for any **particular season** (growing).

**Mathematical thermal conductivity**

Heat flow in steady-state condition has been reached; it is found that the quantity of heat flowing per unit area in unit time is proportional to the difference in temperature across the distance $\Delta x$. Mathematically, it is written, **Fourier's law of heat conduction**

$$qh = \frac{dy}{dx}\lambda$$

where $q'_h$ – quantity of heat passing per unit time through the soil slab from $x_1$ to $x_2$, cal $cm^{-2}$ $sec^{-1}$; $\lambda$= proportionality constant, known as thermal conductivity of the slab in the direction of heat flow, cal $cm^{-1}$ $sec^{-1}$°c. dT/dx temperature gradient, °c $cm^{-1}$.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

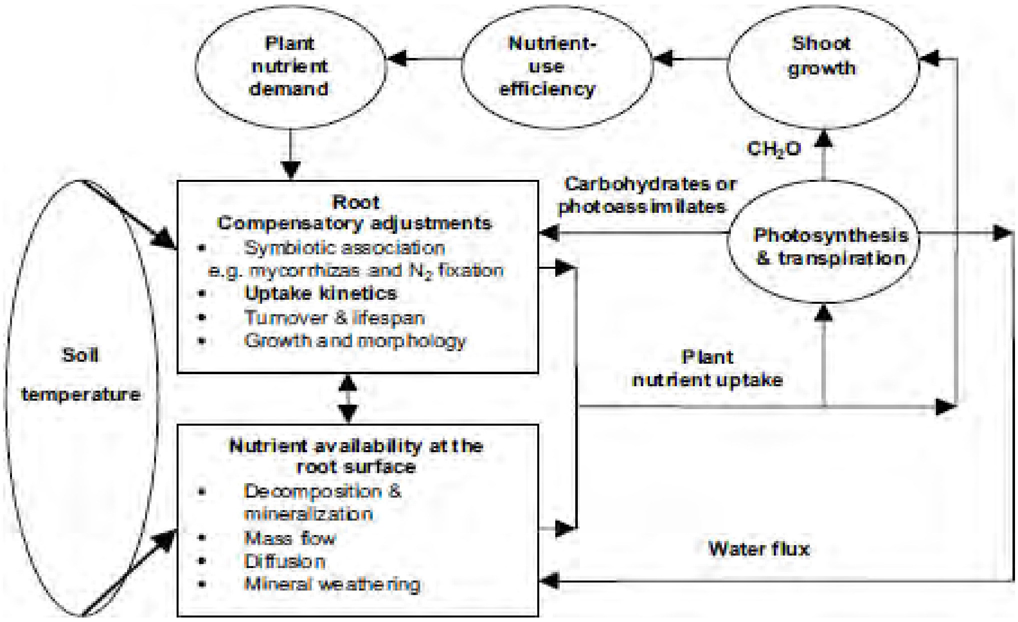



**Fig. 1**. A conceptual diagram depicting relationships between plant and soil factors that control the availability and uptake of mineral nutrients.

Soil temperature affects nutrient uptake directly by altering root growth, morphology, and uptake kinetics. Indirect effects include altered rates of decomposition and nutrient mineralization, mineral weathering, and nutrient transport processes (mass flow and diffusion). (Modified from Fig. 1 in Bassiri Rad 2000).

**Functions of roots**

The functions of roots include anchorage, the absorption of water and mineral nutrients, synthesis of various essential compounds such as growth regulators, and the storage of food in root crops. Plants require a balanced supply of nutrients throughout their development. Generally, they have accumulated most of their nutrients by sometime between the flowering and ripening stages to fill developing fruit or seed.

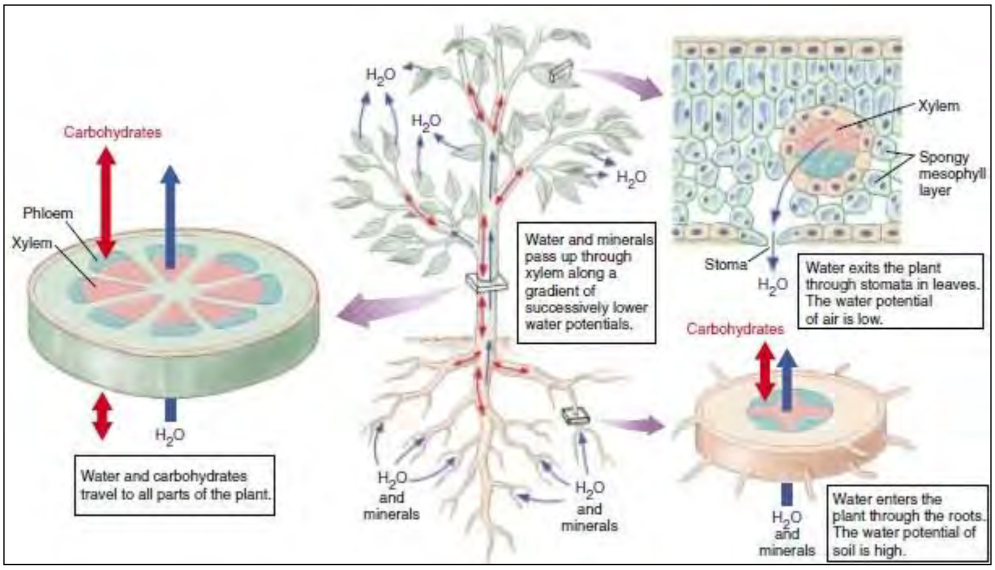



**Fig.2.** This diagram illustrates the path of water and inorganic materials as they move into, though, and out of the plant body.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

Water potential in a plant regulates movement of water. At the roots there is positive water potential (except in the case of severe drought). On the surface of leaves and other organs, water loss called **transpiration** creates a negative pressure. It depends on its osmotic absorption by the roots and the negative pressures created by water loss from the leaves and other plant surfaces (fig.2). The negative pressure generated by transpiration is largely responsible for the upward movement of water in xylem.

Most of the water absorbed by the plant comes in through root hairs, which collectively have an enormous surface area (fig. 2). Root hairs are almost always turgid because their solute potential is greater than that of the surrounding soil due to mineral ions being actively pumped into the cells. Because the mineral ion concentration in the soil water is usually much lower than it is in the plant, an expenditure of energy (supplied by ATP) is required for the accumulation of such ions in root cells. The plasma membranes of root hair cells contain a variety of protein transport channels, through which *proton pumps* transport specific ions against even large concentration gradients. Once in the roots, the ions, which are plant nutrients, are transported via the xylem throughout the plant.

The ions may follow the cell walls and the spaces between them or more often go directly through the plasma membranes and the protoplasm of adjacent cells. When mineral ions pass between the cell walls, they do so non-selectively. Eventually, on their journey inward, they reach the endodermis and any further passage through the cell walls is blocked by the Casparian strips. Water and ions must pass through the plasma membranes and protoplasts

of the endodermal cells to reach the xylem. However, transport through the cells of the endodermis is selective. The endodermis, with its unique structure, along with the cortex and epidermis, controls which ions reach the xylem.

**Nutrient Mobility in Soil and Plants Mechanisms**

Ion absorption by plant roots requires contact between the ion and the root surface. There are generally three ways in which nutrient reach the root surface: (1) Root interception, (2) mass flow and (3) diffusion. The relative importance of these mechanisms in supplying nutrients to plant root is shown in table 1 and 2.

Table. 1. Primary uptake mechanism of nutrient to roots

| Nutrient | Root Interception | Mass flow | Diffusion |
|---|---|---|---|
| N | | ✓ | |
| P | ✓ | | ✓ |
| K | | | ✓ |
| Ca | | ✓ | |


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

| | | | |
|---|---|---|---|
| Mg | | ✓ | |
| S | | ✓ | |
| Mn | | | ✓ |
| Zn | | | ✓ |
| Fe | ✓ | | ✓ |
| Cu | ✓ | | |
| B | | ✓ | |

1. Root interception represents, the root can pump into the ion (physical contact between root and mineral surfaces) as it grows through the soil.
2. Mass flow, the soluble fraction of nutrients which are present in solution (water) and are not held on the soil fractions flow to the root as water is taken up. It is reduced at low temperatures because the transpiration demands of plants and water evaporation at the soil surface decreases at low soil temperatures.
3. Diffusion occurs when an ion moves from an area of high concentration to one of low concentration. As roots absorb nutrients from the surrounding soil solution.

Mass flow and diffusion processes are also important in nutrient management. Soils that exhibit low diffusion rates because of high BC, low soil moisture or high clay content may require application of immobile nutrients near the roots to maximize nutrient availability and plant uptake.

**Table. 2.** Significance of Root interception, Mass Flow and Diffusion in ion transport to crop roots

| Nutrients | Percent nutrient up take by corn crop | | |
|---|---|---|---|
| | Root interception | Mass Flow | Diffusion |
| Nitrogen | <1 | **80** | 19 |
| Phosphorus | 2 | 5 | **93** |
| Potassium | 2 | 18 | **80** |
| Calcium | **150** | **375** | 0 |
| Magnesium | 33 | **600** | 0 |
| Sulphur | 5 | **300** | 0 |

(Dave Mengel, 1995).

## Ion Absorption by Plants

Plants uptake of ions from the soil solution can be described by ***passive and active processes***, where ions passively move to a "boundary" through which ions are actively


Published: 23 Jan. 2024
ISSN: 2583-7850

transported to organ in plant cells that metabolize the nutrient ions. Solution composition or ion concentrations outside and inside of the boundary are controlled by different processes, each essential to plant nutrition and growth.

A molecule or ion is transported actively or passively across a membrane (caseparian band, plasma membrane or tonoplast) depends on the concentration and charge of the ion, or molecule, which in combination represent the electrochemical driving force. Ion and molecules diffuse from areas of high to low concentrations. Thus diffusion does not require the plant to expand energy. In contrast, for ions diffusing against the concentration gradient, energy is required. Thus, passive transport across the plasma membrane for example, occurs with the electrochemical potential and active transport occurs against the electrochemical potential, a process that required the cell expend energy.

**Table. 3.** Rooting depth of various crops

| **Shallow-rooted (0 - 60 cm)** | **Medium-rooted (60 - 90 cm)** | **Deep-rooted (90 - 120 cm)** | **Very deep-rooted (>180 cm)** |
|---|---|---|---|
| Rice | Groundnut | Cotton | Citrus |
| Onion | Castor | Maize | Grapevine |
| Cabbage | Tobacco | Sorghum | Safflower |
| Cauliflower | Wheat | Sugarcane | Coffee |
| Potato | Chillies' | Pearl millet | Lucerne |
| lettuce | French bean | Tomato | |
| | carrots | soybean | |

**Different Types of Thermometers**

1. Electrical Thermometers
2. **Liquid-in-glass Thermometers**

**a. Soil thermometers (Bent-stem soil thermometer)**

3. Bimetallic Thermographs
4. Clock-driven Drums
5. Louvered Screens
6. Ventilated Shields


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

**Soil Thermometer (Bent-stem soil thermometer)**

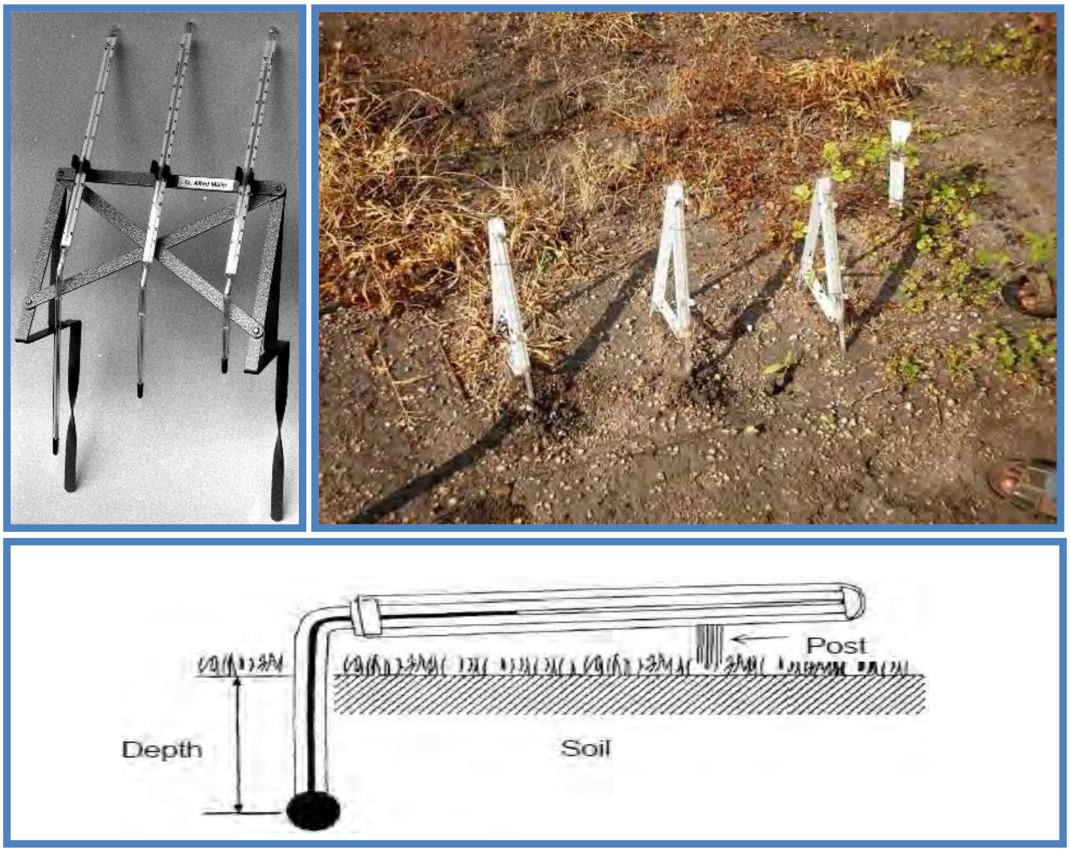



**Fig. 3**. Soil thermometers (Bent-stem soil thermometer)

This thermometer measures the soil temperature. It measures soil temperature of shallow layer, mercury-in-glass thermometer with its stem bent at right angle or any other suitable angle below the lowest graduation. The thermometer bulb is sunk into the ground to the required depth, generally 5, 10, 15 and 20cm.

**Sensors for Measuring Soil Heat Flux**

The HFP01 Soil Heat Flux Plate uses a thermopile to measure temperature gradients across its plate. Operating in a completely passive way, it generates a small output voltage that is proportional to this differential temperature. Assuming that the heat flux is steady, that the thermal conductivity of the body is constant, and that the sensor has negligible influence on the thermal flow pattern, the signal of the HFP01 is directly proportional to the local heat flux. The HFP01's

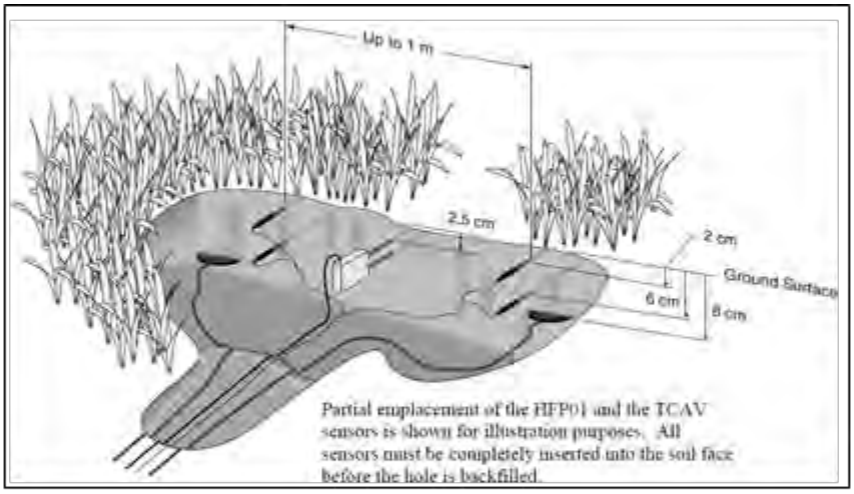



**Fig.4.** Soil Heat Flux Plate uses a thermopile to measure temperature


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
**Published**: 23 Jan. 2024
**ISSN: 2583-7850**

output is in millivolts. To convert this measured voltage to heat flux, it must be divided by the plate's calibration constant. A unique calibration constant is supplied with each sensor.

**Placement in Soil**

The standard set of sensors for measuring soil heat flux includes two HF01 Soil Heat Flux Plates, one TCAV Averaging Soil Thermocouple, and one CS616, CS650, or CS655 water content reflectometer. These sensors are installed as shown in (Figure 4). The location of the heat flux plates and thermocouple should be chosen to be representative of the area under study. If the ground cover is extremely varied, an additional set of sensors is required to provide a valid soil heat flux average. Use a small shovel to make a vertical slice in the soil. Excavate the soil to one side of the slice. Keep this soil intact so that is can be replaced with minimal disruption. The sensors are installed in the undisturbed face of the hole. Measure the sensor depths from the top of the hole. With a small knife, make a horizontal cut 8 cm below the surface into the undisturbed face of the hole. Insert the heat flux plate into the horizontal cut. Not: Install the HFP01 in the soil such that the side with the red label is facing the sky and the side with a blue label facing the soil.

**CAUTION:** In order for the HFP01 to make quality soil heat flux measurements, the plate must be in full contact with the soil. Never run the sensors leads directly to the surface. Rather, bury the sensor leads a short distance back from the hole to minimize thermal conduction on the lead wire. Replace the excavated soil back into it original position after all the sensors are installed. Note: To protect sensor cables from damage caused by rodents, it is recommended to bury them inside of flexible electrical tubing.

**RZT with nutrient interaction & growth**

The role of RZT on plant growth is to control the root zone layer more directly. There is evidence that nutrient / water uptake affected by nutrient solution temperature by (Borowski, 1995). Mozafar *et al*., (1993) have reported that relative translocation of nutrients from roots to shoots seemed to be controlled by Root Zone Temperature. Maize grown at low root temperatures (12 -18$^0$C) not only declined in root growth but also in aerial growth in comparison with values for high temperatures 24$^0$C (Engels and Marschner, 1996).

**RZT with decomposition of Organic matter, nitrogen and carbon**

Temperature directly and indirectly regulates DOM production through its influence on biological activities and physico-chemical processes (Stutter, 2007). Increases in RZT and reduced allocation of N supply to roots and leaves and increased allocation to stem,


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

although an effect on carbon assimilation rate was not observed (Gavito *et al.*, 2001).

**Influence of Temperature on DOC, HI and Nitrate**

The study site was located within a long-term research watershed operation by the USDA in Pennsylvania, USA (Bryant, 2011). In 2009, we installed tension and zero-tension lysimeter at 20(A horizon), 40 and 60 cm (B horizon) depth in a mixed oak-hickory forest that had not been harvested for >50 years. The soil is categorized as Typic Dystrudept. Lysimeters were installed along with one moisture-temperature sensor at each depth (Decagon Devices, USA).

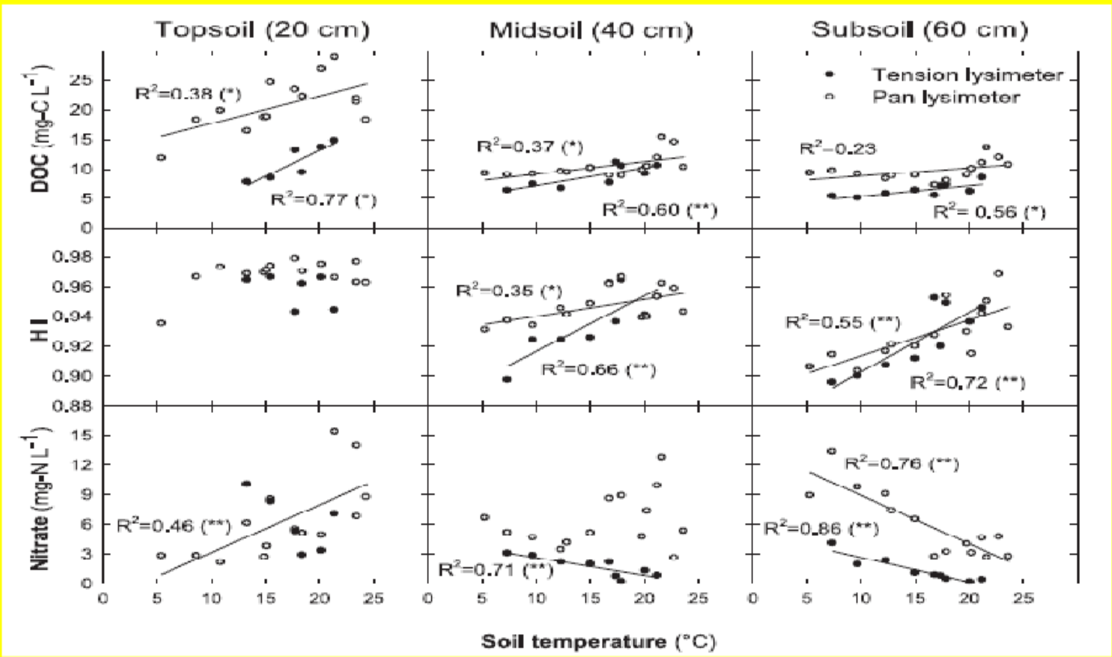



**Fig. 5.** Regression coefficients between dissolved organic carbon (DOC), humification index (HI) and soil solution nitrate with soil temperature. * and ** indicate P values ≤ 0.05 and ≤ 0.01, respectively.

Soil temperature was positively associated with DOC concentration (R2 = 0.23-0.77, P ≤ 0.05) and complexity (HI) of DOM (R2 = 0.35-0.72, P ≤ 0.05) for both lysimeter types (Fig.5). Although soil temperature was positively correlated with nitrate sampled from zero-tension lysimeters at 20 cm, it was negatively correlated with nitrate sampled from the tension lysimeters at 40 cm and both lysimeter types at 60 cm. The regression coefficients among these variables were i) higher for DOM sampled from tension lysimeters and ii) increased with soil depth for HI (Fig. 5).

Under favorable conditions, increasing soil temperature (10°C -30°C) enhances microbial activity, resulting in accelerated SOM solubilization that is subsequently assimilated or mineralized (Bengtson and Bengtsson 2007, Borken, and Matzner, 2009, Swift, 1979). However, the energy budget theory of microbially driven SOM depolymerization suggests that the consistently larger DOM pool at greater soil temperatures (Fig. 5).

**Interaction effects on Constant Shoot and Different RZT Treatments on Wheat**

Root Zone Temperature Experiments: A replicated, 28-dlong experiment consisting of growing vegetative wheat crops in elevated RZTs [+0 °C (24°C), +4 °C (28°C), +6°C (30°C),+8°C (32°C), and +11°C (35°C)], while keeping air temperature constant (24°C), was conducted. The PESTO experiment used 21-d-old plants, but here the experiment was extended to 28 DAP to allow changes in partitioning in response to RZT to be observed. A control of 24°C RZT was used because RZT during the PESTO ground tests equaled the 24°C air temperature.

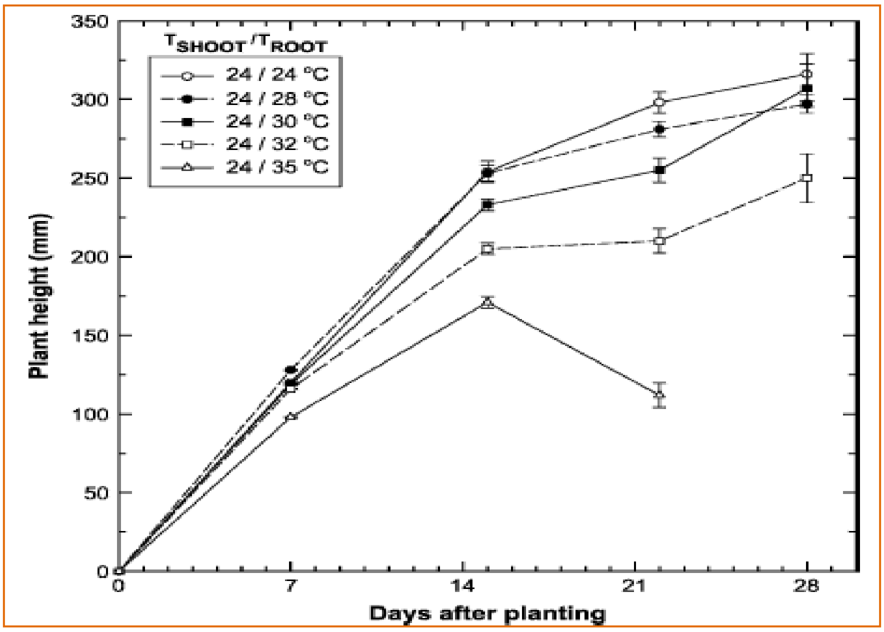



**Fig. 6.** Effects of shoot ($T_{SHOOT}$) and root zone ($T_{ROOT}$) temperature on plant height during

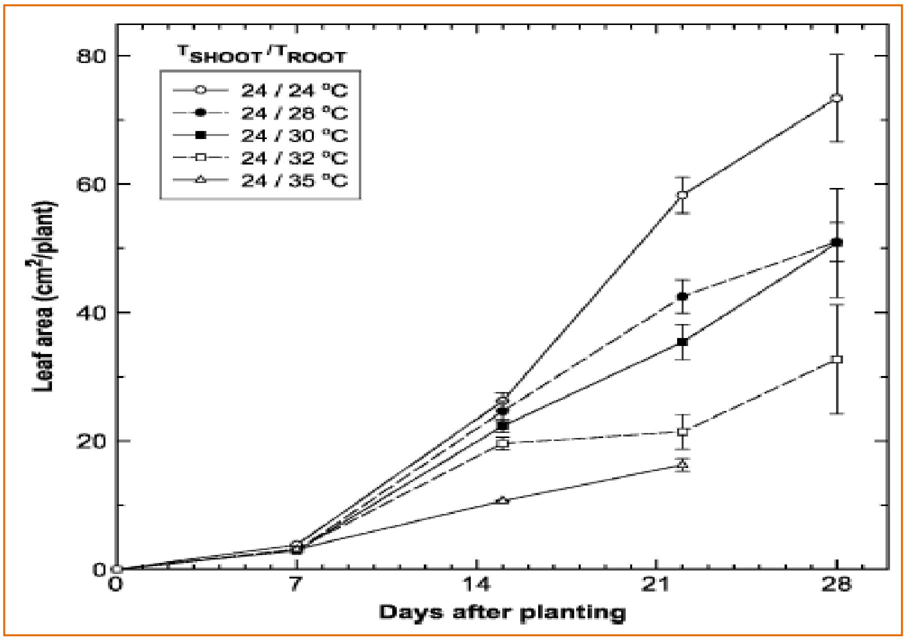



**Fig. 7.** Effects of shoot ($T_{SHOOT}$) and root zone ($T_{ROOT}$) temperature treatments on total leaf area during development of wheat. Observations represent means ± standard error.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

Growth at elevated RZT did not alter the leaf appearance rates because all plants from all treatments reached the same Haun stage of 3.5 by 15 DAP. A + 4°C (28°C RZT) increase in RZT above-air temperature (Fig. 6) did not affect plant height until after 15 DAP (or 10 d after the RZT treatments began). Significant differences in plant height were evident by 15 DAP for RZTs greater than +6°C (30°C RZT) above air temperature. The plants growing at 35°C RZT were severely stunted and eventually died by 22 DAP.

Leaf area was more sensitive to elevated RZT than plant height (Fig. 7). Leaf area was reduced after exposure to 10 d of RZTs exceeding +4 °C (28 °C RZT) above air temperature and after 2 d of exposure at the +11°C (35 °C RZT) treatment. Leaf area expansion had decreased significantly by 22 DAP for RZTs greater than +4 °C above the control (24 °C air temperature and 24 °C RZT). Although morphologic changes were observed when RZT is increased by up to +6 °C, there were no effects observed on physiological processes like leaf photosynthesis or $g_S$. However, at very high RZTs (+11 °C above air temperature), photosynthesis and $g_S$ was severely hampered, and the plants died after 16 d (Oscar Monje, 2007).

**Effect of RZT on different nutrient treatments in cucumber seedlings**

Root-zone temperatures (RZT) (12°C-RZT and 20°C-RZT) and different N, P, and K nutrient regimes on the growth, reactive oxygen species (ROS), and antioxidant enzyme in cucumber seedlings were investigated in hydroponics. The temperature control equipment consisted of a polyvinyl chloride box, plastic pots, sand, and heating wires. The internal dimensions of the polyvinyl chloride box were 240 cm long, 70 cm wide and 20 cm deep. Eachbox contained 48 pots. 8 pots for each nutrient treatment were randomly distributed in the box. The space between pots in the polyvinyl chloride box was filled with sand, in which heating wires (DV, Ningbo, China, 800 W 100 m) were imbedded. Through the heating wires, heat was delivered to sand, and then to the solutions in plastic pots. Temperature was regulated by a temperature controller and timing device (Fig. 8). Plants were grown in the box glass greenhouse under two different nutrient (Hoagland's) solution temperatures while their aerial parts were subjected to the same air temperature condition. The air and root-zone temperatures of a typical experimental day were showed in Fig. 5. The unheated nutrient solution temperature, ranged from 8°C at 18:00 to 11.9°C at 8:00 a.m. of the next day, as the treatment of (12±2)°C (12°C-RZT), and the heated solution temperature was kept at constant


Published: 23 Jan. 2024
ISSN: 2583-7850

(20±2)°C (20°C-RZT) during this period (heating time). The temperatures were recorded by an intelligent digital recorder (LGR-WD41, Hangzhou Logger Technology Co. Ltd., China).

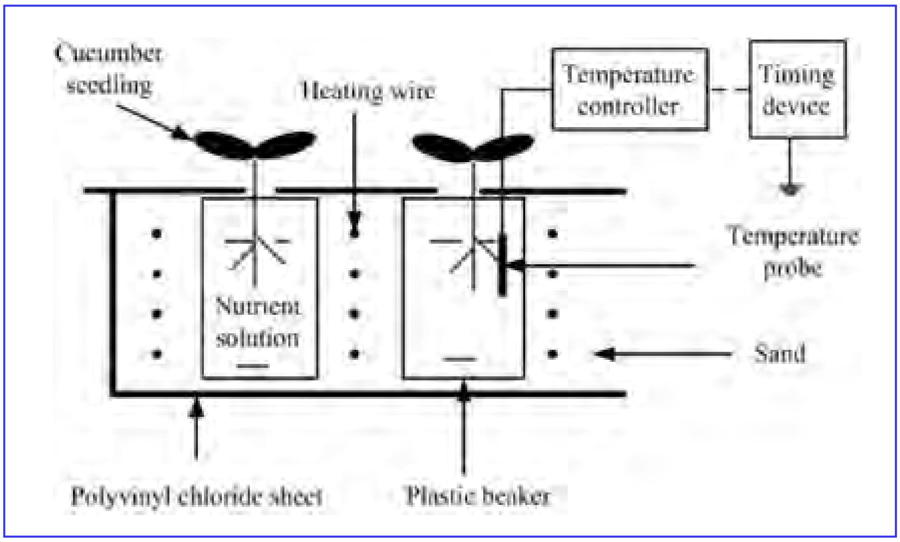



**Fig. 8.** Cross-section diagram of automatic controlling system of root-zone temperature.

Total fresh weights at elevated root-zone temperature (20°C-RZT) were significantly higher than those at low root-zone temperature (12°C-RZT) in all nutrient treatments (data not shown). Table 4 showed the growth indexes affected by RZT and nutrients. There were significant interactions between nutrient solution and RZT for the total plant dry weights ($P$=0.001), root lengths ($P$=0.001), and leaf areas ($P$=0.01), but not for the plant heights and internode lengths (Table 4). RZT had larger effects ($P$=0.001) on plant heights and stem lengths than nutrient solution ($P$=0.05) (Table 4).

**Table 4** Effects of root-zone temperature on growth indexes of cucumber seedlings in the different nutrient treatments[1].

| Root-zone temperature (RZT) | Nutrient treatment | Growth indexes | | | | |
|---|---|---|---|---|---|---|
| | | Total plant dry weight (g/plant) | Plant height (cm) | Internode length (cm) | Root length (cm) | Leaf area ($cm^2$) |
| 12°C-RZT | Control | 1.37 d | 8.57 e | 2.14 e | 16.03 f | 85.17 f |
| | Low-N | 1.24 d | 8.57 e | 2.14 e | 14.50 g | 89.71 f |
| | High-N | 1.96 c | 9.64 e | 2.41 e | 18.12 e | 132.56 b |
| | Low-P | 1.88 c | 10.78 e | 2.69 e | 19.50 e | 124.29 d |
| | High-P | 1.65 cd | 9.78 e | 2.44 e | 18.60 e | 108.80 e |
| | Low-K | 1.54 d | 9.71 e | 2.42 e | 16.50 f | 103.64 e |
| | High-K | 1.25 d | 7.85 e | 1.96 f | 16.04 f | 99.80 ef |
| 20°C-RZT | Control | 2.08 c | 21.42 bcd | 4.28 abcd | 35.70 b | 141.24 ab |
| | Low-N | 1.90 c | 18.92 d | 3.78 d | 24.40 d | 133.68 b |
| | High-N | 2.41 a | 24.00 ab | 4.80 ab | 39.15 a | 147.41 ab |
| | Low-P | 2.22 b | 24.42 a | 4.88 a | 38.50 a | 158.27 a |
| | High-P | 1.96 c | 21.07 bcd | 4.21 bcd | 41.01 a | 121.47 d |
| | Low-K | 1.78 cd | 20.00 cd | 4.00 cd | 28.50 c | 150.25 ab |
| | High-K | 2.29 b | 22.92 abc | 4.58 abc | 41.50 a | 174.43 a |
| Analysis of variance | | | | | | |
| Nutrient solution | | ** | * | * | *** | *** |
| RZT | | *** | *** | *** | *** | *** |
| Nutrient solution×RZT | | *** | NS | NS | *** | ** |

1) Mean values followed by different letters within a column indicated significant differences at $P$=0.05 based on Duncan's multiple range test.
NS, *, **, ***, nonsignificant, significant at $P$=0.05, $P$=0.01, and $P$=0.001, respectively. The same as below.

Total plant dry weights increased at 20°C-RZT under each nutrient treatment compared to those at 12°CRZT. At 12°C-RZT, total plant dry weights increased with increasing nitrogen (N) concentration, but decreased with increasing phosphorus (P) and potassium (K)concentrations. Total plant dry weights in high-N and low-P treatments were significantly higher than those of other nutrient treatments at 12°C-RZT. Irrespective of the nutrient concentrations, plant heights, internode lengths, root lengths and leaf areas were significantly suppressed at 12°C-RZT compared with those of plants grown at 20°C-RZT(Table 4), and no significant difference was found in most nutrient treatments for each growth index at 12°C- RZT, but different effects can be observed between nutrient treatments at 20°C-RZT. At 20°C- RZT, total plant dry weights increased with increasing N and K concentration, but decreased with increasing P concentration. In addition, total plant dry weights in high- N and high-K treatments at 20°C-RZT were significantly higher than those of other treatments. Plant heights in low N and K concentrations at 20°C-RZT were lower than those in high concentration, while those in P treatment showed the reverse result. Plants grown at high- K and low-P had the greatest inter-node length. Root lengths at high-N, low-P and high-P were significantly higher than those of other treatments. Moreover, roots at 12°C-RZT were short, thick, and had fewer root hairs, while those at 20°C-RZT were relatively long, thin and strongly branched.

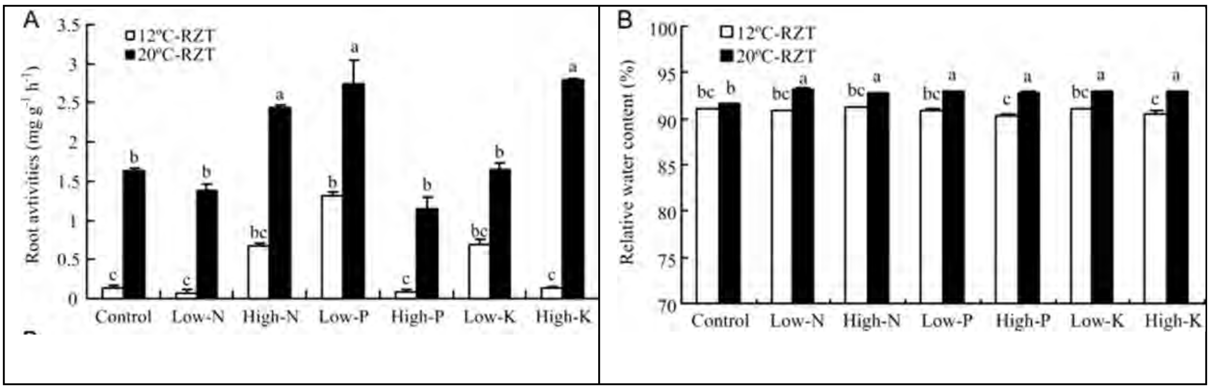



**Fig.9.** Effects of root-zone temperature on root activities (A) and relatively water content (B) of cucumber seedlings (30-d-old) in different nutrient treatments.

The low root-zone temperature (12°CRZT), the root activities of cucumber seedlings suffered seriously and were significantly lower than those at elevated root-zone temperature (20°C-RZT) in all nutrient treatments. Root activities increased with increasing N and K nutrient concentrations, but decreased with the increase of P concentration (Fig.9-A). Leaf relative water contents at 20°C-RZT in all nutrient treatments were significantly higher than those at 12°C-RZT (Fig. 9-B). There was no significant difference between nutrient treatments at each root-zone temperature (Fig. 9-B). Yan Qiu-yan., (2013) reported that


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

application of N could compensate the negative effects of low root temperature on biomass formation compared to those of P and K. Finally, elevating root temperature would be a more effective method than adding nutrients concentration for plant growth in cold season.

**Root Zone Temperature with Phosphorus Interaction**

A study of *Lactuca sativa* L. cv. (baby butter fruit) Palma under aeropical conditions, found that plants grow at optimum cool RZT had higher leaf P concentration compared to the plants grown at hot A-RZT (Tan *et al.*, 2002). Klock *et al.*, (1997) reported Tomato (Solanum lycopersicum L.) plant growing at $36^0$C RZT for 20 d exhibited **decreased shoot growth and P uptake** compare with plants growing at $25^0$C RZT.

In this study, butterhead lettuce (*Lactuca sativa* L. cv. Baby Butter) plants were grown at three root-zone temperatures (RZTs): 25°C, 30°C and ambient-RZT (A-RZT) ranging from 26°C-42°C while their shoots were maintained at hot ambient temperature ranging from 26°C- 42°C. Three phosphorus (P) concentrations: -25% P (minus P, 23.25ppm), control (31.00ppm) and +25% P (plus P, 38.75ppm) were supplied to the plants at each RZT using Netherlands Standard Nutrient Solution in modified hydroponic culturing system. Interactions between RZT and P concentrations on productivity, root morphology, maximum photosynthetic O2 evolution (P max), P uptake and its partitioning between shoot and root were studied.

**Table. 5.** Mean P Concentrations (mg/g DW), Total P Content of Shoot and Root and P Shoot/Root Ratio of *L. sativa* Plants Grown at Different P Concentrations in Nutrient Solution and Different RZTs for 35 Days

| Treatment | | | | | |
|---|---|---|---|---|---|
| | | Tissue | -25% P | Control P | +25% P |
| P concentration (mg/g DW) | 25°C-RZT | Shoot | $5.81 \pm 0.46^{*a}$ | $6.62 \pm 0.58^{a}$ | $7.86 \pm 0.48^{*a}$ |
| | | Root | $5.07 \pm 0.36^{*d}$ | $5.67 \pm 0.40^{d}$ | $7.07 \pm 0.53^{*d}$ |
| | 30°C-RZT | Shoot | $4.8 \pm 0.37^{*b}$ | $5.76 \pm 0.46^{b}$ | $7.01 \pm 0.49^{*b}$ |
| | | Root | $4.73 \pm 0.22^{*e}$ | $5.95 \pm 0.28^{e}$ | $6.83 \pm 0.41^{*e}$ |
| | A-RZT | Shoot | $4.06 \pm 0.37^{*c}$ | $4.79 \pm 0.36^{c}$ | $5.84 \pm 0.49^{*c}$ |
| | | Root | $4.42 \pm 0.27^{*f}$ | $5.31 \pm 0.23^{f}$ | $5.95 \pm 0.35^{*f}$ |
| Total P content (mg) | 25°C-RZT | Shoot | $20.06 \pm 2.06^{*a}$ | $29.17 \pm 2.61^{a}$ | $45.86 \pm 3.34^{*a}$ |
| | | Root | $3.36 \pm 0.32^{*d}$ | $4.22 \pm 0.18^{d}$ | $5.94 \pm 0.37^{*d}$ |
| | 30°C-RZT | Shoot | $11.31 \pm 1.14^{*b}$ | $19.43 \pm 0.88^{b}$ | $31.04 \pm 1.47^{*b}$ |
| | | Root | $2.74 \pm 0.23^{*e}$ | $3.94 \pm 0.28^{b}$ | $5.12 \pm 0.35^{*e}$ |
| | A-RZT | Shoot | $5.06 \pm 0.41^{*c}$ | $9.04 \pm 0.66^{c}$ | $16.56 \pm 1.07^{*c}$ |
| | | Root | $1.83 \pm 0.08^{*f}$ | $2.57 \pm 0.32^{f}$ | $4.39 \pm 0.24^{*f}$ |
| | 25°C-RZT | shoot/root ratio | $5.97 \pm 0.32^{a}$ | $6.44 \pm 0.58^{a}$ | $7.72 \pm 0.38^{*a}$ |
| | 30°C-RZT | shoot/root ratio | $4.13 \pm 0.29^{*b}$ | $4.69 \pm 0.4^{b}$ | $6.06 \pm 0.48^{*b}$ |
| | A-RZT | shoot/root ratio | $2.76 \pm 0.23^{*c}$ | $3.52 \pm 0.17^{c}$ | $4.92 \pm 0.28^{*c}$ |

* Indicates significant difference by comparing to the control P ($P < 0.05$) by t-test at the same RZT. Means within each P treatment followed by different letters are significantly different ($P < 0.05$) based on Fisher's LSD test, n = 5.


Published: 23 Jan. 2024
ISSN: 2583-7850

**P Uptake and Partitioning Between Shoots and Roots**

Phosphorus concentrations of shoot and root as well as its partitioning between shoot and root are summarized in Table **5**. At each given RZT, P concentration of shoot and root were significantly higher in the plus P plants than in the control plants ($P < 0.05$). Meanwhile, P concentrations of shoot and root were significantly lower in the minus P plants compared to those of the control plants ($P < 0.05$). On the other hand, P concentrations of shoot and root were significantly reduced when lettuce plants were grown at hot A-RZT. At each given P concentration in nutrient solution, P concentrations of shoot and root were significantly higher in 25°C-RZT plants than in hot A-RZT plants ($P < 0.05$). Both shoot and root had the highest P concentration when lettuce plants were grown with the plus P concentration at 25°C-RZT. With the minus P concentration and A-RZT, both shoot and root tissues had the lowest P concentrations. These findings suggest that there was a decrease in P concentrations of shoot and root when lettuce plants were grown with lower P concentration in the medium at hot A-

RZT. Lettuce plants grown with plus P concentration at 25°C-RZT had significantly higher shoot and root P concentrations compared to those plants grown with the plus P concentration at A-RZT ($P < 0.05$). These results suggest that P concentrations in both the shoots and root were affected by RZT and P concentration in nutrient solution. The effect of RZT on the accumulation of shoot and root P masked the effect of P concentrations in nutrient solution.

Interaction between the plus P concentration in nutrient solution and 25°C-RZT significantly enhance Pmax, thus the highest shoot and root productivity. However, plants grown with the minus P concentration at 25°C-RZT developed the largest root system. Higher P concentration in growth medium resulted in higher P concentrations in shoots and roots with a greater portion partitioned to the shoots. Luo *et al*, (2009) concluded uptake and transport of P to the shoot was depressed when lettuce plants were grown at hot A-RZT.

**Root Zone Temperature with Potassium Interaction**

Influx of K to roots and transported to xylems of *Hordeum vulgare and Sorghum bicolor* were both reduced significantly when RZT was higher than 35◦C Bassiri Rad et al., (1991). Tan et al., (2002) recorded reduced uptake of K by lettuce plants when grown with low K concentration at hot RZT leads to poor root development. K concentration in nutrient solution, shoot and root fresh weight of lettuce plants grown at $25^0$C RZT were significantly higher than at $30^0$C Hong et al., (2012).

*Lactuca sativa* L. plants were grown at three root-zone temperatures (RZTs): 25°C, 30°C and ambient-RZT (A-RZT) on aeroponic system. Three potassium (K) concentrations: - 25% K (minus K), control (standard K) and +25% K (plus K) were supplied to the plants


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

at each RZT using Netherlands Standard Nutrient Solution.

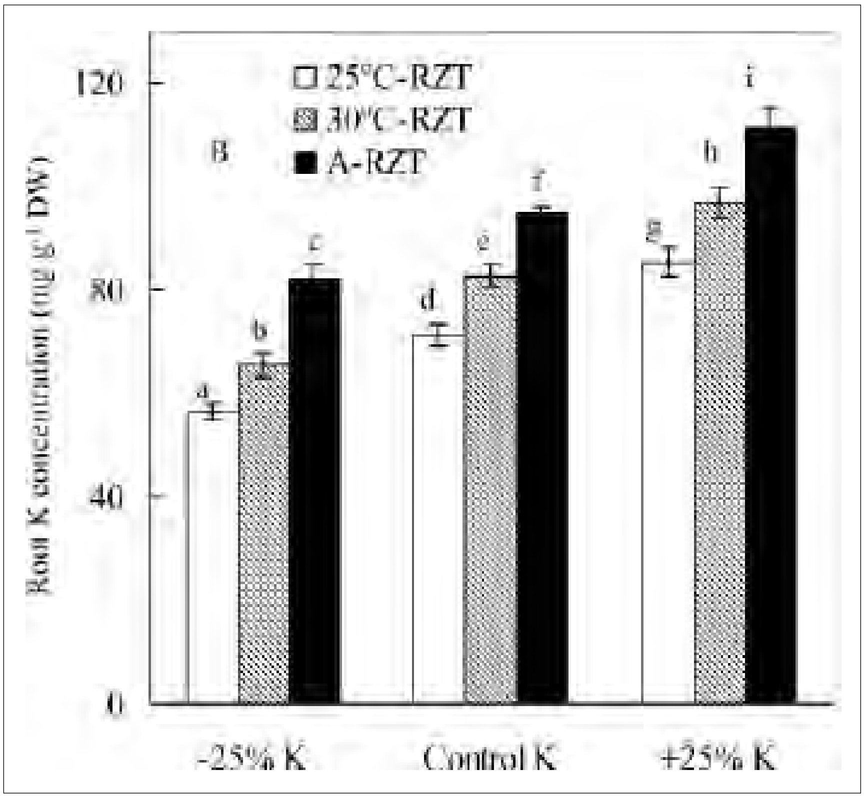



Fig. 10. Root potassium consentration of lettuce plants grown at different concentrations and RZTs.

Lactuca plants had the highest shoot K concentration when grown with the plus K at 25°C C-RZT but they had the lowest shoot K concentration when grown with the minus K at A-RZT. For roots, however, a different pattern was observed. Lowest root K concentration was obtained from the plus K plants at 25°C C-RZT ($P<0.05$) while the highest root K concentration was obtained from plants grown with the plus K at A-RZT. (Hong et al., 2012) find that high productivity of lettuce grown with plus K at all RZTs is the results of high proportion of absorbed K by large root system partitioning to shoots which enhances $P_{max}$ and alters photoassimilate partitioning. To a certain extent, plus K in nutrient solution could alleviate the detrimental effects of hot A-RZT on temperate lettuce grown in the tropics.

**Root Zone Temperature Influences Nutrient Accumulation and Use in Maize**

Root-zone temperature (RZT) changes with season, geographical location and global warming. Nutrient accumulation and use behaviour of two maize (*Zea mays* L.) genotypes were evaluated under low (22.4 ± 5°C) and high (28.8 ± 5°C) root-zone temperatures. In greenhouse study, hybrid maize (FHY-396) and indigenous variety (EV-7004) were sown in calcareous loam soil filled in pots.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

| Nutrient | | High RZT | | Low RZT | | $LSD_{(0.05)}$ |
|---|---|---|---|---|---|---|
| | | Hybrid (FHY-396) | Variety (EV-7004) | Hybrid (FHY-396) | Variety (EV-7004) | |
| | | **Shoot nutrient concentration** | | | | |
| P | mg $g^{-1}$ | 2.70 | 3.09 | 2.56 | 2.96 | 0.13 |
| K | | 5.12 | 4.86 | 5.71 | 5.64 | 0.38 |
| Cu | µg $g^{-1}$ | 12.47 | 12.83 | 9.83 | 9.67 | 0.67 |
| Zn | | 21.33 | 19.50 | 17.05 | 15.03 | 1.17 |
| | | **Root nutrient concentration** | | | | |
| P | mg $g^{-1}$ | 2.88 | 3.33 | 2.82 | 3.23 | 0.09 |
| K | | 2.22 | 2.26 | 1.93 | 2.16 | 0.31 |
| Cu | µg $g^{-1}$ | 41.67 | 40.83 | 35.00 | 35.00 | 1.92 |
| Zn | | 38.39 | 27.63 | 31.08 | 24.58 | 1.37 |
| | | **Ratio-to-shoot concentration ratio** | | | | |
| P | | 1.07 | 1.08 | 1.10 | 1.09 | 0.06 |
| K | | 0.44 | 0.46 | 0.34 | 0.38 | 0.06 |
| Cu | | 0.80 | 0.71 | 1.17 | 0.09 | 0.09 |
| Zn | | 1.80 | 1.42 | 1.82 | 1.64 | 0.08 |

(Low and high RZT differed by 4.2°C)

**Table 6.** Nutrient concentrations in hybrid maize (FHY-396) and indigenous variety (EV-7004) at low and high root-zone temperatures (RZT).

### Concentration of nutrients

There was a significant ($p<0.05$) effect of RZT on concentration of various nutrients in maize genotypes (Table 6). Shoot concentrations of Cu and Zn was increased by about 30% at high RZT than at low RZT. At the higher RZT, shoot P concentration was increased by 5%, whereas, K shoot concentration was decreased at high RZT as compared to low RZT. Nevertheless, root concentration of all the estimated nutrients (including K) was increased at the higher RZT. Ions typically move across the root into the xylem by traversing several layers of plasmalemma.

Root-to-shoot concentration ratio is a reliable tool to study relative translocation of a nutrient from roots to shoots. There was a significant ($p<0.05$) effect of RZT on translocation of K, Cu and Zn (Table 6). ranslocation of both the micronutrients (Cu and Zn) increased at the higher RZT. However, K heavily accumulated in roots with a reduction of its translocation to shoots at the higher RZT. The relative translocation of nutrients from roots to shoots seemed to be controlled by RZT.

### Nutrient Uptake

Uptake (contents plant$^{-1}$) of all the estimated nutrients (P, K, Cu and Zn) in shoots and roots of maize genotypes was significantly ($p<0.05$) increased at high RZT compared to low RZT. There was 1.5-fold increase in P and 1.4-fold increase in K shoot uptake when plants were grown at the higher RZT. Shoot uptake of Cu and Zn was more vividly influenced. A 1.9- fold increase for Cu and 1.8-fold increase for Zn was observed at high RZT than at low RZT.

Cleve *et al*., (1990) found that soil warming improves foliar N, P and K contents. An 83% in shoot Zn uptake was observed in barley with rising RZT from 10°C to 23°C (Schwartz *et al*., 1987).


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

Root is the mineral nutrient uptake organ of plants, and its growth undoubtedly affects nutrient uptake and transport. Nutrient uptake in roots was also similarly affected and it was remarkably more for Cu and Zn (Table 7). Indigenous variety (EV-7004) accumulated significantly ($p$<0.05) more shoot P than hybrid maize (FHY-396), whereas, hybrid maize (FHY- 396) accumulated more root Zn concentration than indigenous variety (EV-7004).

Nutrient uptake per unit parameter of root is an excellent characteristic to estimate efficiency of roots to uptake soil nutrients (Hussain *et al.,* 2009). Root zone temperature was significantly ($p$<0.05) affected nutrient uptake per unit root dry matter (Table 7). On an average, there was 12% increase in P, 40% increase in Cu and 31% increase in Zn uptake per unit root dry matter. Increased uptake per unit root dry matter at the higher RZT could be attributed to root morphology and function, and soil physico-chemical and biological processes that are dependent on RZT (Barber, 1995).

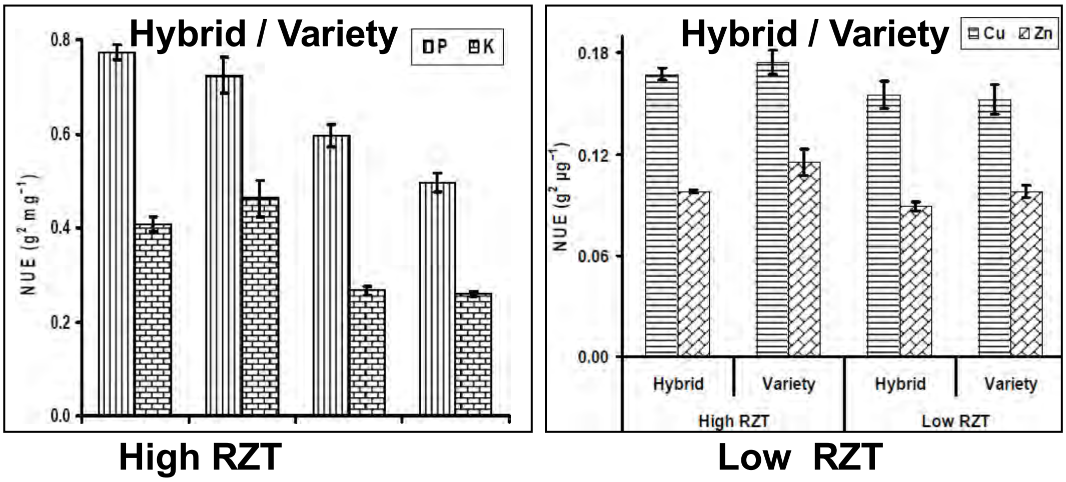



**Fig. 11**. Nutrient utilisation efficiencies (NUE) of hybrid maize (FHY-396) and indigenous variety (EV-7004) at low and high root-zone temperatures (RZT) (Low and high RZT differed by 4.2°C)

**Nutrient utilization efficiency and usage index**

Shoot utilisation efficiencies of all nutrients (P, K, Cu and Zn) was significantly ($p$<0.05) increased at the higher RZT (Fig. 11). Increased nutrient utilisation efficiency meant that nutrient activity in plant tissue was more at the higher RZT. However, Gavito *et al*., (2001) found that P shoot utilisation efficiency decreases in wheat with increase in RZT. Hybrid maize (FHY- 396) efficiently utilized shoot P while Zn utilisation efficiency of indigenous variety (EV-7004) was significantly ($p$<0.05) more than maize hybrid (FHY-396).


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

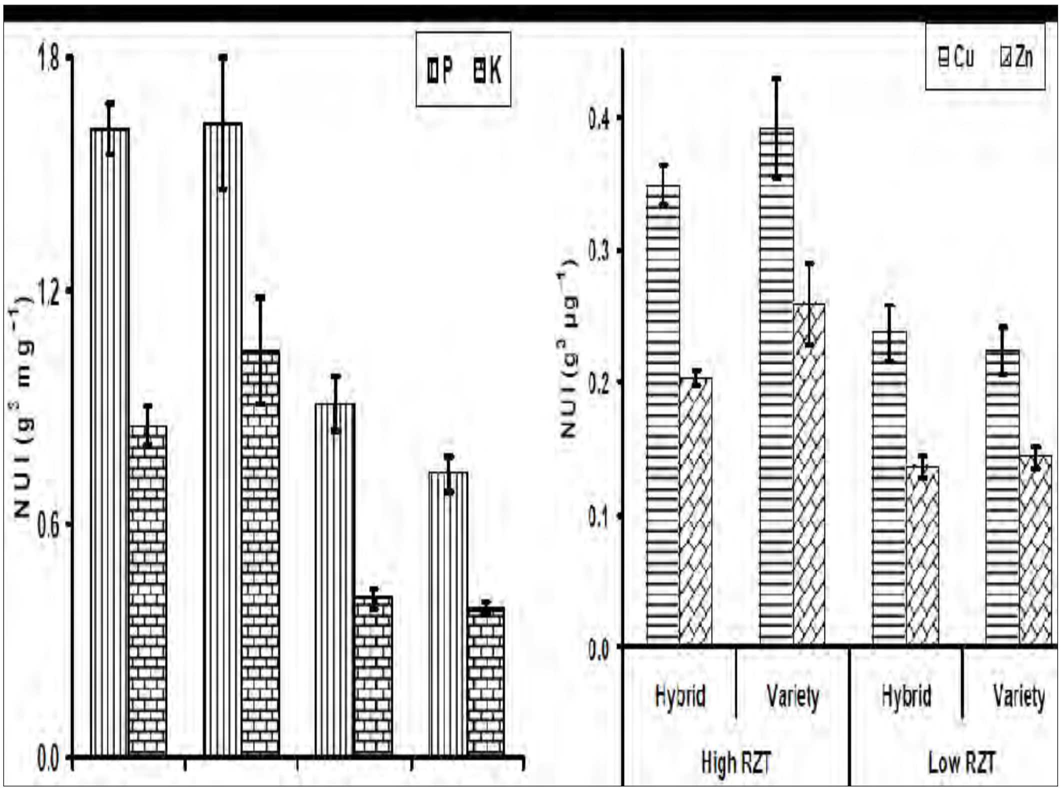



**Fig.12**. Nutrient usage index (NUI) of hybrid maize (FHY-396) and indigenous variety (EV-7004) at low and high root-zone temperatures (RZT) (Low and high RZT differed by 4.2°C)

Nutrient usage index was significantly ($p$<0.05) increased in both the genotypes when grown at the higher RZT (Fig. 12). Shahid hussain, (2011) found that the effect of RZT was more pronounced on NUI than NUE. Shoot NUI of Cu and Zn was increased about 60% at high RZT that at low RZT. At the higher RZT, P and K usage indexes were increased by 98% and 140%, respectively.

**Root Zone Temperature with Chilling effect of Boron**

Chilling in the root zone during early crop growth is likely to affect root growth, root system establishment and the uptake of boron (and other nutrient) than oil seed crops Ye *et al.*, (2003). Chilling decreases root hydraulic conductance and slows down water absorption on the one hand and on the other hand, impairs stomatal control which leads to excessive water loss and leaf wilting (Capell and Dorffling, 1993; Bloom *et al.*, 2004).

**Subtropical / tropical species:** (e.g. cucumber, cassava, sunflower), root chilling at 10–17$^0$C decreases B uptake efficiency and B utilization in the shoot and increases the shoot : root ratio, **Chilling-tolerant temperate species:** (e.g. oilseed rape, wheat) require much lower root chill temperatures (2–5$^0$C) to achieve the same responses.

**Table 8**. Effects of chilling root zone temperature on B nutrition in crop species of different chilling sensitivities (* the sensitivity ranking was based on Kratsch and Wise, 2000)

| Species | Chilling sensitivity* | Root temp. (°C) (day/night) | Canopy temp. (°C) | B supply (μM B) | Chilling effects on B nutrition | References |
|---|---|---|---|---|---|---|
| Cassava | Extreme | 18 | Ambient | 46 | Severe B deficiency symptoms in roots first and then in shoots later. Decreased B absorption rate. Increased shoot : root ratio | Forno *et al.*, 1979 |
| Sunflower | Intermediate | 12 | Ambient | 0·08, 0·16, 0·25, 0·62, and 6·5 | Induced B deficiency symptoms in young leaves at 0·25 μM (but not at 17 °C and above), decreased B uptake at all B supply levels, B transport from root to shoot, B partitioning into young leaves. Increased shoot : root ratio | Ye *et al.*, 2000 |
| Tomato | Intermediate | 10 | Ambient | 93 | No B deficiency symptom, decreased B absorption by roots | Tindall *et al.*, 1990 |
| Wheat | Tolerant | 5 (night only) | 5 (night only) | 0, 10 | No B deficiency symptom, decreased B concentrations in the youngest emerging leaf (flag leaf), but increased B concentration in the ear at 10 μM B and decreased at 0 μM B. | Huang *et al.*, 1996 |
| Oilseed rape | Tolerant | 10 | Ambient | 0·13, 0·19, 8·3 | Decreased shoot : root ratio, delayed B deficiency symptoms at 0·13 μM B, increased shoot B partitioning into actively growing leaves without effect on net B uptake rate, and increased B concentration in the youngest fully opened leaves | Ye *et al.*, 2003 |
| Oilseed rape | Tolerant | 2–5 | Ambient | 0·2, 9·1 | Direct transfer from 10–12 to 2–5 °C in root zone for 5 d decreased water use (per plant), increased shoot : root ratio, B uptake rate, B translocation into shoot, and B partitioning into the new leaves, regardless of B supply. | Ye, 2005 |

The intrinsic chilling sensitivity of crop species seems to be a determining factor in responses of B uptake / transport and B partitioning to root chills (Table 8). However, exposure to 10 _C in the root zone did not decrease B uptake in chilling-tolerant species, such as oilseed rape and wheat (Huang et al., 1996; Ye et al., 2003).

**Root Zone Temperatures on the Phytoextraction of Boron and Aluminium with Potato plants**

The study conducted at different root zone temperatures on the concentration and content of B and Al in potato plants was examined using four different treatments of plastic mulches: T1: transparent polyethylene; T2: white polyethylene; T3: coextruded black and white polyethylene; T4: black polyethylene. An open-air treatment (T0) was used as control. The results showed significantly positive effects of the plastic covers on the root-zone temperatures: T0=16°C, T1=20°C, T2=23°C, T3=27°C and T4=30°C. The soil temperature was measured at 15 cm in depth, using probes (107 type) from Campbell Scientific TM. Root zone temperature was measured (six measurements at 4-hour intervals) every 3 days of the crop cycle.

The different thermal conditions significantly affected the total B concentrations in roots, because T2 and T3 reached maximum concentrations, with 42% more than T0 for both treatments, while the lowest level was given in T1 (some 13% lower than T0). In tubers, the highest levels in total B were observed in T2 and T3 with 27 and 18% higher than T0, respectively, while T1 and T4 obtained similar concentrations to T0. With respect to the B in the stems (Table 9), the highest concentrations were given in T2 and T3, with an increment of 14% in relation to the control, and the lowest level was given in T1 (20% lower than T0), while T4 did not differ statistically from the

control. Finally, in
leaflets, the highest concentration of total B was given in T3 (13% higher than T0) and T1 as 12% lower than T0, while T2 and T4 obtained practically equal concentrations to the control.

**Root Zone Temperatures with Al interaction**

Different temperature in the root zone significantly affects the total Al concentration (Mourad Baghour *et al*., 2002). Strid, (1996) reported synergic effect is observed between RZT and Al concentrations, because the high temperature increases the absorption of Al, showing severe symptoms of Al toxicity at $25^0$C than $15^0$C.

The different temperature in the root zone significantly affected the total Al concentration, evident in the roots of T2, the highest value exceeding control (T0) by 15%, and the lowest concentration being obtained in T4. In the tubers, the highest concentrations were found in T2 and T3, at some 14 and 9%, respectively, higher than control, while T1 was 45% lower than control. For the stems, the highest values were reached in T0 and the lowest in T1 and T3. Finally, in the leaves, T2 and T3 showed the highest concentrations, some 69 and 73% higher than control, while T1 and T0 gave lower values.

Soluble Al in the roots proved higher in T2, surpassing T0 values by 84%, and in T0, we observed the lowest value. In the tubers, T3 showed the highest soluble Al concentration, some 72% higher than in T0, while T1 showed the lowest (17% less than T0). In the stems, T3 and T4 gave the highest levels, surpassing T0 by 17 and 15%, respectively, and the lowest values were obtained in T0 and T1. Finally, in the leaflets, T2 to T4 did not differ statistically, exceeding T0 and T1 concentrations. Mourad Baghour *et al.* (2007) conclude that under our experimental conditions, the potato plant can be a hyper accumulator of B and Al, aided by the control of the root temperature by the mulch application.

**Root Zone Temperature Influences Zinc Requirement in Maize**

Temperature is an important plant growth factor (Fageria et al., 1997; Pregitzer and King, 2005). Soil temperature affects the rates of physico-chemical and biological processes of nutrient availability in soils and hence affects nutrient uptake and growth of plants. However, influence of soil temperature on nutrient uptake by plant roots has not been thoroughly investigated (Bowen, 1991; Pregitzer and King, 2005).

The zinc (Zn) requirement of a maize (Zea mays L.) hybrid ('FHY-396') and an indigenous variety ('EV-7004') was measured at low (22.4 $\pm$ 5◦C) and high (28.8 $\pm$ 5◦C) root-zone temperatures (RZT). Four Zn rates (0, 3, 9 and 27 mg kg−1 soil) were applied to a calcareous loam soil in pots for the glasshouse study.

In both the cultivars, Zn uptake per unit root dry matter ($\mu$g Zn plant$^{-1}$ g$^{-1}$ root dry matter) was significantly ($P < 0.01$) increased at high RZT than at low RZT (Figure 13). Incremental Zn application rates significantly ($P < 0.01$) increased Zn uptake per unit root dry matter. Increased Zn uptake per unit root dry matter at high RZT could be attributed to temperature depended root and soil physico-chemical and biological processes.

The relationship of relative shoot dry matter with concentration of Zn in shoots of maize hybrid 'FHY-396' and variety 'EV-7004' regardless of the RZT, maximum relative shoot dry matter yield in hybrid 'FHY-396' and variety 'EV-7004' was produced when Zn was applied at 9 and 3 mg Zn $kg^{-1}$ soil, respectively. Shoot and root dry matter yields were significantly more at the higher RZT. Zinc concentration in roots and shoots of both the cultivars increased with Zn application rates and was significantly higher at the higher RZT.

Cultivars differed in optimum shoot Zn concentration and this difference was narrowed down at high RZT. S. Hussain *et al.* (2010) concluded high RZT had a positive effect on growth and Zn nutrition of maize cultivars. Genetic differences among species and cultivars exist for response to soil temperatures.

Likewise, Zn requirement of maize changes with cultivar and RZT. The $C_{Zn}$ C ranged from 25 to 39 mg Zn $kg^{-1}$ plant tissue for optimum growth of both the cultivars at low and high RZT. Therefore, further studies are warranted on nutritional requirement of crops for their sustained production under changing climatic conditions.

RZT is important for plant growth & development in various stages at different temperature. Optimum RZT helps in physico-chemical and biological processes of plants and nutrient uptake. The nature of RZT increases or decreases the concentration, uptake and nutrient use efficiency. The RZT may have direct adverse effect on plants growth, development and yield under rainfed conditions. Thus ideal RZT would improve seed germination, water / nutrient uptake in plant and maintain physico-chemical properties of soil and plant.

**Future thrust**

- Identification of RZT in different plants and their optimal temperature for effective crop growth.
- Integration of RZT with nutrients application for attaining ecologically better fertilizer management.
- Better identification of RZT may have the advantage of requiring lower rates of fertilizer or less frequent applications.
- Conducting periodic surveys of the RZT status of crops and soil in different climatic region.


Published: 23 Jan. 2024
ISSN: 2583-7850

## References

Bassirirad, H. 2000. Kinetics of nutrient uptake by roots: Responses to global change. *New Phytol.,* 147: 155-169.

Bengtson, P., G. Bengtsson. 2007. Rapid turnover of DOC in temperate forests accounts for increased $CO_2$ production at elevated temperatures, Ecol. Lett. 10: 783-790.

Bloom .A.J., Zwieniecki. M.A., Passioura. J.B., Randall. L.B., Holbrook. N.M., St Clair. D.A. 2004. Water relations under root chilling in a sensitive and tolerant tomato species. Plant, Cell and Environment 27: 971–979.

Borken, W., E. Matzner. 2009. Reappraisal of drying and wetting effects on C and N mineralization and fluxes in soils, Global Change Biol. 15 : 808-824.

Campbell Scientific Australia Pty. Ltd. (CSA). 2012. Model HFP01Soil Heat Flux Plate. www.campbellsci.com.

Capell. B., K. Dorffling. 1993. Genotype-specific differences in chilling tolerance of maize in relation to chilling-induced changes in water status and abscisic acid accumulation. Physiologia Plantarum 88: 638–646.

Day, T. A., S. A. Heckathorn, and E. H. Delucia. 1991. Limitation of photosynthesis in *Pinus taeda* L. (loblolly pine) at low soil temperatures. *Plant Physiology* 96: 1246–1254.

Gavito, M.E., P.S. Curtis, T.N. Mikkelsen and I. Jakobsen. 2001. Interactive effects of soil temperature, atmospheric carbon dioxide and soil N on root development, biomass and nutrient uptake of winter wheat during vegetative growth. *J. Exp. Bot.,* 52: 1913-1923.

Harsco Corporation. 2013. Improving drought, heat and could stress tolerance in plants with Silicon. Product information bulletin, web: www.crossover-fertilizer.com.

Klock, K.A., H.G. Taber, and W.R. Graves. 1997. Root respiration and phosphorous nutrition of tomato plants grown at a 36°C root-zone temperature. J. Amer. Soc. Hort. Sci. 122:175–178.

Landhausser, S. M., R. W. Wein, and P. Lange. 1996. Gas exchange and growth of tree arctic tree-line tree species under different soil temperature and drought preconditioning regimes. *Canadian Journal of Botany* 74: 686–693.

Levitt. 1980. Responses of plants to environmental stress, Vol. 1 and $2^{nd}$ ed. Academic press, New York.

Longbin Huang., Zhengqian ye, Richard W. Bell and Bernard Dell. 2005. Boron Nutrition and Chilling Tolerance of Warm Climate Crop Species. Annals of Botany 96: 755–767. doi:10.1093/aob/mci228, available online at www.aob.oxfordjournals.org.

Luo. H.Y., S.K. Lee and J. He. 2009. Integrated Effects of Root-Zone Temperatures and Phosphorus Levels on Aeroponically-Grown Lettuce (*Lactuca sativa* L.) in the Tropics. *The Open Horticulture J. :* 6-12. E-mail: jie.he@nie.edu.sg.

Luo. H.Y., S.K. Lee and J. He. 2012. Interaction between Potassium concentration and Root-Zone Temperature on growth and Photosynthesis of Temperate LETTUCE grown in the Tropics, J. Plant Nutrition, 35:7.1004-1021.

Mourad Baghour , Diego A. Moreno , Gemme Villora , Joaquin Hernández , Nicolas Castilla & Luis Romero. 2002. The Influence of The Root Zone Temperatures on the Phytoextraction of Boron and Aluminium with Potato Plants Growing in the field. J. Environmental Science and Health, Part A: Toxic/Hazardous Substances and Environmental Engineering, 37:5, 939-953. To link to this article: http://dx.doi.org/10.1081/ESE- 20003599.

Oscar Monje, Sylvia Anderson, and Gary W. Stutte. 2007. The Effects of Elevated Root Zone Temperature on the Development and Carbon Partitioning of Spring Wheat. J. AMER. SOC. HORT. SCI. 132(2):178–184.

Pregitzer, K. S and J. S. King. 2005. Effect of soil temperature on nutrient uptake. In: nutrient Acquisition by Plants, An Ecological perspective, ed. H. Bassiri Rad, pp. 277–310. Berlin: Springer.


Published: 23 Jan. 2024
ISSN: 2583-7850

Schwarz, P. A., T. J. Fahey, and T. E. Dawson. 1997. Seasonal air and soil temperature effects on photosynthesis in red spruce (*Picea rubens*) saplings. *Tree Physiology* 17: 178–194.

Shahid Hussain , Muhammad Aamer Maqsood , Rahmatullah & Shamsa Kanwal. 2010. Root Zone Temperature Influences Zinc Requirement of Maize Cultivars on a Calcareous Loam Soil, J. Plant Nutrition, 33:13.1960-1969. http://dx.doi.org/10.1080/01904167.2010.512054.

Shahid Hussain and Muhammad Aamer Maqsood. 2011. Root Zone Temperature influences Nutrient accumulation and USE in Maize. *Pak. J. Bot.*, 43(3): 1551-1556.

*Correspondence author E-mail: id.hussain@yahoo.com .

Stutter, M. I., D.J. Lumsdon, V. Thoss. 2007. Physico-chemical and biological controls on dissolved organic matter in peat aggregate columns, Eur. J. Soil Sci. 58:646-657.

Swift, M.J., O.W. Heal, J.A. Anderson. 1979. Decomposition processes at molecular level. Decomposition in Terrestrial Ecosystems, Blackwell Scientific Publication, 167-219.

Ten Hulscher, T.E.M and G. Cornelissen. 2002, Effect of temperature on sorption equilibrium and sorption kinetics of organic micropollutants e a review, Chemosphere 32:609-626.

YAN Qiu-yan, DUAN Zeng-qiang, MAO Jing-dong, LI Xun1 and DONG Fei. 2013. Low Root Zone Temperature Limits Nutrient Effects on Cucumber Seedling Growth and Induces Adversity Physiological Response. J. Integrative Agriculture,

TRENDS IN AGRICULTURE SCIENCE
Vol.3 Special Issue 01 January 2024, Page: 25-46

# Importance of Micronutrients for Soil, Plant, Animal and Human Health

**S. Suganya**
Senior Scientist (Soil Science), Tamil Nadu Agricultural University, Coimbatore-641 007
https://doi.org/10.5281/zenodo.10550918

## Introduction

Our planet's survival depends on the precious link between soil and water. Over 95 percent of our food originates from these two fundamental resources. Soil water, vital for nutrient absorption by plants, binds our ecosystems together. This symbiotic relationship is the foundation of our agricultural systems. However, in the face of climate change and human activity, our soils are being degraded, putting excessive pressure on our water resources. Erosion disrupts the natural balance, reducing water infiltration and availability for all forms of life. Sustainable soil management practices, such as minimum tillage, crop rotation, organic matter addition, and cover cropping, improve soil health, reduce erosion and pollution, and enhance water infiltration and storage. These practices also preserve soil biodiversity, improve fertility, and contribute to carbon sequestration, playing a crucial role in the fight against climate change.

Agriculture is the main source of food and nutrients for animals and humans alike. Fertilizers have played a key role in the success of India's Green Revolution and subsequent attainment of self-reliance and sustainability in food-grain production. Demand of fertilizers witnessed double digit growth rates over the past several years in the country on the strength of their 50% contribution to the increase in food production. However, partial factor productivity declined over the years due to accelerated emergence of micronutrient deficiencies in soils. Micronutrients are the essential nutrient elements, albeit required in very small quantities for overall growth of plants. Essential micronutrients involved in plant nutrition are: zinc (Zn), copper (Cu), iron (Fe), manganese (Mn), boron (B), molybdenum (Mo), chlorine (Cl), and nickel (Ni); for animals Zn, Fe, Mn, Cu, selenium (Se), iodine (I) and cobalt (Co) have been identified as being essential; and list for humans includes Zn, Cu, Fe, Mn, Mo, Co, I, Se, fluorine (F), and chromium (Cr). Boron is considered as beneficial trace element for animals and humans both because it prevents losses of Ca and Mg from their bodies. As enshrined in the essentiality criteria, every micronutrient performs specific role in plant, animal and human metabolism and its deficiency/role cannot be mitigated/substituted by any other element. Minerals applied to crops for their nourishment improve their concentration/content in the plant tissues. Inadequate supply of these nutrients in micronutrient deficient soils can lead to loss of yield as well as quality of produce, and consequentially health of animals and humans (Shukla *et al*., 2018).


**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

Fertility of Indian soils is generally poor exacerbated with progressively emerging micronutrient deficiencies due to their catalyzed removal under agricultural intensification. The Intensification of agriculture-induced whooping nutrient mining of micronutrients from their finite soil resources led to what we experienced in terms of widespread micronutrient deficiencies. Continuous shipping away/export of micronutrients by crops has depleted soil micronutrient reserves and rendered the large tracts of the country deficient in these nutrients. Research evidences suggest that the need-based inclusion of micronutrients in the fertilizer schedules would not only eliminate their deficiencies in soils but also enhance the efficiency of macronutrient fertilizers (Shukla and Behera, 2019). Stagnation in crop productivity can also be eliminated by following balanced fertilization schedule with micronutrients as its essential component. This will ensure reduction in cost of cultivation. Hence, innovative fertilizer products (specialty fertilizers, which include high solubility fertilizer, micronutrient mixtures, slow-release, controlled release, coated, fortified, chelated, organo-mineral, liquid fertilizers, bio-stimulants, bio-based and nanofertilizers) need to be introduced with farmers.

***Micronutrients in plant health***

**Zinc:** Zinc plays a key role in plants as a structural constituent or regulatory co-factor of a wide range of different enzymes and proteins. These are mainly concerned with carbohydrate metabolism, both in photosynthesis and in the conversion of sugars to starch, as well as resistance to infection by certain pathogens.

**Boron:** It aids production of sugar and carbohydrates and essential for seed and fruit development.
**Iron:** It is essential for chlorophyll formation and key constituent of electron transport chain.
**Copper:** It is important for reproductive growth and aids in root metabolism and helps in protein utilization.

**Manganese:** Manganese plays a crucial part in the tricarboxylic acid cycle in oxidation and reduction reactions. It activates several enzymes such as oxidoreductases, hydrolases and lyases. Manganese is a primary component of water-splitting enzyme related to photosystem II.

**Molybdenum:** it is the structural component of nitrogenase enzyme for nitrogen fixation by rhizobium and essential for absorption and translocation of iron in plants.
**Chlorine:** It aids plant metabolism and involve in the production of oxygen during photosynthesis.
**Nickel:** It is the component of urease enzyme and essential for grain development.

***Micronutrients in Human health***

Micronutrients like Zn and Fe are essential for human health.
**Zinc:** is vital for more than 300 enzymes in the body and plays a key role in protein synthesis, wound healing, key component of WBC that fight against infections, DNA synthesis, cell division and required for proper sense of taste and smell.

Some of the symptoms of zinc deficiency in humans especially in infants and young children are diarrhoea, pneumonia, stunted growth, weak immune system, retarded mental growth and dwarfism, impaired cognitive function, behavioural problems, memory impairment, problems with spatial learning and neuronal atrophy. The widespread Zn deficiency has led t Zn malnutrition in the humans.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

**Iron:** plays an important role in oxygen transport, DNA synthesis and muscle metabolism. Iron deficiency is the main cause of anaemia. In adults, Fe deficiency including fatigue, impaired physical performance and decreased work productivity.

**Micronutrient deficiencies in Soils, Plants, Animals and Humans**

***Soil***

Micronutrient content in soil is dependent on several factors viz., geochemical composition (total micronutrient contents of the soil parent material); soil type (clay mineralogy, particle size distribution, soil horizon, soil age, soil formation processes); intrinsic soil properties like pH, redox potential (Eh), soluble salt concertation (EC); quality and quantity of soil organic matter and calcium carbonate content); inputs of trace elements (supplied through atmospheric deposition, pesticides, manures, fertilizers); available content of macronutrients; micronutrient interactions; and vegetation (Shukla *et al*., 2016). Indian soils are fairly satisfactory with respect to total micronutrient content. But in spite of the relatively high total contents, micronutrient deficiencies have been frequently reported in many crops due low levels of available micronutrients in soils (Behera and Shukla, 2014; Shukla and Tiwari, 2016). Status of the micronutrients deficiencies was assessed in different soils during 2011-2017. Analysis of more than 2.0 lakhs soil samples during 2011-2017 revealed that on an average, 36.5, 12.8, 4.2, 7.1 and 23.4% soils were deficient in Zn, Fe, Cu, Mn and B, respectively (Table 1).

***Plants***

Ideal concentrations of micronutrients in plants are 100, 100, 50, 20, 20, 6, 0.1 and 0.1 mg $kg^{-1}$ of dry matter for Cl, Fe, Mn, B, Zn, Cu, Mo and Ni respectively. Plants show deficiency symptoms or enter the hidden hunger condition when the concentrations of micronutrients fall below their respective critical concentrations (Table 2).

***Hidden Hunger***

*Hidden hunger* refers to a situation in which a crop needs more of a given nutrient yet has shown no deficiency symptoms. The nutrient content is above the deficiency symptom zone but still considerably needed for optimum crop production (Fig. 1.) With most nutrients on most crops, significant responses can be obtained even though no recognizable symptoms have appeared.

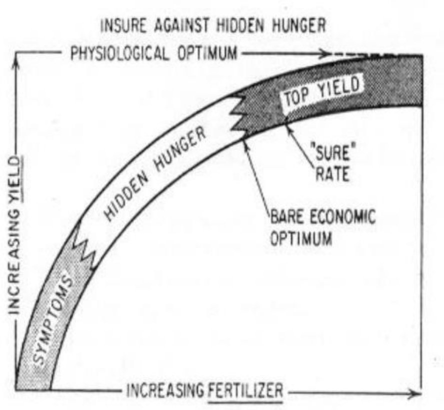



**Fig. 1. Hidden hunger**


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

**Table 1.** State-wise per cent distribution of micronutrient deficiencies in India

| State | Zinc | Iron | Copper | Manganese | Boron |
|---|---|---|---|---|---|
| Andhra Pradesh | 22.92 | 17.24 | 1.33 | 1.63 | 4.08 |
| Arunachal Pradesh | 4.63 | 1.44 | 1.40 | 3.01 | 39.15 |
| Assam | 28.11 | 0.00 | 2.80 | 0.01 | 32.75 |
| Bihar | 45.25 | 12.00 | 3.19 | 8.77 | 39.39 |
| Chhattisgarh | 25.59 | 7.06 | 3.22 | 14.77 | 20.59 |
| Goa | 55.29 | 12.21 | 3.09 | 16.91 | 12.94 |
| Gujarat | 36.56 | 25.87 | 0.38 | 0.46 | 18.72 |
| Haryana | 15.42 | 21.72 | 5.13 | 6.16 | 3.27 |
| Himachal Pradesh | 8.62 | 0.51 | 1.43 | 6.68 | 27.02 |
| Jammu & Kashmir | 10.91 | 0.41 | 0.34 | 4.60 | 43.03 |
| Jharkhand | 17.47 | 0.06 | 0.78 | 0.26 | 60.00 |
| Karnataka | 30.70 | 7.68 | 2.28 | 0.13 | 36.79 |
| Kerala | 18.34 | 1.23 | 0.45 | 3.58 | 31.21 |
| Madhya Pradesh | 57.05 | 8.34 | 0.47 | 2.25 | 4.30 |
| Maharashtra | 38.60 | 23.12 | 0.14 | 3.02 | 20.69 |
| Manipur | 11.50 | 2.13 | 2.46 | 2.06 | 37.17 |
| Meghalaya | 3.84 | 1.33 | 1.03 | 2.95 | 47.93 |
| Mizoram | 1.96 | 0.49 | 0.98 | 1.22 | 32.76 |
| Nagaland | 4.62 | 2.00 | 0.53 | 3.05 | 54.31 |
| Odisha | 32.12 | 6.42 | 7.11 | 2.12 | 51.88 |
| Punjab | 19.24 | 13.04 | 4.67 | 26.20 | 18.99 |
| Rajasthan | 56.51 | 34.38 | 9.15 | 28.28 | 2.99 |
| Tamil Nadu | 63.30 | 12.62 | 12.01 | 7.37 | 20.65 |
| Telangana | 26.77 | 16.65 | 1.36 | 3.54 | 16.49 |
| Tripura | 5.51 | 1.57 | 2.36 | 0.00 | 23.62 |
| Uttar Pradesh | 27.27 | 15.56 | 2.84 | 15.82 | 20.61 |
| Uttarakhand | 9.59 | 1.36 | 1.51 | 4.82 | 13.44 |
| West Bengal | 14.42 | 0.03 | 1.76 | 0.98 | 37.05 |
| All India average | 36.50 | 12.8 | 4.20 | 7.10 | 23.4 |


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

**Table 2. Critical concentration of micronutrients in crop plants**

| Micronutrients | Crops | Critical concentration (mg kg⁻¹) for deficiency |
|---|---|---|
| Zn | Cereals | 15 |
| | Millets | 15 - 20 |
| | Legumes | 7 - 20 |
| | Vegetables (French bean) | 36 |
| | Oilseeds | 12 - 25 |
| B | Cereals | 4 – 10 |
| | Millets | 7 – 15 |
| | Legumes | 3 – 15 |
| | Vegetables | 3 – 5 |
| | Oilseeds | 5 - 10 |
| Mn | Cereals | 25 |
| | Millets | 10 |
| | Legumes | 10-35 |
| | Vegetables | 30 – 40 |
| | Oilseeds | 5 - 18 |
| Cu | Cereals | 2 – 4 |
| | Millets | 2 – 3.5 |
| | Legumes | 4 – 8 |
| | Vegetables | 2 – 6 |
| | Oilseeds | 2 - 10 |

**Generalized Visual Leaf and Plant Nutrient Element Deficiency Symptoms**

**Zinc (Zn)**

Deficiency — Upper leaves will show interveinal chlorosis with an eventual whiting of the affected leaves. Leaves may be small and distorted with a rosette form.

**Boron (B)**

Deficiency — Abnormal development of the growing points (meristematic tissue) with the apical growing points eventually becoming stunted and dying. Rowers and fruits will abort. For some grain and fruit crops, yield and quality is significantly reduced.

**Copper (Cu)**

Deficiency — Plant growth will be slow and plants stunted with distortion of the young leaves and death of the growing point.

**Iron (Fe)**

Deficiency — Interveinal chlorosis will occur on the emerging and young leaves with eventual bleaching of the new growth. When severe, the entire plant may be light green in color.

**Manganese (Mn)**

Deficiency — Interveinal chlorosis of young leaves while the leaves and plants remain generally green in color. When severe, the plants will be stunted.

**Molybdenum (Mo)**

Deficiency — Symptoms will frequently appear similar to N deficiency. Older and middle leaves become chlorotic first, and In some instances, leaf margins are rolled and growth and flower formation are restricted.

**Chlorine (Cl)**

Deficiency — Younger leaves will be chlorotic and plants will easily wilt. For wheat, a plant disease will infest the plant when Cl is deficient.


Published: 23 Jan. 2024
ISSN: 2583-7850

The visual micronutrient deficiency symptoms in major crops are shown in Fig. 2.

| | |
|---|---|
|  |  |
| Zn deficiency in rice | Cu deficiency in rice |
|  |  |
| Mn deficiency in groundnut | Fe deficiency in sugarcane |
|  |  |
| B deficiency in coconut | B deficiency in cabbage |
|  |  |
| Mo deficiency in cabbage | Mo deficiency in cauliflower |

**Fig. 2. Visual micronutrient deficiency symptoms in major crops**


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

***Animals***

Uptake of mineral nutrients by crops and pastures from soil is influenced by several factors such as soil types and their properties like soil acidity, soil moisture content, temperature, climatic condition, crop type and variety, crop management practices, application of fertilizer and organic matter and microbial activity of soil etc. Among the factors, soil acidity plays pivotal role in influencing trace mineral uptake by the crops and pastures. Higher soil pH leads to an enhanced biological availability of some trace elements such as Se and Mo, whereas with lower soil pH, availability of Se is less. But the uptake of some cationic trace elements like Cu is increased. Sometimes, the level of Cu, Zn, Mn, Fe and Co in crops is sufficient for optimum yields but is not adequate to meet the needs of livestock animals.

***Humans***

Good human health is linked with healthy soils, which produce variety of food. Estimated 40% of the world's population, mostly in low income countries is facing a problem of micronutrient malnutrition. Burgeoning rise in the number of the people affected with micronutrient malnutrition during last four decades in India coincides with expansion of the area under rice-wheat or rice-rice cropping systems (low nutritional quality food) having high yielding varieties (HYVs) at the expense of traditional cereal-pulses/legume (high nutritional quality food) systems. Dietary intake ought to be changed with increased consumption of pulses to ensure adequate and balanced micronutrient supply to one and all in an affordable manner (Welch *et al*., 1997). Widespread prevalent nutritional deficiencies of vitamin A, Fe, Zn, and iodine have been adversely influencing the health of women and young children. Shortage of micronutrients in the diet can limit growth, weaken immunity, cause xerophthalmia (an irreversible eye disorder leading to blindness), and increase mortality. Neutropenia and leucopoenia, skeletal defects and degradation of nervous system (Prasad, 1961), defective melanin synthesis, which manifests as depigmentation or hypopigmentation (lack of colour) of hair and skin, keratinization of hair, steely hair are other signs of micronutrient deficiencies in the humans (Davis and Mertz, 1987).

In general, agriculture is the primary supplier of food and nutrients to all human on earth. The biggest challenge is to feed and nourish a burgeoning human population with limited land resources for productive agriculture. In addition, multimicronutrient deficiencies in soils worldwide leading to production of poor quality crop produce, particularly low in trace elements, ultimately affect the animal and human health (Shukla *et al,* 2014, 2016; Behera and Shukla, 2014). Toxicity of trace elements (particularly Fe, Al, Se, As, F, Cr etc.) in soil and water may also affect animal and human health.

***Zinc***

The available Zn in Indian soils ranges from 0.01 to 52.9 mg $kg^{-1}$. It constitutes less than 1% of the total Zn content. Currently 36.5% of soil samples across the country are deficient in available Zn; about 8, 29 and 15% area of the country is suffering from acute deficiency, deficiency and latent deficiency of Zn, respectively (Fig. 3.). Acute Zn-deficient soils are intensively cultivated ones characterized by coarse texture (sandy/ loamy sand), high pH (> 8.5 or alkali/ sodic soils) and/or calcareousness, and low soil organic carbon (< 0.4%) content (Shukla *et al*., 2014). Zinc deficiency disorders are known by different nomenclatures like 32khaira disease in rice, rosetting in wheat, white bud in maize, little leaves and mottling in vegetables, and reduced fruit formation in citrus.

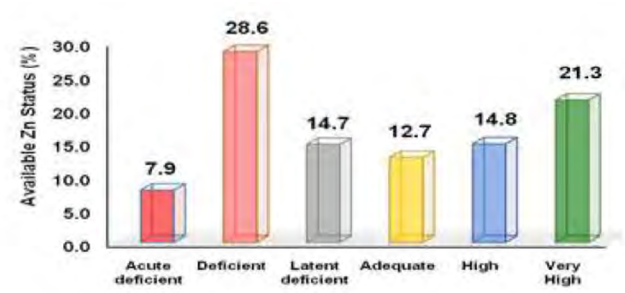



**Fig.3. Available zinc status in soils of India**

Feed and fodders produced on micronutrient-deficient soils and fed to cattle in Haryana resulted in higher percentage of Zn, Cu and Mn deficiency in their blood serum, hair and milk (Table 3). Survey in Vadodara district of Gujarat showed that dry fodder tested low in Fe (61%), Zn (72%) and Cu (87%) and green fodders were low in Fe (17%), Zn (5%) and Cu (23%) although most of the soils on which this was grown were adequate in terms of available Fe, Mn and Cu. A specific disorder resulting from zinc deficiency in animals is parakeratosis – a disorder of the epidermal layer of the skin occurring in calves, sheep, goats and piglets. Phytate (inositol hexaphosphate): Zn ratio plays an important role in influencing the Zn bioavailability in animal body. Excess intake of Zn is relatively rare in farm animals. However,excess zinc may reduce the digestibility of phosphorus, and cause anemia and digestive disorders. Poisoning is conditioned primarily by the antagonistic relationship of zinc with iron and copper. Excessive intake of Zn additives may lead to the essential fatty acid metabolism which influences synthesis of prostaglandin.

**Table 3.** Average percentage of mineral nutrient deficiency in blood serum, hair and milk in cattle of Haryana

| Deficiency percentage based on | Cu | Zn | Mn |
|---|---|---|---|
| Serum mineral status | 40.0 | - | |
| Hair mineral status basis | - | 50.3 | 47.6 |
| Milk mineral status basis | 29.0 | 42.9 | |


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

In humans, Zn deficiency was recognized as a health concern for the first time in 1961. The human Zn deficiency syndromes are growth stunting, delayed sexual development and hypogonadism in young adults Besides, Zn deficiency leads to diarrhoea, respiratory malfunctions, weak immune system, impaired cognitive function, neuronal atrophy, behavioural problems, memory impairment, spatial learning, lesions on dermal tissue/keratin (Fig. 4.) and parakeratosis. In general, a very strong correlation has been reported between soil Zn status and human Zn deficiency level (Singh, 2009; Shukla *et al*., 2016).

**Fig. 4. Zinc deficiency symptoms in humans**

***Iron***

In India, the problem of iron deficiency mainly occurs in calcareous and alkaline soils with pH > 7.5. Availability of Fe gets aggravated under drought or moisture stress conditions due to conversion of ferrous form of iron (Fe2+) into less available ferric form (Fe3+). hinder iron availability to the crop plants. About 4, 9 and 6% area of the country is inflicted with acute deficiency, deficiency and latent deficiency of Fe, respectively (Fig. 5). About 10, 11 and 60% area is characterized by adequate, high and very high levels of available Fe, respectively. Strongly acid and waterlogged soils have very high level of available Fe. There is a peculiar problem in flooded (paddy) rice soils where rice yields get severely reduced by Fe toxicity. Iron chlorosis in plants, also called lime-induced chlorosis, is generally observed in upland crops especially aerobic rice, sorghum, groundnut, sugarcane, chick pea grown in Fe-deficient highly calcareous soils, compact soil with restricted aeration, soils with low in active Fe and high in P and bicarbonate content. (Takkar et al., 1989; Singh and Dayal, 1992).


Published: 23 Jan. 2024
ISSN: 2583-7850

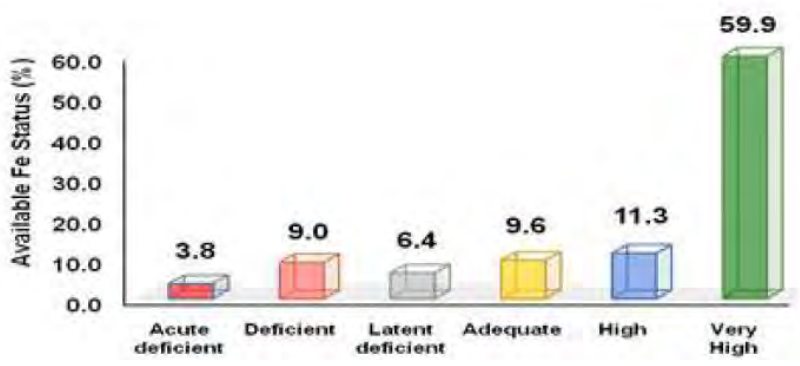



**Fig. 5. Available iron status in soils of India**

Iron is one of the most abundant element (4th at 5%) on Earth. Globally, Fe-deficiency anemia is the most common widespread nutritional disorder, affecting more than 50% pregnant women and 40% of infants and preschool children. Although only 14.4% Indian soils are deficient in available Fe, iron deficiency anaemia (IDA) is quite acute and widespread in marginalised section of our country.

The low Fe content in forage and food grains produced in arid and semi-arid regions is attributed to acute Fe deficiency in these soils (34% in Rajasthan, 26% in Gujarat, 22% in Haryana, and 23% in Maharashtra). However, in some humid and subhumid regions of the country where Fe is in sufficient amount in soil, increased IDA may be attributed to poor accumulation of Fe in plants grown on these soils. For example, IDA is very high in north-eastern region of the country where about 84.9% women reportedly suffer from IDA due to rice-based diet, as rice is a poor accumulator of Fe.

***Copper***

Copper deficiency in Indian soils is almost negligible. Available Cu content in Indian soils ranges from 0.01 to 136.4 mg $kg^{-1}$ with an average value of 2.05 mg Cu $kg^{-1}$ (Shukla and Tiwari, 2016). About 2, 2 and 3% area of the country is having acute deficiency, deficiency and latent deficiency of Cu, respectively (Fig. 5). Copper availability is mainly influenced by pH, SOC, $CaCO_3$ and clay content in soils. It increases with increase in organic matter and clay content, while decreases with increase in pH and $CaCO_3$ content of the soil (Katyal and Agarwal, 1982; Rattan *et al*., 1999). Copper deficiency mainly occurs in sandy, calcareous, eluviated and organic matter-rich soils. Addition of organic matter releases the $CaCO_3$-bound Cu fraction in soil and rebind it in organic fraction, enhancing the Cu availability in calcareous and sandy loam soils. However, presence of excess organic matter reduces the Cu availability in organic peat soils (Histosols) of Kerala, hill (Alfisols) and submontane soils (Mollisols) of the Himalayan tarai zone of Uttarakhand and Himachal Pradesh (Singh, 2008; Patel *et al*., 2009; Behera *et al*., 2012).


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

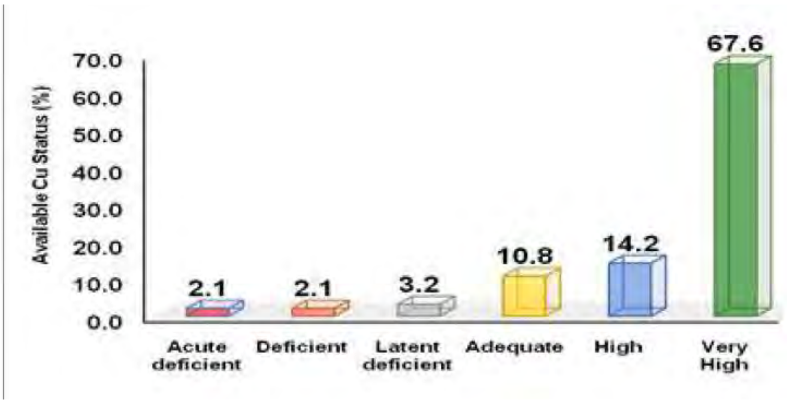



**Fig. 6. Available iron status in soils of India**

In India, Cu deficiency is responsible for leucoderma (Vitilogo), depigmentation of hair and skin around the neck, face, hind limbs and abdomen in buffaloes. Copper deficiency also caused 'falling disease' in milch cows. Copper concentrations in the livers of affected animals was lower (32.6 mg $kg^{-1}$) as compared to healthy cow (55.7 mg $kg^{-1}$) (Vasudevan, 1987). Post parturient haemoglo-binuria (PPH), molybdenosis induced hypocupraemia, commonly referred as nutritional haemoglobinuria, was observed, in high yielding cattle and buffaloes in India (Dhillon and Dhillon, 1991; Singh and Randhawa, 1990).

Copper deficiency in human leads to hypocupraemia, neutropenia and leucopoenia, degradation in nervous system, skeletal defects, hypopigmentation of hair and skin, keratinization of hair, cardiovascular disorders, osteoporosis, arthritis and infertility (Davis and Mertz, 1987).

Manganese

The available Mn content varies from 0.01 to 445.0 mg $kg^{-1}$ with a mean value of 21.8 mg $kg^{-1}$ (Shukla *et al*., 2014). About 1, 6 and 10% area of the country suffers from acute deficiency, deficiency and latent deficiency of Mn, respectively (Fig. 7). In general, Mn deficiency problems occur on soils with low total contents of Mn (heavily weathered tropical and sandy soils), on peaty soils, or organic-rich soils with a pH above 6, and on mineral soils with pH values of 6.5 or above, calcareous soils, or acid soils which have been heavily limed. In India, incidence of Mn deficiency has increased very fast, particularly in rice–wheat cropping systems under sandy or loamy sand soils of Punjab and Haryana. Mn is more mobile in imperfectly drained soils (waterlogged) and often Mn toxicity is observed in rice grown under continuous submerged conditions on such soils. Deficiency of Mn results in appearance of greenish-grey specks at the lower base of younger leaves in monocots, which finally become yellowish to yellow-orange. It may lead to development of marsh spots (necrotic areas) on the cotyledon of legumes. In sugarcane, Mn deficiency is called as pahala blight.

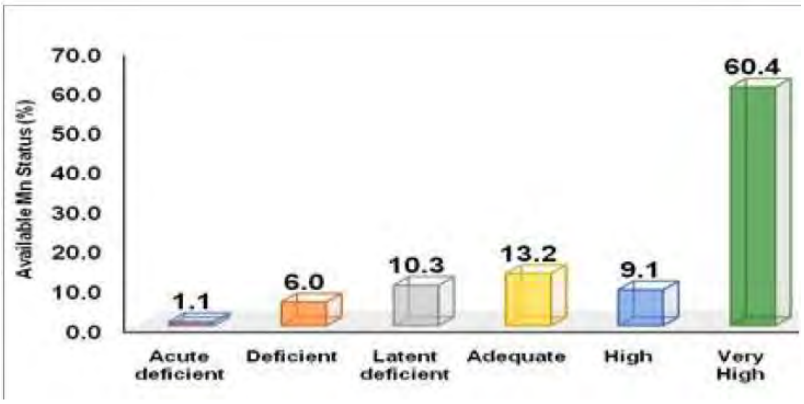



**Fig. 7. Available manganese status in soils of India**

Crops like wheat grown in Mn deficient soils or hidden hunger of Mn in Haryana not only produced low yields but led to infertility in cattle due to low Mn content in fodder and grain. Evidence of increased infertility was recorded in cattle fed with low Mn fodder grown in highly calcareous soils (free $CaCO_3$ content 20-48%) (Singh, 2009). Productivity of these animals was low and their blood serum Mn concentration was also low as compared to that in cattle fed with fodders grown in Mn-adequate soils.

***Boron***

In India, extent of B deficiency is next only to Zn. Total B content in Indian soils ranges from 2.6 to 630 mg $kg^{-1}$ (Takkar, 2011) and available (hot water soluble – HWS) B ranges from 0.04 to 250 mg B $kg^{-1}$, with an average of 21.9 mg $kg^{-1}$ soil (Shukla and Tiwari, 2016). About 4, 19 and 21% area of the country faces acute deficiency, deficiency and latent deficiency of B, respectively (Figure 8). Availability of B to plants is governed by soil pH, $CaCO_3$ and organic matter contents. In addition total B content in soil, its interactions with other nutrients, plant type or variety and environmental factors also have strong influence on B availability.

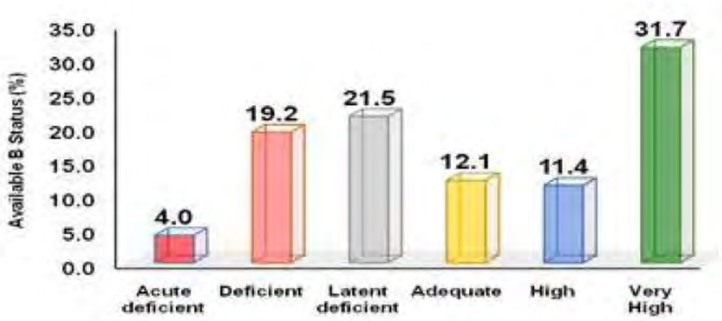



**Fig. 8. Available boron status in soils of India**

B deficiency adversely impacts the crop productivity in highly calcareous soils, sandy leached soils, limed acid soils or reclaimed yellow or lateritic soils. In general, extent of B


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

deficiency is higher in eastern region of the country due to its excess leaching in sandy loam soils because of high rainfall (Takkar, 1996; Shukla and Behera, 2012; Shukla and Tiwari, 2016). Boron deficiency symptoms first appear on the growing tips and younger leaves with stunted plant growth. It results in production of hollow heart in peanut, black heart in beet, distorted and lumpy fruit in papaya, and hollow pith in cabbage and cauliflower. B in various physiological functions, especially in improving the utilization of bone forming minerals like calcium, phosphorus and magnesium, immunity and antioxidant defence mechanisms (Bhasker *et al*., 2016). Boron supplementation in farm animals enhanced the immunity by increasing the serum levels of tumour necrosis factor and interferon-gamma. Further B supplementation lowered the levels of serum triglycerides, HDL cholesterol, ALT and ameliorated the hepatic tissue alterations induced by the lower Ca intake, thus exhibiting hepato-protective effect (Bhasker *et al*., 2017).

**Molybdenum**

Molybdenum is least studied micronutrients in India. Total Mo in Indian soils ranges between 0.1 to 12 mg $kg^{-1}$ and available Mo, extracted with ammonium oxalate (pH 3.3), varies from traces to 2.8 mg $kg^{-1}$ (Behera *et al*., 2011, 2014). Molybdate anions ($MoO_4^{2-}$) are strongly adsorbed on soil minerals and colloids (at pH < 6.0) and sometimes are also trapped due to formation of secondary minerals. Hydrous aluminium silicates may also strongly fix Mo. Soils formed from shale and granite parent materials have high Mo concentrations, whereas those derived from sandstone, basalt and limestone are characterized by low Mo contents. Most of the soils are adequate in Mo but its deficiency is noticed in some acidic, sandy and leached soils. Its deficiency is rarely reported in calcareous alkaline soils of arid and semi-arid regions as these soils have fairly high available Mo contents. Molybdenum deficiencies severely affect legumes, crucifer vegetables and oilseed crops on acid and severely leached soils. Molybdenum deficiency results in stunted plant growth and restricted flower formation. It causes whiptail disease of cauliflower. Molybdenum deficiency is reported in eastern high rainfall zone soils low in available Mo. In northern parts of West Bengal, problem of hair and hooves falling in cattle has been reported widely due to low Mo in alluvial leached soils. Grain legumes have higher concentration of Mo. In human, Mo helps in breakdown of build-up of toxic compounds such as sulphites. Molybdenum has been shown to help fight cancer-causing nitrosamines and even assists in preventing cavities. The most associated function of molybdenum is its role in the production of uric acid. Adequate Mo prevents dental caries, mouth and gum disorders, oesophageal cancer, and sexual impotence in old people.

**Zinc in Soil-Plant-Animal/Human Continuum – A Case Study**

A systematic study on Zn in soil-plant-animal/human continuum was carried out jointly by AICRP - MSPE and AIIMS, Bhopal in two tribal districts of Madhya Pradesh to assess the relationship between soil and human health (Shukla *et al.,* 2018). Analysis of Zn content in soil, grain, straw feed, animal and human blood serum established a strong correlation and interdependence among soil-plant-animal-human continuum (Fig. 9). The results indicated a strong relationship of soil Zn with plant and human blood serum Zn. The coefficient of determination (R2) were 0.36 between soil Zn content and grain Zn concentration, and 0.48 between Zn concentration in human blood serum and grain Zn concentration. However, no significant relationship was observed between straw Zn content and animal blood serum Zn concentration. When contribution of Zn through feed and Zn content in grazing grass was included with fodder Zn content, significant relationship emerged with animal blood serum Zn (R2 = 0.61).

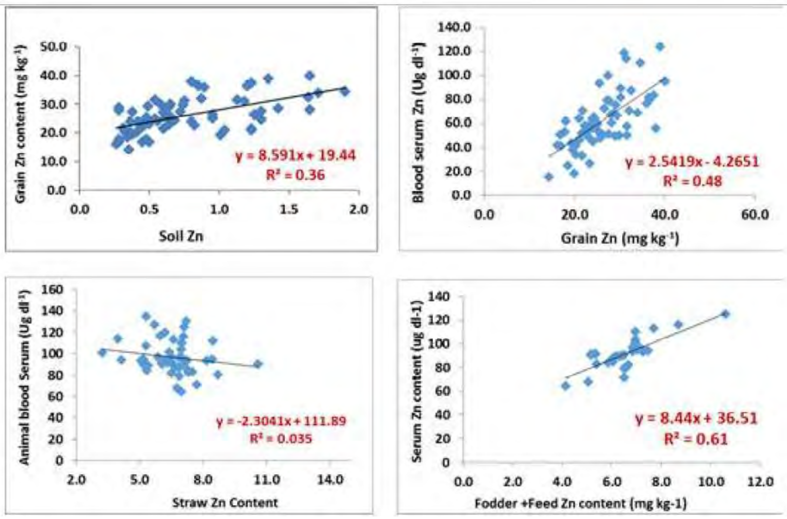



**Fig. 9. Relationship between soil, plant, animal and human Zn**

**Zinc and Covid 19**

Zinc played a critical role in boosting immunity in human beings to fight deadly diseases like Covid-19 during pandemic. Widespread deficiency of Zn in human population has resulted in poor immunity to fight against diseases (Soumitra Das and Andrew Green, 2023). Many Indians have a lower intake of Zn than the required levels for optimal immune function. Zinc deficiency often makes people more susceptible to flu, cold and viral infections. A several lack of zinc can massively reduce the activity of immune cells and production of antibodies. Adult body contains 2-3 g of Zn and a daily intake of up to 15 mg of Zn is needed to maintain a steady state as there is no Zn storage system in the body.

**Micronutrients and Food grain production**

An increasing trend in consumption of micronutrient fertilizers and production of food grains plus oilseeds reveals that the importance of micronutrients for sustainable crop production.


Published: 23 Jan. 2024
ISSN: 2583-7850

Micronutrients requirement for agricultural and horticultural crops in India are shown in Table 4. The current requirement of different micronutrients has been calculated based on current level of deficiency, nutrient mining from the soil and micronutrient recommendations for different crops. The future recommendations have been estimated based on area likely to be deficient and enhanced crop requirement due to intensification of agriculture by 2035 and 2050 (Shukla *et al*., 2021). Of the total Zn used, 70% used for field crops and remaining 30% to vegetables and fruit crops, while the reverse in case of Mn, Fe and Cu. Of the total B application, about 60% is applied to vegetables and fruit crops and 40% to food grain and oilseed crops.

**Table 4. Micronutrient requirement for agricultural and horticultural crops in India**

| Micronutrients | Micronutrient requirements ('000 tons) | | |
|---|---|---|---|
| | 2020 | 2035 | 2050 |
| Zn | 285 | 147 | 402 |
| B | 129 | 147 | 167 |
| Fe | 177 | 193 | 216 |
| Mn | 118 | 127 | 138 |
| Cu | 29 | 31 | 34 |

**Strategies to Improve Micronutrient Nutrition in Animals and Humans**

Issues pertaining to deficiency and toxicity of micronutrients in animal and human health emanate from low and very high flow of these elements to animals and humans through the soil-water-plant-animal-human food chain in different geographical areas. Soil is the major source supplying micro-nutrient elements to food chain. Cereals namely, rice and wheat grown in Zn- and Fe deficient soils produce grains in low Zn and Fe content. Consequently, the cereal-based food/diet, that contributes 70 % of the daily calorie intake of the poor population, is also low in Zn and Fe concentration. The approaches used to manage and/or prevent Fe and Zn deficiency and improve their status in humans are as follows.

**Supplementation**

Oral use of Fe and Zn tablets, capsules, and emulsions alone or in combination with vitamins as per the prescription of physicians and nutritionists is effective in mitigating the deficiencies of iron and zinc.

**Fortification**

Adding Fe and Zn to foods, such as flour, bread, biscuits, milk, salt, weaning food etc. has been

recognized as an effective approach to improve micronutrient level and alleviate their deficiency in humans as per Copenhagen Consensus of 2012. Fortification is effective in increasing micronutrient concentration in serum. Hematologic markers, including haemoglobin concentrations, showed a significant rise when food was fortified with vitamin A, iron and


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

multiple micronutrients. Fortification with zinc had no significant adverse impact on haemoglobin levels. Multiple micronutrient fortification showed non-significant impacts on height for age, weight for age and weight for height Z-scores, although they indicated the positive trends. Iron fortification led to a significant increase in serum ferritin and haemoglobin levels in women of reproductive age and pregnant women.

**Dietary Diversification**

The foods with the highest concentration of Fe, Zn and vitamin A are generally animal meats, fish, egg, pulses, whole grains, millets, nuts, legumes, and yeast (Table 5). Although dietary diversification is a potential preventive approach to improve Fe and Zn status and reduce their deficiency in the humans, but it is very expensive and beyond the purchasing capacity of the poor population vulnerable to the risk of micronutrient malnutrition.

**Table 5. Major dietary sources and substances promote Fe, Zn and vitamin A bioavailability**

| Major dietary sources | Promoter substance | Nutrient |
|---|---|---|
| Fresh fruits and vegetables | Organic acids | Fe and /or Zn |
| Animal meats | Haemoglobin | Fe |
| Animal meats | Amino acids | Fe and /or Zn |
| Human breast milk | Long-chain fatty acids | Zn |
| Animal fats, vegetable fats | Fats and lipids | Vitamin A |
| See foods, Tropical nuts | Selenium | Iodine |
| Animal meats | Iron, zinc | Vitamin A |
| Coloured vegetables | β-carotene | Fe, Zn |
| Garlic, Onion, Wheat | Insulin and other non-digestible carbohydrates | Ca, Fe and Zn |

**Producing Micronutrient-rich Food**

Production of micronutrient-rich food involving genetic modification in crops and change in fertilizer strategies through innovative agricultural interventions such as biofortification, offers a sustainable solution to tackle micronutrient malnutrition in the poverty-ridden population.

**Genetic Biofortification**

Genetic biofortification is a seed-based approach where the germ plasm is enriched with specific nutrients: micronutrients, protein, amino acids etc. It can be done by conventional breeding, marker driven molecular breeding, or genetic engineering. Some of the promising products of this approach are Zn- and Fe- rich rice, wheat and maize. Golden rice rich in beta-carotene, high Fe rice (high ferritin gene from mangroves) are examples of genetic engineering for bio fortification.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

**Agronomic Biofortification**

Agronomic biofortification is an inexpensive and simple approach which can be utilized to enrich the genetically-inefficient cultivars by application of micronutrient fertilizers at different rates, methods and at different crop growth stages.

**Physiological Intervention**

Accumulation of micronutrients in edible portion of seeds is controlled by physiological and biochemical barriers in plants. These barriers are the result of tightly controlled homoeostatic mechanisms that regulate metal absorption, translocation, and redistribution in plants allowing adequate, but nontoxic levels of these nutrients to accumulate in plant tissues. ***Nipping*** (apical bud removal) and defoliation (25% leaf removal) are two important practices to change the physiology of legume crops. Plant releases greater amount of soluble organic acids, phytosiderophores, enzymes and reluctants or oxidants to recoup from injury caused by nipping and defoliation. It has been observed that nipping and defoliation practices could enhance Fe concentration both in efficient and inefficient cultivars of chickpea and pigeon pea (Shukla et al., 2016). ***Defoliation*** (25% of leaves) at pre-flowering stages could enhance the Fe concentration in grain by 7 and 4%, respectively in efficient and inefficient cultivars.

**Soil Health Improvement technologies developed at TNAU**

**Soil Test Crop Response based Integrated Plant Nutrition System (STCR-IPNS) and Secondary and Micronutrients recommendation**

All these problems can be rectified by better management options and application of amendments and the current challenge is to adopt economically and ecologically sound management strategies like Soil Test Crop Response based Integrated Plant Nutrition System (STCR-IPNS) for achieving crop productivity, nutrient use efficiency, profitability with sustained soil health. It involves application of nutrients through inorganic fertilisers, organic manures and biofertilizers based on soil fertility status and yield targets. Ready reckoner of fertiliser doses and secondary and micronutrient recommendations for principal crops are provided in CPG Agriculture 2020 and CPG Horticulture 2020.

- **Major nutrient recommendations (STCR-IPNS) :** 37 crops & 10 cropping sequences
- **Secondary & Micronutrients recommendations:** 44 crops & 10 cropping sequences

**Benefits over Blanket recommendations/Farmers' fertilization practice**

- **Yield increase:** 15-25% in Agricultural crops & 25-35% in Horticultural crops
- **Rationalized Fertilizer usage**
    - **Saving in high fertile soils: 25-50% for NPK**

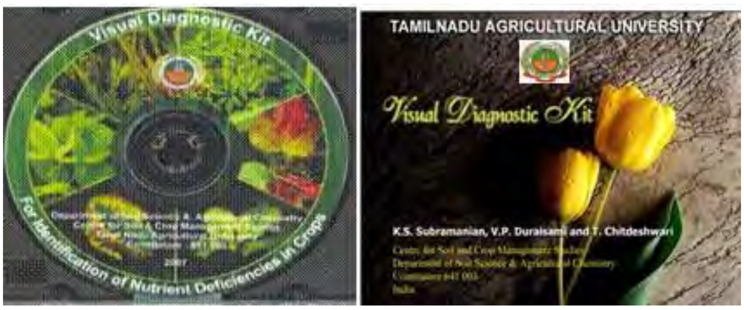
- **Fertilizer saving: $FP_2O_5$ & $FK_2O$: 26 & 25 kg $ha^{-1}$ saving for rice under Noyyal series in terms of SSP: 193 tonnes & MOP: 49 tonnes due to built up over initial status if SP & SK are 28 & 438 kg $ha^{-1}$.**

❖ **Secondary and Micronutrients fertilization only in deficient areas**

**Decision Support System for Integrated Fertiliser Recommendation (DSSIFER)**


Decision Support System for Integrated Fertiliser Recommendation (DSSIFER) is a user friendly software developed in Visual Basic 6.0 as a "Stand Alone" version encompasses soil test crop response based fertiliser recommendations through Integrated Plant Nutrition System **(STCR-IPNS) developed by the ICAR-AICRP-STCR**, Department of Soil Science and Agricultural Chemistry, TNAU and Mitscherlich-Bray percentage sufficiency recommendations developed by the Soil Testing Wing of the State Department of Agriculture, Tamil Nadu. **If both recommendations are not available** for a particular soil – crop situation, **the software can generate prescriptions using blanket recommendations but based on soil test values**. Therefore, adoption of this technology will not only ensure site specific balanced fertilisation to achieve targeted yield of crops but also result in correction of inherent soil nutrient deficiencies, higher response ratio, minimizing nutrient losses besides sustaining soil fertility. In addition, the software also provides technology for **problem soil management and irrigation water quality appraisal**.

**Visual Diagnostic Kit (VDK)**




The computer software Visual Diagnostic Kit (VDK) aids in identifying nutrient deficiencies of crops. It has documentation of deficiency symptoms of 65 crops.

Both DSSIFER and VDK softwares are of much use for all the Soil Testing Laboratories of State Department of Agriculture, KVKs, Agriclinic cum Mini Soil Testing Laboratories at each block level, Soil Testing Laboratories of PACBs, NGOs, private entrepreneurs, scientists, research scholars, progressive farmers for identifying deficiency symptoms, prescribing fertiliser doses and soil and water quality management technologies. This is being used in the Soil Testing and Technology Advisory centre (SOTAC) of Department of Soil Science and Agricultural

Chemistry, TNAU, Coimbatore for providing analytical and advisory services to the farmers and other stakeholders.

**TNAU Crop Specific Micronutrient Mixtures**

Micronutrients use efficiency is abysmally low and generally does not exceed 5% in crops. Development of new and innovative micronutrient fertilizer products for higher use efficiency is the need of the hour. In this context,

- Micronutrient mixtures were developed by the Department of Soil Science and Agricultural Chemistry, TNAU for 11 major crops *viz.*, Rice, Maize, Pulses, Groundnut, Sunflower, Gingelly, Castor, Cotton, Sugarcane, Turmeric and Coconut for both irrigated and rainfed situations and the following recommendations are being adopted.


- Application of MN mixtures as Enriched FYM will help to tackle the multi-micronutrient deficiency problems besides balanced fertilization to crop.
- Indirect benefits: Balanced fertilization of crops through fertilizer mixtures will ensure enhanced crop productivity besides sustaining soil fertility.

The recommendation of TNAU Crop specific micronutrient mixtures for various crops are given in table 5.

**Table 5.** TNAU Crop specific Micronutrient Mixtures Recommendation for various crops

| S. No | Crop | Dosage (kg ha$^{-1}$) | |
|---|---|---|---|
| | | Irrigated | Rainfed |
| 1. | Rice - wetland | 25.0 | - |
| | Rainfed | - | 12.5 |
| 2. | Maize | 30.0 | 7.5 |
| 3. | Pulses | 5.0 | 5.0 |
| 4. | Sugarcane | 50.0 | - |
| 5. | Cotton | Variety - 12.5<br>Hybrid - 15.0 | 7.5 |
| 6. | Groundnut | 12.5 | 7.5 |
| 7. | Gingelly | 12.5 | 7.5 |
| 8. | Sunflower Variety<br>Hybrid | 12.5<br>15.0 | 7.5<br>10.0 |
| 9. | Castor Variety<br>Hybrid | 12.5<br>15.0 | 7.5<br>10.0 |
| 10. | Turmeric | Split application of 15 kg TNAU Micronutrients mixture as EFYM at 50 % | - |


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

| | | | |
|---|---|---|---|
| | | basal and 50 % top dressing on 90 DAP | |
| 11. | Coconut varieties/hybrid | 1 kg / tree / year | - |

**Cost of TNAU MN Mixture: Rs. 130/kg (Including GST)**

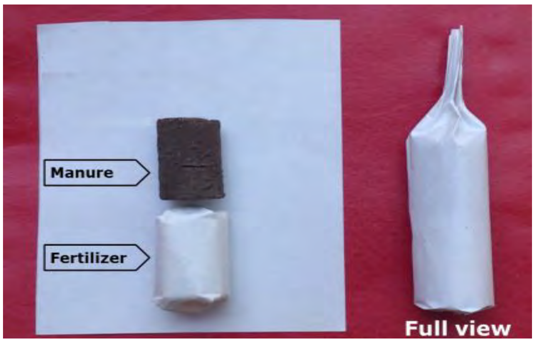
**Method of application: As basal soil application**

- TNAU MN mixture (at the recommended dose for each crop) is to be thoroughly mixed with FYM @ 1:10 ratio at friable moisture condition and incubated for 15 to 30 days under shade)
- For Turmeric, Split application of 15 kg TNAU Micronutrients mixture as EFYM at 50 % basal and 50 % top dressing on 90 DAP for irrigated turmeric

**TNAU-Water Soluble Fertilizer (TNAU-WSF)**

Water Soluble Fertilizers are essential for efficient and balanced use of fertilizer nutrients. They are 100 per cent water soluble and suitable for fertigation of all crops and soil types. Higher fertilizer use efficiency, crop yields and more profit to the farmers. TNAU has established pilot WSF production unit at TNAU, Coimbatore and supplying TNAU WSF All 19 @ Rs. 200/kg.

**Nutri seed /Nutri pellet Packs**




Nutriseed Pack contains seed at top, enriched manure in the middle and encapsulated fertilizer at bottom. Nutriseed Packs are meant for single time placement in soil at the time of sowing to act as nutrient pile for slow release of nutrients. Nutriseed Pack gives support for each plant in the root zone in terms of optimum nutrient supply, biological activity and consequently enables the fullest utilization of nutrients by plants. There is no wastage of fertilizer nutrients with Nutriseed Packs.

**Conclusion**

The widespread occurrence of micronutrient malnutrition can be solved by food supplementation, food fortification and biofortification. Biofortification is the best option for alleviation of multi nutrient deficiency. Soil Test Crop Response - Integrated Plant Nutrition system (STCR-IPNS) is a pivotal approach, offering a multifaceted strategy to enhance the


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

efficacy of fertilizer use and maintenance of soil fertility Hence, there is a balanced supply of required quantities of nutrients to the crop thereby over usage or under usage is avoided. This prevents environmental hazards and results in higher net returns.

**References**

Behera, S.K. and Shukla, A.K. 2014. Total and extractable manganese and iron in some cultivated acid soils of India - status, distribution and relationship with some soil properties. *Pedosphere*, **24**: 196-208.

Behera, S.K., Lakaria, B.L., Singh, M.V. and Somasundaram, J. 2011. Molybdenum in soils, crops and fertilizers: An overview. *Indian Journal of Fertilisers,* **7(5)**: 52-57.

Behera, S.K., Shukla, A.K. and Lakaria, B.L. 2014. Deficiency of boron and molybdenum in soils and crops in India and their amelioration. *Indian Farming*, **63(12)**: 27-29.

Behera, S.K., Shukla, A.K. and Singh, M.V. 2012. Distribution variability of total and extratctable copper in cultivated acid soils and their relationship with some soil properties. *Agrochimical,* **VI:** 28-41.

Bhasker, T.V., Gowda, N.K.S., Krishnamoorthy, P., Pal, D.T., Sejian, V., Awachat, V.B., Pattanaik, A.K. and Verma, A.K. 2017. Boron supplementation provides hepatoprotective effect and improves performance in Wistar rats-fed calcium deficit diet. *Indian Journal of Animal Sciences,* **87**: 1213-1218.

Bhasker, T.V., Gowda, N.K.S., Mondal, S., Krishnamoorthy, P., Pal, D.T., Mor, A., Bhat, S.K. and

Pattanaik, A.K. 2016. Boron influences immune and antioxidant responses by modulating hepatic superoxide dismutase activity under calcium-deficit abiotic stress in Wistar rats. *Journal of Trace Elements in Medicine and Biology*, **36:** 73-79.

Davis, G.K., and Mertz, W. 1987. Copper. *In*: Trace Elements in Human and Animal Nutrition, 5th Edition, Volume 1. (W. Mertz, Ed.), pp. 301– 364. Academic Press, San Diego, California, USA.

Dhillon, K.S. and Dhillon, S.K. 1991. Selenium toxicity in soils, plants and animals in some parts of Punjab, India. *International Journal of Environmental Studies*, **37:** 15-24.

Patel, K.P., Patel, P.C., Patel, K.C. and Ramani, V.P. 2009. Effect of multinutrient mixture on yield, micronutrient uptake and quality of fodder maize grown on Typic Ustochrept soils of Anand. *GAU Research Journal,* **34**:, 44-48.

Pattanaik, A.K. 2016. Boron influences immune and antioxidant responses by modulating hepatic superoxide dismutase activity under calcium-deficit abiotic stress in Wistar rats. *Journal of Trace Elements in Medicine and Biology*, **36:** 73-79.

Pattanaik, A.K. 2016. Boron influences immune and antioxidant responses by modulating hepatic superoxide dismutase activity under calcium-deficit abiotic stress in Wistar rats. Journal of Trace Elements in Medicine and Biology, **36**: 73-79.

Shukla, A.K. and Behera, S.K. 2012. Micronutrient fertilisers for higher productivity. *Indian Journal of Fertilisers*, **8(4):** 100-117.

Shukla, A.K. and Behera, S.K. 2019. All India Research Project on Micro- and Secondary Nutrients and Pollutant Elements in Soils and Plants: Research achievements and future thrusts. *Indian Journal of Fertilizers*, **15:** 522-543.

Shukla, A.K. and Tiwari, P.K., 2016. Micro and Secondary Nutrients and Pollutant Elements Research in India. Coordinator's Report. AICRP on Micro- and Secondary Nutrients and Pollutant Elements in Soils and Plants, ICAR-IISS, Bhopal.

Shukla, A.K., Behera, S. K. and Singh, G. 2021. Micronutrients fertilizers in Indian Agriculture – Product profile, availability, forecast and agronomic effectiveness. *Indian Journal of Fertilizers*, **17(4)**: 348-360.

Shukla, A.K., Behera, S.K., Lenka, N.K., Tiwari, P.K., Prakash, C., Malik, R.S., Sinha, N.K., Singh, V.K., Patra, A.K. and Chaudhary, S.K. 2016. Spatial variability of soil micronutrients in the intensively cultivated Trans-Gangetic plains of India. *Soil and Tillage Research*, **163**:282-289.

Shukla, A.K., Sanjib K. Behera, Abhijit Pakhre and S.K. Chaudhari. 2018. Micronutrients in Soils, Plants, Animals and Humans. *Indian Journal of Fertilizers*, **14 (4)**: 30-54.

Shukla, A.K., Tiwari, P.K. and Prakash, C. 2014. Micronutrients deficiencies vis-à-vis food and nutritional security of India. *Indian Journal of Fertilisers*, **10(12):** 94-112.

Singh, B. and Randhawa, S.S. 1990. *In*: National Symposium. 9$^{th}$ Annual Convention of Indian Society of Veterinary Medicines, Hyderabad.

Singh, M.V. 2008. Micronutrients deficiency in Indian soils and crops. In Micronutrient Deficiencies in Global Crop Production. (B.J. Alloway, Ed.), pp. 93-125. Springer, Dordrecht.

Singh, M.V. 2009. Micronutrient nutritional problems in soils of India and improvement for human and animal health. *Indian Journal of Fertilisers*, **5(4):** 11-26.

Soumitra Das and Andrew Green. 2023. Micronutrients for Soil, Crop and Human health sustenance. *Indian Journal of Fertilizers,* **19 (2)**: 1280-1288.

Takkar, P.N. 1996. Micronutrient research and sustainable agricultural productivity in India. *Journal of the Indian Society of Soil Science*, **44:** 562–581.

Takkar, P.N. 2011. A roundtable meeting on boron in Indian agriculture: Keynote address. *Indian Journal of Fertilisers*, **7(4)**: 142-148.

Takkar, P.N., Chhibba, I.M., and Mehta S.K. 1989. Twenty Years of Coordinated Research on Micronutrients in Soils and Plants. IISS Bulletin No. 1, pp. 1-394. Indian Institute of Soil Science, Bhopal.


**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

TRENDS IN AGRICULTURE SCIENCE
Vol.3 Special Issue 01 January 2024, Page: 47-48

# Water Quality and Its Management for Crop Production

**N.S. Venkataraman**
School of Agriculture, BIHER, Chennai - 73
https://doi.org/10.5281/zenodo.10550945

Water shortage is viewed as a major hindrance to sustainable agricultural intensification in order to meet the food needs of a fast-rising human population. The world's ever-increasing human population, climate change caused by increased greenhouse gas (GHG) emissions, and agricultural intensification are all putting significant strain on the world's two major non-renewable resources, soil and water, posing a significant challenge to producing enough food to meet current food demand. The present world population of 7.3 billion people is predicted to grow to more than 9 billion by 2050, with the majority of this growth taking place in developing nations, the majority of which are already experiencing food shortages. If these population growth forecasts are right, it will take a 70% increase in present agricultural output to generate enough food. In this context, global efforts are being conducted to improve the efficacy of water that will be used to boost irrigated crop production.

Irrigation water quality is a critical aspect of greenhouse crop production. There are many factors which determine water quality. Among the most important are alkalinity, pH and soluble salts. But there are several other factors to consider, such as whether hard water salts such as calcium and magnesium or heavy metals that can clog irrigation systems or individual toxic ions are present. In order to determine this, water must be tested at a laboratory that is equipped to test water for agricultural irrigation purposes.

Poor quality water can be responsible for slow growth, poor aesthetic quality of the crop and, in some cases, can result in the gradual death of the plants. High soluble salts can directly injure roots, interfering with water and nutrient uptake. Salts can accumulate in plant leaf margins, causing burning of the edges. Water with high alkalinity can adversely affect the pH of the growing medium, interfering with nutrient uptake and causing nutrient deficiencies which compromise plant health.

Water quality has a direct impact on soil fertility and crop development, hence its importance in agriculture cannot be emphasized. Its measurement is critical for optimizing agricultural output.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

Crops, soil quality, and yields can all suffer as a result of poor water quality. Monitoring water quality allows for the early discovery of potential problems such as excessive salinity, pollution, or pH imbalance, allowing for rapid intervention. By addressing these issues through the development of cost-effective testing procedures, agricultural practitioners would be able to improve soil fertility, crop health, and yield while changing irrigation strategies and applying appropriate treatments—all in support of sustainable agriculture practices.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

TRENDS IN AGRICULTURE SCIENCE
Vol.3 Special Issue 01 January 2024, Page: 49-58

# Botanicals: The most suitable tool for Crop Health Management

**Dr. S. Malarvannan**

Associate Professor (Agricultural Entomology), School of Agriculture,
Bharath Institute of Higher Education and Research, Selaiyur, Chennai, India
https://doi.org/10.5281/zenodo.10550957

## Introduction

Globally, Agriculture is facing numerous challenges including climate change, biodiversity loss and rising demands for food production (Rockstrom *et al.,* 2009; Tilman *et al.,* 2011; Deutsch *et al.,* 2018). Pests and diseases destroy up to 40% of the world's food crops each year. This incurs an annual agricultural trade loss of more than $220 billion, and results in hunger, and eventually interferes with rural income (Vandana and Uniyal, 2021). Pesticides are the cornerstones upon which the pest management practices are based, and are likely to remain so as long as effective and inexpensive chemicals are available (Haynes, 1988). It is estimated that more than 6,500 species of plants have been examined for anti-insect properties. Of these, more than 2,500 species belonging to 235 families have shown a bio pesticide activity (Celis *et al.,* 2008; Walia *et al.,* 2012). Plant as whole or extracts have been used as herbal drugs since ages.

## Botanical Pesticides – A rich resource

Botanical pesticides are naturally occurring chemicals extracted from plants. Natural pesticidal products are available as an alternative to synthetic chemical formulations but they are not necessarily less toxic to humans. Some of the most deadly, fast acting toxins and potent carcinogens occur naturally (Regnault-Roger *et al.,* 2005; Regnault-Roger and Philogène, 2008). The characteristic features of the botanical pesticides such as lack of persistence and bioaccumulation in the environment, selectivity towards beneficial insects and low toxicity to humans (Grdisa and Grsic, 2013) led to the significant studies of botanical pesticides from different plant sources. They are generally safer to humans and the environment than conventional chemical pesticides (Dimetry, 2014). The terms ‘’botanical insecticide”, “plant extracts”, biopesticides, “insecticidal activity” or “pesticidal activity” revealed 15 (33.3%) (Apiaceae, Apocynaceae, Asteraceae, Boraginaceae, Brassicaceae, Campanulaceae, Fabaceae, Lamiaceae, Myrtaceae, Papaveraceae, Polygonaceae, Primulaceae, Proteaceae, Rosaceae, Rubiaceae and

Scro- phulariaceae) out of 44 plant families that have been involved in habitat manipulation studies, had at least one plant genus or species with insecticidal activity. Pro- teaceae had one plant used in habitat manipulation in the same genus as another plant used as a biopesticide. All other plant families had at least one plant species tried for its insecticidal activity and tested in habitat manipulation studies (Fiedler *et al.,* 2008; Lavandero *et al.,* 2006; Vattala *et al.,* 2006).

**Types of Botanicals Insecticides and their effects**

**Essential oils**

Essential oils extracted from aromatic plants have increased considerably as insecticides owing to their popularity with organic growers and environmentally conscious consumers. They have repellent, insecticidal, antifeedants, growth inhibitors, oviposition inhibitors, ovicides, and growth-reducing effects on a variety of insects (Don-Perdo, 1996; Elzen and Hardee, 2003; Koshier and Sedy, 2001; Lu, 1995; Pereira *et al.,* 2006; Regnault-Roger *et al.,* 2012; Shelton *et al.,* 2002; Sithisut *et al.,* 2011; Tripathi *et al.,* 2003).

**Alkaloids**

Alkaloids are the most important group of natural substances playing an important role in insecticidal (Balandrin *et al.,* 1985; Rattan, 2010). Wachira *et al.,* (2014) concluded that pyridine alkaloids extracted from *Ricinus communis* against the malaria vector *Anopheles gambiae*. Furocoumarin and quinolone alkaloids extracted from *Ruta chalepensis* leaves showed larvicidal and antifeedant activities against the larvae *Spodoptera littoralis* (Emam *et al.,* 2009). Acheuk and Doumandji-Mitiche (2013) found that alkaloids extract of *Pergularia tomentosa* caused antifeeding and larvicidal effects. Lee (2000) concluded that pipernonaline and piperidine alkaloids have mosquito larvicidal activity. Alkaloids from Arachis hypogaea extract have larvicidal activity against chikungunya and malarial vectors (Velu *et al.,* 2015).

**Flavonoids**

Flavonoids could be useful in a pest-management strategy. Flavonoids play an important role in the protection of plants against plant feeding insects' and herbivores (Acheuk and Doumandji-Mitiche, 2013). Both flavonoids and isoflavonoids protect the plant against insect pests by influencing their behavior, growth, and development (Simmonds, 2003; Simmonds and Stevenson, 2001). Rutin and quercetin-3-glucoside in Pinus banksiana inhibit the development and increase the mortality of *L. dispar* (Gould and Lister, 2006). Quercetin and rutin glycosides in peanuts caused increased mortality of the tobacco armyworm (*Spodoptera litura*) (Mallikarjuna *et al.,* 2004). In rice, three flavone glucosides inhibit digestion in insects and function as deterrent agents in *Nilaparvata lugens* and herbivores (Acheuk and Doumandji-Mitiche, 2013).


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

**Glycosides**

Cyanogenic glycosides are known as plant defense chemicals and found in cassava, bamboo, flax, and other plants. They are effective against stored-product insects as fumigants. Due to their insecticidal activity to insects, cyanohydrins can be used as an alternative fumigant and also as soil fumigants (Park and Coats, 2002). Dave and Lediwane (2012) found that anthraquinones isolated from Cassia species possess as antimalarial and insecticidal activity. Glycosides from *A. hypogaea* extract have larvicidal activity against chikungunya and malarial vectors (Velu *et al.,* 2015). Juvenogens have a potential application in insect pest control (Wimmer *et al.,* 2007).

**Esters and Fatty acids**

Fatty acids methyl esters were isolated from Solanum lycocarpum have larvicidal activity against the vector *C. quinquefasciatus* (Silva *et al.,* 2015). Mullens et al. (2009) showed that saturated fatty acids (particularly C8, C9 and C10) used as repellents or antifeedants against houseflies, horn flies and stable flies. Samuel et al. (2015) concluded that fatty acids mixture (C8910) has toxicity and repellence against insecticide susceptible and resistant strains of the major malaria vector Anopheles funestus. Yousef et al. (2013) reported that toxicity and reduction in larval body weight of linoleic acid against the larvae of *S. littoralis*.

**Mode of Action of Botanicals**

Botanical pesticides affect the insect pests in different ways depending on the physiological characteristics of the insect species as well as the type of the insecticidal plant. The components of various botanical insecticidal can be classified into six groups namely; repellents, feeding deterrents/ antifeedants, toxicants, growth retardants, chemosterilants, and attractants (Rajashekar *et al.,* 2012). Usually, the mode of action includes the specific enzyme, protein, or biological step affected. While most of the mode of action of the botanical pesticides are classified based on the pests controlled, physical characteristics, or chemical composition (Khambay *et al.,* 2003; Bloomquist *et al.,* 2008).

**Repellents**

A botanical pesticide have a repellent property, where keeps away the insect pest, and protect the crops (Isman, 2006) with minimal impact on the ecosystem, as they drive away the insect pest from the treated materials by stimulating olfactory or other receptors (Talukder, 2006; Talukder, *et al.,* 2004). Botanical pesticides are considered safe in pest control because they have low or none pesticide residue making them safe to the people, environment and ecosystem (Talukder *et al.,* 2004). Ghavami et al. (2017) found that essential oils of *Ziziphora tenuiore*, *Myrtus communis*, *Achillea wilhelmsii* and *M. piperita* have repellent activities against human fleas. Rahdari and Hamzei (2017) demonstrated the efficacy of *M. piperita*, *R. officinalis*, and


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

*Coriandrum sativum* oils for applying in organic food protection due to repellent activity of essential oils on *Tribolium confusum*.

**Feeding deterrents/antifeedants**

Botanical pesticides that inhibit feeding or disrupt insect feeding by rendering the treated materials unattractive or unpalatable (Rajashekar *et al.,* 2012; Talukder, 2006). The insects remain on the treated material indefinitely and eventually starve to death. Liao et al. (2017) demonstrated that oil of *M. alternifolia* and their chemical constituents possessed obvious antifeedant activities against *Helicoverpa armigera* Hubner. The phytoconstituents found in the leaf extract of Khaya senegalensis include tannins, saponins, flavonoids, steroids, and alkaloids may have been responsible for the mortality of Dinoderus porcellus (Loko *et al.,* 2017). Chaudhary *et al.,* (2017) and Ghoneim and Hamadah (2017) pointed that azadirachtin which is prominent constituent of neem established as a pivotal insecticidal ingredient. It acts as an antifeedant, repellent, and repugnant agent and induces sterility in insects by preventing oviposition and interrupting sperm production in males.

**Growth retardants and development inhibitors**

Botanical pesticides showed deleterious effects on the growth and development of insects, reducing the weight of larva, pupa and adult stages and lengthening the development stages (Talukder, 2006). Plant derivatives also reduce the survival rates of larvae and pupae as well as adult emergence (Koul *et al.,* 2008). It has been reported that both azadirachtin and neem seed oil increased aphid nymphal mortality significantly at 80 and 77%, respectively, and at the same time increasing development time of those surviving to adulthood (Kraiss and Cullen, 2008).

**Neem based products**

Neem based products are extracted from the neem tree, Azadirachta indica, a member of the Meliaceae family (Campos *et. al.,* 2016). The potent active ingredients of the neem are azadirachtin, meliantriol, salannin, desacetyl salannin, nimbin, desacetyl nimbin, and nimbidin. Azadirachtin, a tetranortriterpenoid limonoid, is one of the most potent active compounds of the neem tree (Mordue (Luntz) and Blackwell, 1993). Azadirachtin is present in higher concentration (0.2 – 0.6%) in the seeds of the neem compared to other parts of the neem tree (Govindchari, 1992). Azadirachtin A is the most active biological ingredient which shows insecticidal activity compared to other analogs of azadirachtin (Koul *et. al*., 2004; Sola *et. al*., 2014). Azadirachtin has a wide spectrum of actions on insects such as repellents, antifeedant, insect growth regulatory, and anti – ovipositional properties (Schmutterer, 1990; Bramhachari, 2004). It is most effective against 550 insect species, mostly relating to orders Dictyoptera, Orthoptera, Heteroptera, Isoptera, Lepidoptera, Diptera, Coleoptera, Homoptera, Siphonaptera and Hemiptera (Sadre *et. al*., 1983; Mordue (Luntz) and Blackwell, 1993).

**Pyrethrum**

Pyrethrum is one of the most important botanical pesticides used in India, which is extracted from the flowers of Chrysanthemum cinerariaefolium (El-Wakeil, 2013). The higher concentration of pyrethrum is found mainly in the flowers of the plant compared to other parts of the plant (Rhoda *et. al*., 2006; Isman, 2006; Sola *et. al*., 2014). Pyrethrum is the mixture of six active ingredients, namely, pyrethrin I, pyrethrin II, cinerin I, cinerin II, jasmolin I, and jasmolin II. Pyrethrum, and Eucalyptus Leaf Extract has been registered and allowed to use as botanical pesticides commercially for various purposes under Insecticide Act, 1968. Out of three, Azadirachtin or neem based pesticides are mostly used as the botanical pesticides in the agricultural pest management system followed by pyrethrum, and Eucalyptus Leaf Extract.

**Conclusion**

Botanical pesticides from natural origin have greater scope in international as well as national level as they are comparatively safe, easily degradable and have multiple actions against insect pests. The source for the botanicals is also vast and there are many pesticidal plants which are yet to be explored. The increasing concern of the insect resistance to chemical pesticides has warranted the search for viable alternatives. The advantage of botanicals is the cost and it can be prepared by the farmers themselves without any sophisticated techniques. For a wider reach, many industries have come up with botanical formulations and are readily available in the market. The research findings prove that there is a steady and continuous increase in the preference for botanicals over the last 10 years. Hence, the future emphasis should be on development of a wide range of botanical formulations with the particular molecules for better performance. This will ensure sustainable agriculture and will enhance the beneficial insects, thus maintain a biotic balance. However, all the botanicals are not safe to human being, hence adequate precautionary measures has to be followed while spraying the botanical pesticides in the field. Plant-based pesticides are predominantly used in low-income and emerging nations to control pests because of their cost-effectiveness, availability, accessibility, and easy-to-use.

**References**

Acheuk, F. and Doumandji-Mitiche, B. (2013). Insecticidal activity of alkaloids extract of *Pergularia tomentosa* (Asclepiadaceae) against fifth instar larvae of *Locusta migratoria cinerascens* (Fabricius 1781) (Orthoptera: Acrididae). International Journal of Science and Advanced Technology, 3(6), 8–13.

Aerts, R.J. and Mordue, A.J. (1997). Feeding Deterrence and Toxicity of Neem Triterpenoids. Journal of Chemical Ecology, 23, 2117-2132.

Arora, R, Singh, B. and Dhawan, A. K. (2012). Theory and Practice of Integrated Pest Management. Jodhpur: Scientific Publishers.



**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

Asawalam, E. and Adesiyan, S. (2001). Potential of *Ocimum basilicum* (Linn) for the control of maize weevil *Sitophilus zeamais* (Motsch). Nigeria Agricultural Journal, 32(1), 195–201.

Asghar U, Malik, M.F. and Javed, A. (2016). Pesticide Exposure and Human Health: A Review. J. Ecosys. Ecograph, S5: 005. DOI: 10.4172/2157-7625.S5-005.

Auger, J. and Thibout, E. (2002). Substances soufrées des Allium et des Crucifères et leurs potentialités phytosanitaires. In: Regnault-Roger C, Philogène BJR, Vincent C (Eds) Biopesticides d'Origine Végétale. Lavoisier Tech and Doc, Paris, pp 77–95.

Balandrin, M. F, Klocke, J. A, Wurtele, E. S, and Bollinger, W. H. (1985). Natural plant chemicals: Sources of industrial and medicinal materials. Science, 7; 228(4704), 1154–1160. https://doi.org/10.1126/science.3890182.

Batish D.R, Singh, H.P, Setia, N, Kaur, S. and Kohli, R.K. (2006). Chemical composition and phytotoxicity of volatile essential oils from intact and fallen leaves of *Eucalyptus citriodora*. Z. Naturforsch. c61: 465 – 471.

Batish, D.R, Singh, H.P, Kohli, R.K. and Kaur, S. (2008). Eucalyptus essential oil as a natural pesticide. For. Ecol. Manag., 256: 2166 – 2174.

Belmain, S.R, Amoah, B.A, Nyirenda, S.P, Kamanula, J.F. and Stevenson, P.C. (2012). Highly Variable Insect Control Efficacy of *Tephrosia vogelii* Chemotypes. Journal of Agricultural and Food Chemistry, 60, 10055-10063. http://dx.doi.org/10.1021/jf3032217.

Bloomquist, J.R, Boina, D.R, Chow, E, Carlier, P.R, Reina, M and GonzalezColoma, A. (2008). Mode of action of the plant-derived silphinenes on insect and mammalian GABAA receptor/chloride channel complex. Pestici Biochem and Physiol 91:17–23.

Celis, Á, Mendoza, C, Pachón, M, Cardona, J, Delgado, W. and Cuca, L.E. 2008. Extractos vegetales utilizados como biocontroladores con énfasis en la familia Piperaceae. Una revisión. Agron. Colomb. 26(1), 97-106.

Campos, EVR, de Oliveira,JL, Pascoli, M, de Lima R and Fraceto, L.F. (2016). Neem oil and crop protection: From now to the future, Front Plant Sci., 7:1494.

Chaudhary, S, Kanwar, R. K, Sehgal, A, Cahill, D. M, Barrow, C. J, Sehgal, R. and Kanwar, J. R. (2017). Progress on Azadirachta indica based biopesticides in replacing synthetic toxic pesticides. Frontiers in Plant Science, 8, 610.

Dave, H. and Lediwane, L. (2012). A review on anthraquinones isolated from Cassia species and their applications. Indian Journal of Natural Products and Resources, 3, 291–319.

Deutsch, C. A., Tewksbury, J. J., Tigchelaar, M., Battisti, D. S., Merrill, S. C., Huey, R. B., et al. (2018). Increase in crop losses to insect pests in a warming climate. *Science* 361, 916–919.

Dimetry, N.Z. (2014). Different Plant Families as Bio resources for Pesticides. In: Advances in Plant Biopesticides, D. Singh (Ed.), Springer India. DOI: 10.1007/978-81-322-2006-0_1.

Don-Perdo, K. M. (1996). Investigation of single and joint fumigant insecticidal action of citrus peel oil components. Journal of Pest Science, 46, 79–84.

Elzen, G. W., and Hardee, D. D. (2003). United state department of agricultural-agricultural research on managing insect resistance to insecticides. Pest Management Science, 59, 770–776. https://doi.org/10.1002/ (ISSN) 1526-4998.

Emam, A. M, Swelam, E. S. and Megally, N. Y. (2009). Furocoumarin and quinolone alkaloid with larvicidal and antifeedant activities isolated from *Ruta chalepensis* leaves. Journal of Natural Products, 2, 10–22.

Fiedler, AK, Landis, DA. and Wratten, S.D. (2008). Maximizing ecosystem services from conservation biological control: the role of habitat management. Biol Control 45:254–271.

Ghavami, M. B, Poorrastgoo, F, Taghiloo, B. and Mohammadi, J. (2017). Repellency effect of essential oils of some native plants and synthetic repellents against human flea, *Pulex irritans* (Siphonaptera: Pulicidae). Journal of Arthropod Borne Diseases, 11(1), 105–115.

Ghoneim, K. and Hamadah, K. (2017). Antifeedant activity and detrimental effect of Nimbecidine (0.03% Azadirachtin) on the nutritional performance of Egyptian cotton leaf worm *Spodoptera littoralis* Boisd. (Noctuidae: Lepidoptera). Bio Bulletin, 31, 39–55.

Gould, K. S. and Lister, C. (2006). Flavonoid functions in plants. In Flavonoids: Chemistry, biochemistry, and applications (pp. 397–443). Boca Raton, FL: CRC Press LLC.

Govindchari, TR. (1992). Chemistry and biological investigation on *Azadirachta indica* (the neem tree). Curr. Sci., 63: 117 – 122.

Grdisa, M. and Grsic, K. (2013). Botanical Insecticides in Plant Protection. Agriculturae Conspectus Scientificus, 78 (2): 85 – 93.

Haynes, KF. (1988). Sub lethal effects of neurotoxic insecticides on insect behaviour. Ann Rev Entomol 33:149–168.

Henn, T. and Weinzierl, R. (1989). Botanical Insecticides and Insecticidal Soaps. University of Illinois at Urbana Champaign, College of Agriculture, Cooperative Extension Service.

Henn T, Weinzierl R, Gray M. and Steffey, K. (1991). Alternatives in insect management: field and forage crops. Cooperative extension service, University of Illinois at Urbana-Champaign, Circ. 1307.

Hollingworth, R, Ahammadsahib, K, Gadelhak, G. and McLaughlin, J. (1994). New inhibitors of complex I of the mitochondrial electron transport chain with activity as pesticides. Biochemical Society Transactions, 22(1), 230–240.

Isman, MB. (2006). Botanical insecticides, deterrents, and repellents in modern agriculture and an increasingly regulated world. Annu. Rev. Entomol., 51: 45 – 66.

Khambay, B.P, Batty, D, Jewess, P.J, Bateman G.L. and Hollomon, D.W. (2003). Mode of action and pesticidal activity of the natural product dunnione and of some analogues. Pest Manag Sci 59:174–182.

Khater, H.F. (2012). Prospects of Botanical Biopesticides in Insect Pest Management. Pharmacologia, 3, 641-656. http://dx.doi.org/10.5567/pharmacologia.2012.641.656.

Koshier, E. L, and Sedy, K. A. (2001). Effect of plant volatiles on the feeding and oviposition of Thrips tabaci. In R. Marullo, and L. Kound (Eds.), Thrips and Tospoviruses (pp. 185–187). Australia: CSIRO.

Koul, O, Waliai, S. and Dhaliwal, G. S. (2008). Essential oils as green pesticides: Potential and constraints. Biopesticides International, 4(1), 63–84.

Koul O, Singh G, Singh R, Singh J, Daniewski, WM. and Berlozecki, S. (2004). Bioefficacy and mode of action of some limonoids of salannin group from *Azadirachta indica* A. Juss and their role in a multicomponent system against lepidopteran larvae. J. Biosci., 29: 409 – 416.

Kraiss, H. and Cullen, E. M. (2008). Insect growth regulator effects of azadirachtin and neem oil on survivorship, development and fecundity of *Aphis glycines* (Homoptera: Aphididae) and its predator, *Harmonia axyridis* (Coleoptera: Coccinellidae). Pest Management Science, 64(6), 660–668.

Lavandero, B, Wratten, S.D, Didham, R.K. and Gurr, G. (2006). Increasing floral diversity for selective enhancement of biological control agents: a double-edged sword? Basic Appl Ecol. 7:236–243.

Lee, S. E. (2000). Mosquito larvicidal activity of pipernonaline, a piperidine alkaloid derived from long pepper, Piper longum. Journal of the American Mosquito Control Association, 16(3), 245–247.

Liao, M, Xiao, J. J, Zhou, L. J, Yao, X, Tang, F, Hua, R. M, Cao, H. Q. (2017). Chemical composition, insecticidal and biochemical effects of Melaleuca alternifolia essential oil on the Helicoverpa armigera. Journal of Applied Entomology, 2017, 1–8.

Loko, L. Y, Alagbe, O, Dannon, E.A, Datinon, B, Orobiyi, A, Thomas-Odjo, A. and Tamò, M. (2017). Repellent effect and insecticidal activities of *Bridelia ferruginea*, *Blighia sapida*, and *Khaya senegalensis* leaves powders and extracts against *Dinoderus porcellus* in infested dried yam chips. Psyche, 2017 Article ID 5468202, 18 pages.

Lu, F. C. (1995). A review of the acceptable daily intakes of pesticides assessed by the world health organization. Regulatory Toxicology and Pharmacology, 21, 351–364.

Mallikarjuna, N, Kranthi, K. R, Jadhav, D. R, Kranthi, S. and Chandra, S. (2004). Influence of foliar chemical compounds on the development of *Spodoptera litura* in interspecific derivatives of groundnut. Journal of Applied Entomology, 128, 321–328.Mordue (Luntz), A.J. and Blackwell, A. (1993). Azadirachtin: An Update. J. of Insect Physiology, 39, 903-924.

Park, D. S. and Coats, J. R. (2002). Cyanogenic glycosides: Alternative insecticides? The Korean Journal of Pesticide Science, 6(2), 51–57.

Pereira, S. G, Sanaveerappanavar, V. T. and Murthy, M. S. (2006). Geographical variation in the susceptibility of the diamond back moth *Plutella xylostella* L. to *Bacillus thuringiensis* products and acyl urea compounds. Pest Management, 15, 26–26.

Rahdari, T. and Hamzei, M. (2017). Repellency effect of essential oils of *Mentha piperita*, *Rosmarinus officinalis* and *Coriandrum sativum* on *Tribolium confusum* duval (Coleoptera: Tenebrionidae). Chemistry Research Journal, 2(2), 107–112.

Rajashekar, Y., Bakthavatsalam, N., and Shivanandappa, T. (2012). Botanicals as grain protectants. Psyche, 2012, 1–13.

Rattan, R. S. (2010). Mechanism of action of insecticidal secondary metabolites of plant origin. Crop Protection, 29, 913–920.

Regnault-Roger C, Philogène BJR (2008) Past and current prospects for the use of botanicals and plant allelochemicals in integrated pest management. Pharmac Biol 46:41–52.

Regnault-Roger C, Philogène BJR, Vincent C (eds). (2005). Biopesticides of plant origin. Lavoisier, Paris, p 313.

Regnault-Roger, C. and Philogène, B. J. R. (2008). Past and current prospects for the use of botanicals and plant allelochemicals in integrated pest management. Pharmaceutical Biology, 46, 41–52.

Regnault-Roger, C, Vincent, C. and Arnason, J. T. (2012). Essential oils in insect control: Low-risk products in a high-stakes world. Annual Review of Entomology, 57, 405–424.

Rhoda B, Freyer, B. and Macharia, J. (2006). Towards reducing synthetic pesticide imports in favour of locally available botanicals in Kenya. Conference on International Agricultural Research for Development. October 11 – 13, 2006, Tropentag, Bonn. Retrieved from http://www.tropentag.de/2006/abstracts/full/158.pdf.

Rockstrom, J, Stefen, W, Noone, K, Persson, A, Chapin, F.S, Lambin, E, Lenton, T.M, Schefer M, Folke C, Schellnhuber HJ, Nykvist B, de Wit CA, Hughes T, van der Leeuw S, Rodhe H, Sorlin S, Snyder PK, Costanza R, Svedin U, Falkenmark M, Karlberg L, Corell RW, Fabry VJ, Hansen J, Walker B, Liverman D, Richardson K, Crutzen P, Foley J. (2009). Planetary boundaries: exploring the safe operating space for humanity. Ecol Soc 14:32.

Sadre, N.L, Deshpande, V.Y, Mendulkar, K.N. and Nandal, D.H. (1983). Male *Azadirachta indica* in different species. Proc. 2nd Int. Neem Conf., Rauischholzhausen, pp 482.

Samuel, M, Oliver, S. V, Wood, O. R, Coetzee, M. and Brooke, B. D. (2015). Evaluation of the toxicity and repellence of an organic fatty acids mixture (C8910) against insecticide susceptible and resistant strains of the major malaria vector *Anopheles funestus* Giles (Diptera: Culicidae). Parasites and Vectors, 8, 321.

Shelton, A. M, Zhao, J. Z. and Roush, R. T. (2002). Economic, ecological, food safety and social consequences of the deployment of B-transgenic plants. Annual Review of Entomology, 47, 845–881.

Schmutterer, H. (1990). Properties and potential of natural pesticides from the neem tree, *Azadirachta indica*. Annu. Rev. Entomol., 35: 271 – 297.

Silva, V. C. B, Ribeiro Neto, J. A, Alves, S. N. and Li, L. A. R. S. (2015). Larvicidal activity of oils, fatty acids, and methyl esters from ripe and unripe fruit of *Solanum lycocarpum* (Solanaceae) against the vector *Culex quinquefasciatus* (Diptera: Culicidae). Revista da Sociedade Brasileira de Medicina Tropical, 48(5), 610–613.

Simmonds, M. S. (2003). Flavonoid–insect interactions: Recent advances in our knowledge. Phytochemistry, 64, 21–30.

Simmonds, M. S. and Stevenson, P. C. (2001). Effects of isoflavonoids from cicer on larvae of *Helicoverpa armigera*. Journal of Chemical Ecology, 27, 965–977.

Sithisut, D, Fields, P. G. and Chandrapathya, A. (2011). Contact toxicity, feeding reduction and repellency of essential oils from three plants from the ginger family (Zingiberaceae) and their major components against *Sitophilus zeamais* and *Tribolium castaneum*. The Journal of Stored Products, 104, 1445–1454.

Talukder, F. A. (2006). Plant products as potential stored product insect management agents-A mini review. Emirates Journal of Food and Agriculture, 18(1), 17–32.

Talukder, F, Islam, M, Hossain, M, Rahman, M. and Alam, M. (2004). Toxicity effects of botanicals and synthetic insecticides on *Tribolium castaneum* (Herbst) and *Rhyzopertha dominica* (F.). Bangladesh. Journal of Environmental Sciences, 10(2), 365–371.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

Thibout, E. and Auger, J. (1997). Composés soufrés des Allium et lutte contre les insectes. Acta Bot Gallica 144:419–426.

Thibout E, Lecomte C. and Auger, J. (1986). Substances soufrées des Allium et insectes. Acta Bot Gallica 143:137–142.

Tilman, D., Balzer, C., Hill, J. and Befort, B. L. (2011), 'Global food demand and the sustainable intensification of agriculture', Proceedings of the National Academy of Sciences of the United States of America, 108(50): pp. 20260–64.

Tripathi, A. K., Prajapati, V., Khanuja, S. P. S., and Kumar, S. (2003). Effect of d-limonene on three stored-product beetles. Journal of Economic Entomology, 96, 990–995. https://doi.org/10.1093/jee/96.3.990.

Vandana, M. and V.P. Uniyal. 2021. Insect pest diversity of standing crops and traditional pest management in agricultural areas of the Mandakini Valley, Garhwal Himalaya, Uttarakhand, India. International journal of Horticulture, Agriculture and Food Science (IJHAF) ISSN: 2456-8635 [Vol-5, Issue-4, Jul-Aug, 2021].

Vattala, H.D, Wratten, S.D, Phillips, C.B. and Wackers, F.L. (2006). The influence of fewer morphology and nectar quality on the longevity of a parasitoid biological control agent. Biol Cont 39:179–185.

Velu, K, Elumalai, D, Hemalatha, P, Babu, M, Janaki, A. and Kaleena, P. K. (2015). Phytochemical screening and larvicidal activity of peel extracts of Arachis hypogaea against chikungunya and malarial vectors. International Journal of Mosquito Research, 2(1), 01–08.

Wachira, S. W, Omar, S, Jacob, J. W, Wahome, M, Alborn, H. T, Spring, D. R. and Torto, B. (2014). Toxicity of six plant extracts and two pyridine alkaloids from *Ricinus communis* against the malaria vector *Anopheles gambiae*. Parasites and Vectors, 7, 312.

Walia, S, Kumar, D. and O. Koual. (2012). Botanical biopesticides in pest management: Potential and constraints. pp. 146-182. In: Koul, O., G.S. Dhaliwal, S. Khokhar, and S. Ram (Eds.). Biopesticides in environment and food security: issues and strategies. Scientific Publishers, Jodhpur, India.

Weinzierl, R.A. (2000). Botanical insecticides, soaps, and oils. In: Biological and Biotechnological Control of Insect Pests, Ed. J. E. Rechcigl, N. A. Rechcigl, pp 101 – 121.

Wimmer, Z, Alexandra, J. F. D. M, Floro, Zarevúcka, M, Wimmerová, M, Sello, G. and Orsini, F. (2007). Insect pest control agents: Novel chiral butanoate esters (juvenogens). Bioorganic and Medicinal Chemistry, 15(18), 6037–6042.

Yousef, H., EL-Lakwah, S. F., & EL Sayed, Y. A. (2013). Insecticidal activity of linoleic acid against *Spodoptera littoralis* (BOISD.). Egyptian Journal of Agricultural Research, 91(2), 573.

Zhang, W., Zhang, Z., Chen, Z., Liang, J., Geng, Z., Guo, S., Deng, Z. (2017). Chemical composition of essential oils from six Zanthoxylum species and their Repellent activities against two stored-product insects. Journal of Chemistry, Article ID 1287362, 7 pages.

TRENDS IN AGRICULTURE SCIENCE

Vol.3 Special Issue 01 January 2024, Page: 59-66

# Effect of Integrated Nutrient Management on Influence of Dry Matter Production and Post Harvest Soil Analysis in Ashgourd (*Benincasa hispida* cogn.) cv. CO-1

**M.Thangamuniyandi**

Research Scholar, Department of Vegetable Science, Horticulture College and Research Institute, Periyakulam – 625 604.

https://doi.org/10.5281/zenodo.10550974

***Abstract***

An investigation on effect of integrated nutrient management on post harvest soil analysis in ashgourd (*Benincasa hispida* cogn.) cv. CO-1 was undertaken at Department of Horticulture, Faculty of Agriculture, Annamalai University, Annamalai Nagar during 2013-2014. The results of the study indicated that précised application of various organic inputs with inorganic fertilizer had significant influence of post harvest soil analysis. Application of FYM @ 10 kg pit$^{-1}$ plus 50 per cent RDF plus EM @ 1:1000 dilution significantly increased the post harvest soil available nitrogen, post harvest soil available phosphorous and post harvest soil available potassium in ashgourd.

**Key words:** Ashgourd, Soil, Nitrogen, Phosphorous, Potassium

## INTRODUCTION

Ashgourd (*Benincasa hispida* cogn.) is an important cucurbitaceous vegetable grown widely in tropical regions of the world. It has a greater demand in export market due to waxy coat of the fruit which ensures outstanding storage quality. It is available even in the lean period when other vegetables are scarce. Among the cucurbitaceous vegetables, ashgourd has shown the longest shelf life and higher profitability to marginal farmers. It is a very common crop and only a few varieties with high yield potential and better quality have been released. In spite of its many advantages, research thrust has not been given for the improvement of this vegetable. Among the various strategies followed to improve the productivity of a crop, integrated nutrient management plays a significant role. INM involves the integrated use of mineral fertilizers in combination with organic manures along with microbial inoculants to sustain optimum yield and to maintain and improve the soil fertility (Abrol and Katyal, 1990). Integrated nutrient supply has become an accepted strategy to bring about improvement in soil fertility and protecting the environment. Various organic and inorganic inputs *viz.,* Farm yard manure, Poultry manure, Panchakavya, Effective microorganisms, and Recommended dose of fertilizers (RDF) are very effective to improve the growth, yield and quality characters. Hence, the present study was conducted to find out the suitable combination of organic nutrients and inorganic fertilizer or dry matter production and post harvest soil analysis of ashgourd (*Benincasa hispida* cogn.) cv.CO-1.

## MATERIALS AND METHODS

The present experiment on "Effect of integrated nutrient management on growth and flowering characters in ashgourd (*Benincasa hispida* cogn.) cv. CO-1." was undertaken at Department of Horticulture, Faculty and Agriculture, Annamalai University, Annamalai Nagar during 2013-2014. The experiments includes six treatments *viz.,* $T_1$ - FYM + 100 % RDF, $T_2$ - FYM + 75 % RDF + EM, $T_3$ - FYM + 75 % RDF + Panchakavya, $T_4$ - FYM + 75 % RDF + EM + Panchakavya, $T_5$ - PM + 100 % RDF, $T_6$ - PM + 75 % RDF + EM, $T_7$ - PM + 75 % RDF + Panchakavya, $T_8$ - PM + 75 % RDF + EM + Panchakavya, $T_9$ - FYM + 50 % RDF + EM, $T_{10}$ - FYM + 50 % RDF + Panchakavya, $T_{11}$ - FYM + 50 % RDF + EM+ Panchakavya, $T_{12}$ - PM + 50 % RDF + EM, $T_{13}$ - PM + 50 % RDF + Panchakavya, $T_{14}$ - PM + 50 % RDF + EM + Panchakavya. (FYM-Farmyard manure, PM-Poultry manure, RDF-Recommended dose of fertilizer as soil application, EM-Effective microorganisms and Panchakavya as foliar spray). The experiment was laid out in a Randomized Block Design and replicated in three times. Biometrical observations *viz.,* dry matter production, post harvest soil available nitrogen, post harvest soil available phosphorous and post harvest soil available potassium were taken from all the vines in each treatment and replication. Soil samples were collected from the experimental plots at a depth of 20-30 cm after the completion of harvest of the crop. The samples were dried under shade, powdered, sieved and used for analysis. The data were subjected to statistical analysis as suggested by Panse and Sukhatme (1978). The site is geographically situated at 11° 24' N latitude 79° 44' E longitude and at an altitude of + 5.79 m above mean sea level. The soil of the experimental plot is clay loam with pH of 7.81 and EC 0.76 millimhos $cm^{-1}$.

## RESULTS

### Effect of INM on dry matter production in ashgourd

It can be observed from the data in table 1 that significant differences existed among the various treatments. The dry matter production was found to be the maximum in the treatment $T_8$ (PM @ 3 kg $pit^{-1}$ plus 75 per cent RDF plus EM @ 1:1000 dilution plus panchakavya @ 3 per cent) which registered a value of 682.06 g $plant^{-1}$. Application of FYM @ 10 kg $pit^{-1}$ plus 75 per cent RDF plus EM @ 1:1000 dilution plus panchakavya @ 3 per cent ($T_4$) had recorded the next


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

best value of 659.17 g plant$^{-1}$. The treatment $T_7$ and $T_6$ lied on par with each other. The minimum dry matter production was recorded in the treatment $T_9$ (399.54 g plant$^{-1}$).

**Effect of INM on post harvest soil analysis in ashgourd**

The computed data pertaining to the nitrogen availability in the soil due to the effect of various organic and inorganic inputs are presented in table 2. Significant influences were observed between the treatments for this trait. Among the various treatments, the highest nitrogen availability in soil was observed in the treatment $T_9$ (FYM @ 10 kg pit-1 plus 50 per cent RDF plus EM @ 1:1000 dilution) which recorded a value of 224.86 kg ha$^{-1}$. This was followed by the treatment $T_{12}$ (220.44 kg ha$^{-1}$). The lowest nitrogen availability in soil was recorded in the treatment $T_8$ (186.11 kg ha$^{-1}$, 6.67 kg ha$^{-1}$ and 217.69 kg ha$^{-1}$).

Significant variations was noticed among the treatments with respect to phosphorus availability in the soil (Table 3). Application of FYM @ 10 kg pit$^{-1}$ plus 50 per cent RDF plus EM @ 1:1000 dilution ($T_9$) had resulted in the maximum phosphorus availability in the soil (10.17 kg ha$^{-1}$). The treatment $T_{12}$ (PM @ 3 kg pit$^{-1}$ plus 50 per cent RDF plus EM @ 1:1000 dilution) was found to be the next best (9.72 kg ha$^{-1}$). The least value of 6.67 kg ha$^{-1}$ was observed in the plots which received the application of PM @ 3 kg pit$^{-1}$ plus 75 per cent RDF plus EM @ 1:1000 dilution plus panchakavya @ 3 per cent ($T_8$).

The data recorded on the effect of INM on potassium availability in is furnished in the table 4. The maximum potassium availability of soil (264.98 kg ha$^{-1}$) was observed in $T_9$ which received the application of FYM @ 10 kg pit$^{-1}$ plus 50 per cent RDF plus EM @ 1:1000 dilution. Application of PM @ 3 kg pit$^{-1}$ plus 50 per cent RDF plus EM @ 1:1000 dilution ($T_{12}$) had recorded the next best value (258.13 kg ha$^{-1}$). The potassium availability of soil was found to be the least in the treatment $T_8$ (217.69 kg ha$^{-1}$).

## DISCUSSION

Stephenson *et al.* (1990) and Oladotun (2002) reported that poultry manure contains macro and micro nutrients such as N, P, K, S, Ca, Mg, Cu, Mn, Zn, Bo and Fe. Panchakavya suppresses the pathogen by encouraging the local antagonists of the pathogen leading to increased vigour in tomato, resulting in increased root length and maximum dry weight, which paves way for heavy yield. This might be due to the increased translocation of stored carbohydrates and amino acids contributed by the nutrients of panchakavya and other metabolites to the major storage organs of the plant, where these were utilized for the formation of secondary metabolites (Vadivel, 2007). This might be due to the slow release of nutrients from the FYM, resulting in the lesser loss and further availability of nutrients can also be achieved in due course of time due


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

to degradation. The use of EM increases fermentation and decomposition of organic matter and release greater quantities of these three essential elements in inorganic and organic forms. This in turn enhances the fertility of the soil and thereby its quality and sustainability

From the present investigation, it may be concluded that application of FYM @ 10 kg pit-1 plus 50 per cent RDF plus EM @ 1:1000 dilution was found to have beneficial effect on post harvest soil analysis in ashgourd (*Benincasa hispida* cogn.) cv. CO-1.

**Table 1. Effect of INM on dry matter production in ashgourd (*Benincasa hispida* cogn.) cv. CO-1.**

| Treatments | Dry matter production (g plant$^{-1}$) |
|---|---|
| $T_1$ | 538.82 |
| $T_2$ | 591.02 |
| $T_3$ | 594.11 |
| $T_4$ | 659.17 |
| $T_5$ | 570.82 |
| $T_6$ | 626.41 |
| $T_7$ | 631.82 |
| $T_8$ | 682.06 |
| $T_9$ | 399.54 |
| $T_{10}$ | 425.07 |
| $T_{11}$ | 492.87 |
| $T_{12}$ | 437.89 |
| $T_{13}$ | 488.53 |
| $T_{14}$ | 527.34 |
| SEd | 10.10 |
| CD (p=0.05) | 20.18 |


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

**Table 2. Effect of INM on post harvest soil available nitrogen in ashgourd (*Benincasa hispida* cogn.) cv. CO-1.**

| Treatments | Post harvest soil available Nitrogen |
|---|---|
| $T_1$ | 207.13 |
| $T_2$ | 205.81 |
| $T_3$ | 200.12 |
| $T_4$ | 193.86 |
| $T_5$ | 206.55 |
| $T_6$ | 199.67 |
| $T_7$ | 194.11 |
| $T_8$ | 186.11 |
| $T_9$ | 224.86 |
| $T_{10}$ | 217.11 |
| $T_{11}$ | 212.19 |
| $T_{12}$ | 220.44 |
| $T_{13}$ | 216.68 |
| $T_{14}$ | 211.72 |
| SEd | 1.34 |
| CD (p=0.05) | 2.76 |


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

**Table 3. Effect of INM on post harvest soil available phosphorous in ashgourd (*Benincasa hispida* cogn.) cv. CO-1.**

| Treatments | Post harvest soil available Phosphorous |
|---|---|
| $T_1$ | 8.62 |
| $T_2$ | 7.99 |
| $T_3$ | 7.83 |
| $T_4$ | 7.04 |
| $T_5$ | 8.02 |
| $T_6$ | 7.59 |
| $T_7$ | 7.31 |
| $T_8$ | 6.67 |
| $T_9$ | 10.17 |
| $T_{10}$ | 9.45 |
| $T_{11}$ | 8.81 |
| $T_{12}$ | 9.72 |
| $T_{13}$ | 9.07 |
| $T_{14}$ | 8.79 |
| SEd | 0.11 |
| CD (p=0.05) | 0.23 |


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

**Table 4. Effect of INM on post harvest soil available Potassium in ashgourd (*Benincasa hispida* cogn.) cv. CO-1.**

| Treatments | Post harvest soil available Potassium |
|---|---|
| $T_1$ | 235.54 |
| $T_2$ | 231.93 |
| $T_3$ | 225.67 |
| $T_4$ | 219.94 |
| $T_5$ | 233.86 |
| $T_6$ | 224.16 |
| $T_7$ | 220.68 |
| $T_8$ | 217.69 |
| $T_9$ | 264.98 |
| $T_{10}$ | 252.36 |
| $T_{11}$ | 243.72 |
| $T_{12}$ | 258.13 |
| $T_{13}$ | 250.97 |
| $T_{14}$ | 241.92 |
| SEd | 1.69 |
| CD (p=0.05) | 3.37 |

## Reference

Abrol, I. P. and J. C. Katyal. 1990. Managing soil fertility for sustained Agriculture In: Proc. Int. Symp. Natural resources management for a sustainable Agriculture (Vol. 2). **Indian Soc. Agron.,** New Delhi.

Oladotun, A. O. 2002. Managing manure as a fertilizer; Saskatchewani, Agriculture, Food and Rural Revitalization. p 5.

Panse, V. G. and P. V. Sukhatme. 1978. **Statistical methods for Agricultural workers.** ICAR, New Delhi.

Stephenson, A. H., T. A. McCaskey and B. G. Ruffin. 1990. A survey of broiler litter composition and potential value as a nutrient resource. **Biological Wastes 34:** 1-9.

Vadivel, E. 2007. The theory and practice of panchakavya. **ATIC**, Directorate of extension education, TNAU, Coimbatore. Pp: 32-33.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

TRENDS IN AGRICULTURE SCIENCE

Vol.3 Special Issue 01 January 2024, Page: 67-76

# Clean Technology Through Bio Char to Enhance Soil and Water Quality

**T.Geetha Jebarathnam and V. Prakash**

School of Agriculture,
Bharath Institute of Higher Education and Research,
Selaiyur, Tambaram, Chennai – 73.

https://doi.org/10.5281/zenodo.10550987

***Abstract***

The ancient indigenous knowledge preserved in Amazonian Dark Earths (ADEs), a type of extremely fertile soil that contains large amounts of charcoal and archaeological arti facts and is typically high in calcium and phosphorus, is the source of inspiration for the potential use of bio char in modern agriculture. The humid tropics face significant challenges when it comes to sustainable soil fertility management. As a result, ADEs have raised public awareness by serving as an example of how soil fertility improvements and long-term carbon sequestration can coexist. This has increased interest in bio char, a traditional method converted into carbon**.** The surge in food demand and environmental concerns provide numerous obstacles for modern agriculture. The potential applications of bio char in carbon sequestration, greenhouse gas emission reduction, renewable energy, waste mitigation, and soil amendment are becoming more and more acknowledged by scientists and policy makers. The use of bio char in soil has the potential to significantly impact the dynamics of nutrients, soil pollutants, and microbial functions. Consequently, applying bio char to soil strategically may have positive effects on agriculture, the environment, and the economy. Additionally, recent research has demonstrated that bio char plays an important role as a soil conditioner and fertilizer to increase crop output as well as improve soil quality and health. Applying bio char as a soil supplement appears to improve soil nutrient density, water-holding capacity, fertilizer requirements, improve soil microbiology, and boost crop yields. Furthermore, using bio char has a number of positive effects on the environment, the economy, and possible integration with carbon credit schemes. The solution to these basic needs could be found in bio char, also referred to as bio carbon.

***Keywords:*** *bio char, soil amendment, sustainability, carbon sequestration, soil conditioner*

## INTRODUCTION

The global economy is shaped in large part by agriculture. Nowadays, one of the main concerns is food security. Even with the tremendous improvements in farming techniques following World War II, the world's food supply still cannot meet current demand. In addition, there are still concerns related to soil contamination, climate change, and desertification that need to be resolved for the agriculture industry [Pullagurala etal;2018]. With a growing population, it is predicted that global food demand will rise by 70% by 2050 [Samantarai etal;2014], and achieving this demand without sacrificing the health of the soil and the agro ecosystem has become a major concern for the agriculture industry. Bio char as a soil amendment has been suggested as a tactic for mitigating climate change as well as enhancing soil quality and production because of the benefits of improved soil characteristics and long-term carbon collection. Since burning crop leftovers releases black carbon in the form of dispersed particulate matter, which can contaminate surrounding metropolitan areas, burning crop residues is becoming a major problem in most nations. Consequently, one of the practical methods for increasing the rates at which carbon is naturally sequestered in the soil, lowering agricultural waste, and enhancing soil quality is the pyrolysis process of turning organic waste into bio char. The widespread use of pesticides, plant growth regulators, fertilizers, and other chemicals without thought has become the norm in response to the urgent need for food.

Because of its detrimental effects on the ecology and the entire food chain, their overuse is a serious reason for concern. Significant risks to the sustainability of agricultural production in tropical regions include depletion of soil nutrients and organic matter, decline in agricultural productivity from overuse of chemical fertilizers, and changes in climate brought on by human activity. Thus, in order to preserve soil health and improve sustainability, it is becoming increasingly vital to utilize organic fertilizer in addition to inorganic fertilizer. In addition to organic manures and composts, using bio char is a relatively new strategy that could be advantageous for agriculture and the environment. In light of current and impending issues, bio char could hold the key to creating a sustainable future and incorporating valuable products into the circular economy model. Researchers hope to find a way to increase soil quality and boost agricultural sustainability by amending the soil with bio char [Samantarai etal; 2014]. A soil's texture, ability to support and maintain microbial activity, and capability to hold on to moisture and nutrients are factors that define its quality [Sandhu etal; 2017]. Although bio char is typically used untreated, new research indicates that it may be utilized to enhance performance through chemical or physical modification [Sun etal;2017]. Plant yields and soil health have been proven to benefit from bio char while maintaining the integrity of the soil [. Bashir etal;2018].

## BIO CHAR PRODUCTION PROCESS

When producing bio char, thermochemical conversion technologies are more widely used than biochemical ones because the latter produce hydrogen at a much slower rate and with a lower yield. Gasification, pyrolysis, and combustion are additional subcategories of the former. Figure: 1; depicts the several thermochemical reactions that go into the creation of bio char. With the primary objective of improving soil, bio char is a highly porous, fine-grained product rich in


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

paramagnetic centres of both organic and inorganic nature. It is obtained through slow pyrolysis of biomass waste, which can come from agricultural, municipal, animal, or industrial sources. A significant portion of its surface is covered in aromatic surfaces and oxygen functional groups. Between 300 to 1000°C are the typical pyrolysis temperatures used. Bio char, solid rich in carbon, is produced from the residue of pyrolysis, a fast-heating process that removes hydrogen and carbon monoxide from biomass in the absence of oxygen. An energy-dense liquid known as "bio-oil" can be created by capturing and condensing the volatile gases that are emitted during this process. more refinement can yield diesel and more hydrocarbon-based products. The carbonization of organic wastes produces bio char, which has been demonstrated to be a viable replacement that alters the physicochemical and biological properties [Zhang etal;2017] of soil in addition to influencing soil carbon.

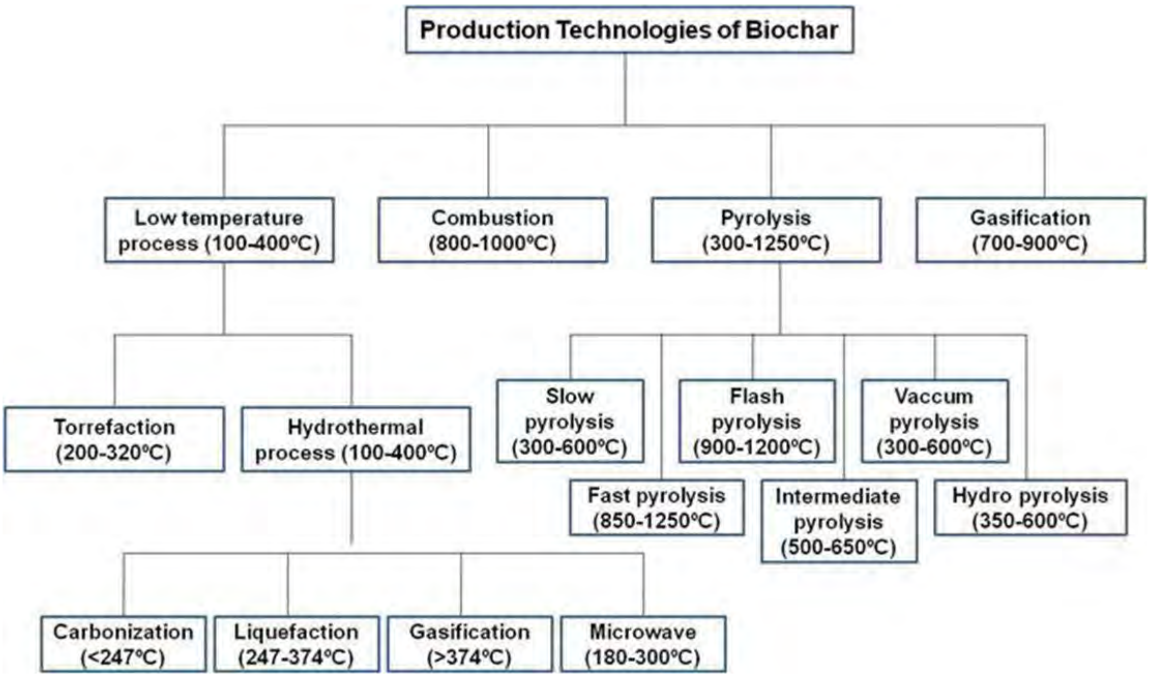



**Figure 1: Bio char Production Process**

## THE BENEFITS OF BIO CHAR ON SOIL HEALTH

A soil's ability to ful fill various agronomic and environmental tasks is referred to as its state of health. Response to management and inputs, resilience to biotic and abiotic stressors, and biomass/agronomic productivity are crucial among these roles. In agricultural land use, soil health pertains to the ability of the soil to preserve or enhance environmental quality while simultaneously supporting and fostering the growth of crops and animals. A soil management regime's success depends on maintaining a certain amount of soil organic matter and nutrient biological cycling. Erosion, compaction, salinization, nutrient shortage, loss of biodiversity, and


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

desertification are among the soil degradation processes that are facilitated by the reduction in SOM sequestration [Zhang et al,. 2017].

## IMPACT OF BIO CHAR ON THE ENVIRONMENT, SOIL HEALTH, AND AGRICULTURAL PRODUCTIVITY

Current conditions highlight the pressing challenges of food security, deteriorating soil fertility, climate change, and profitability. In view of the ongoing global climate change, soil carbon is crucial for food security, ecosystem health, and environmental durability. Pyrolysed agricultural residue, or bio char, has the ability to sequester carbon due to its biological origin and physico-chemical characteristics. Longer-term nutrient availability in accordance with crop needs is ensured by its increased resistance to decay and capacity to hold onto nutrients. Both direct and indirect effects on soil fertility are associated with the application of bio char. As for the indirect effects, they come from the improved physical, chemical, and biological characteristics of the soil (Beusch, 2021, Singh et al., 2022). The direct effects include an enhanced nutrient availability (potassium [K], phosphorus [P], calcium [Ca], magnesium [Mg], and so on). According to studies conducted by Das et al. (2021), Singh et al. (2022) and Hu et al. (2023), the primary impacts on chemical and biological parameters are increases in soil pH, cation exchange capacity, mineral nitrogen (N) availability, dissolved organic carbon, and microbial diversity (bacterial and fungal). While a large body of research shows that applying bio char at higher rates to highly eroded, coarse-textured tropical soils improve soil quality parameters, very little to no effect has been found in other soil types, such as Mediterranean calcareous soils (Nogues et al., 2023).

## THE CONTRIBUTION OF BIOCHAR TO INCREASING FERTILIZER EFFICIENCY

According to El-Sharkawy et al. (2022) there is evidence that applying biochar improves maize and wheat productivity and reduces abiotic pressures in saline-sodic soils. Although wood-based bio char is less effective than bio char made from manure, greenhouse waste, and grasses for supplementing nutrients, the potential for carbon sequestration of wood-based bio char is higher (Ippolito et al., 2020). Both the increased nutrient retention and the decreased leaching of applied fertilizers out of the soil–plant ecosystem are caused by bio char-amended soils' improved water-holding capacity and increased cation and anion exchange capabilities.

## HOW BIOCHAR AFFECTS THE PHYSICAL PROPERTIES OF SOIL

The physicochemical characteristics of damaged or nutrient-depleted soils may be improved by adding bio char as a soil amendment. The combination of surface functioning and porosity in bio char determines its capacity to hold onto soil water . Because of the porous internal structure of bio char, soil porosity is increased, aiding in the expansion of soil's surface area and


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

improving water penetration. According to earlier research, adding bio char to infertile soils increases total pore volume, reduces bulk density, and boosts water-holding capacity. Applying bio char lowered the tensile strength of soil cores, according to Chen et al. 2007, suggesting that using bio char can lower the likelihood of soil compaction. Thus, the amount of bio char amendment added to the soil appears to be correlated with enhanced soil aggregation. It appears that a recent Italian study on bio char made from forest biological mass supports these conclusions (Baiamonte et al., 2021).

## EFFECT OF BIOCHAR ON SOIL BIODIVERSITY

The diversity, abundance, and activity of soil biotic communities are likely to be impacted by the addition of bio char to soils as opposed to the addition of fresh organic matter [Lehman etal; 2011]. Bio char's very porous nature allows it to change biological functionality by affecting the availability of substrate and enzyme activity on or around bio char particles, as well as helping to provide a habitat for microorganisms [Gomez etal ;2014]. Microbial biomass and composition may be impacted by bio char, and bacteria have the power to modify the material's characteristics [Lehman etal; 2011]. According to Abujabhah et al. 2016,the addition of bio char increased microbial abundance. Soil microorganisms may be physically protected by the pores of bio char. Microbial activity, variety, and abundance are significantly influenced by soil response. In instances where it does not alter the pore volume or other physical and chemical features of the soil, bio char itself is resistant to microbial breakdown, therefore significant changes in microbial populations or biomasses should not be anticipated (Soinne et al., 2020). In the microhabitats within the bio char particles, the buffering ability of the soil solution provided by the CEC of bio char may also aid in reducing pH variations and maintaining ideal pH levels [Rousk etal;2010]. Research has indicated that the use of fertilizer combined with bio char enhanced microbial biomass in comparison to mineral fertilizer. In soils when leaching has occurred, microbial immobilization is a crucial strategy for retaining nitrogen. A higher N demand is caused by increased microbial activity stimulated by increased C availability, which encourages NO3-immobilization and recycling. In phosphate-rich soils, bio char increased PSM activity for P mobilization; in P-deficient soils, bio char greatly increased crop production [Deb etal;2017].

## IMPACT OF BIOCHAR ON THE ENVIRONMENT

Bio char has been noted to have a significant impact on carbon emissions and to be crucial for achieving global climate targets [Woolf etal;2016]. Although adding bio char to soils boosts agricultural yields significantly, bio char-bioenergy systems can be a valuable part of a worldwide plan since they aid with carbon capture and storage at lower carbon prices. Therefore, the efficient


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

use of bio char is crucial for sequestering carbon. The combustion of fossil fuels and the breakdown of biomass release an excessive amount of carbon dioxide into the atmosphere these days, raising the atmospheric carbon content daily. Because bio char may store 50% of the carbon in feedstock, its application aids in reducing carbon dioxide emissions [Sohi etal;2010]. Because of its exceptional stability, bio char can considerably reduce the amount of carbon dioxide released during organic decomposition. in order for it to be crucial in tracking the soil's release of nitrogen dioxide and methane, which are now the main contributors to climate change. Offsite pollution can also be decreased by applying bio char to the soil. It contributes to minimizing soil nutrient loss into groundwater and enhancing soil nutrient retention, particularly in phosphorus and nitrogen. Therefore, it has a significant impact on preventing nutrient erosion and increasing nutrient availability for crop production. A considerable reduction in the phosphorous mobility of animal manures can be obtained through pyrolysis [Venkatesh etal;2018] . This method also helps to lighten and reduce the volume of the manures, which will facilitate their disposal. Additionally, it facilitates the transformation of the manure's soluble inorganic phosphate into adsorbed phosphate. Several organic contaminants in the environment bond to bio char in an essential way. The adsorption of organic pollutants on bio char as well as their transport and destiny have been found to be significantly impacted by the heavy metals found in the soil. Since bio char is a naturally occurring substance, it has a strong affinity for organic contaminants, such as persistent organic pollutants (POPs), which can be adsorbed by it .Sites contaminated by heavy metals may benefit from the use of bio char in conjunction with phytoremediation techniques to stabilize and clean the area. However, several scientists have issued health advisories about the dangers of polycyclic aromatic hydrocarbon exposure (Zhang etal; 2021).

## CONSTRAINTS IN BIO CHAR APPLICATIONS

As a value-added by product of pyrolysis, bio char has been hailed for some time for its ability to enhance and preserve soil fertility and health while also increasing the advantages of storing carbon in the atmosphere. For several hours, the temperature of kilns used for its production must be kept between 400 and 700 C, producing carbon gases and a significant amount of thermal energy. The agronomic efficiency of bio char is difficult to predict because there haven't been many research done in various soil types, climatic zones, and land use scenarios. Prior to the establishment of commercial-scale pyrolysis facilities, the heterogeneous nature and manufacturing cost of bio char will continue to be a significant barrier for research and field use. [Par mar etal; 2014] are a few experimental restrictions on the application of bio char in agricultural systems.

1. Lack of enough bio char to be used on a large scale
2. Dry bio char's susceptibility to wind erosion;
3. Local farming communities' lack of adoption of bio char;
4. A shortage of sufficient farm labor; and
5. The high wages associated with gathering and processing crop residues
6. Insufficient agricultural equipment for crop residue recycling on-farm
7. Insufficient rewards for crop residue recycling.

The use of contaminated feed stocks or improper process conditions, such as temperatures above 500°C, during the synthesis of bio char might lead to contamination risk of bio char with heavy metals, dioxins, and Polycyclic aromatic hydrocarbons. Reduced integration of bio char into soils due to the removal of crop remains from the field for bio char synthesis affects numerous soil parameters. Earthworm survival rates may be negatively impacted in some circumstances by the application of bio char at an exceptionally high rate [Venkatesh et al; 2017&2018].

## DECREASING THE EMISSIONS OF GHG (GREEN HOUSE GAS)

Although the application of bio char has been shown in multiple studies to lower soil greenhouse gas (GHG) emissions (Zhang et al., 2020), the exact processes by which bio char reduces soil GHG emissions remain unknown. Nitrous oxide (N2O) emission is influenced by the charcoal feedstock, pyrolysis conditions, C:N ratio, and application rates. However, following the application of bio char, reports of an increase in soil methane (CH4) and CO2 emissions were also made (Mukherjee and Lal, 2013).

## FUTURE PERSPECTIVES

In the agriculture sector primarily, adding bio char to soils can be one of the finest ways to combat biotic stress and boost crop output. As this chapter has covered, pyrolysis could be one of the processes that has greatly impacted the properties of bio char. As a result, bio char seems like a very promising solution for removing pollutants. When creating recoverable bio char for a variety of environmental applications, economic effects and recyclability should be taken into account. Despite the current surge in interest in bio char usage, there remains a significant information vacuum that requires attention. It is yet unknown what will happen to bio char in the end when it is used in the field and how it will affect soil quality in the long run. Further investigation is required into the effects of bio char on the microbial populations, soil physicochemical characteristics, and alterations in biogeochemical cycles [Ding *et al.*, 2016]. As soils are altered using bio char, researchers must look for ways to significantly reduce greenhouse gas emissions [Mandal *et al.*, 2016].


Published: 23 Jan. 2024
ISSN: 2583-7850

## CONCLUSION

The loss of agricultural land due to population growth must be managed by implementing sustainable crop production methods. While direct crop residue integration preserves soil nutrients and organic carbon content, it also causes significant crop management issues by delaying the breakdown process. Over a decade, a great deal of research has been done on the effectiveness of bio char in enhancing crop productivity, environmental mitigation, reclamation of land, and soil health. Depending on the kind of soil, crop, type of bio char, and setting, this research has revealed a range of results, from noticeable improvements in soil health to essentially no change when compared to the control. Large-scale field trials have produced relatively little information thus far, presumably as a result of the high price of bio char on the market. Perhaps the most promising uses would be in very specialized applications to deal with certain environmental issues. When employing bio char as a strategy for sequestering carbon dioxide, it is important to take into account the global greenhouse gas emissions associated with its production and the need for an appropriate regulatory framework to mitigate any potential dangers of soil contamination caused by pollutants found in the material. Understanding how to modify the properties of bio char is crucial for the deployment of bio char in the future so that the amendment can be specifically tailored to each region, crop type, climate, and soil. Overall, research shows that bio char improves crop yields and soil quality, but there may be certain limitations that need to be investigated. The greatest quality of bio char should be seen as its diversity. Bio char appears to be a substance that could be customized to address specific problems in agriculture. Because of its physical-chemical characteristics, bio char can be utilized for water purification, reducing the bioavailability of pollutants that harm living things, and sequestering carbon from soil. In practical field situations, it is yet unclear how long-lasting the effects of bio char are on soil processes and mechanisms besides soil health, environmental quality, and long-term carbon sequestration can all be improved by adding bio char as a soil supplement.

## REFERENCES

Abujabhah IS, Bound SA, Doyle R, Bowman JP (2016) Effects of biochar and compost amendments on soil physico-chemical properties and the total community within a temperate agricultural soil. Applied Soil Ecology 98:243-253.

Baiamonte, G., Crescimanno, G., Parrino, F. & De Pasquale, C. 2021. Biochar Amended Soils and Water Systems: Investigation of Physical and Structural Properties. Applied Sciences, 11(24): 12108. http://dx.doi.org/10.3390/app112412108 Chen J, Zhu D, Sun C (2007) Effect of heavy metals on the sorption of hydrophobic organic compounds to wood charcoal. Environmental Science & Technology 41(7):2536-2541.

Bashir S, Zhu J, Fu Q, Hu H (2018) Cadmium mobility, uptake and anti-oxidative response of water spinach (Ipomoea aquatic) under rice straw biochar, zeolite and rock phosphate as amendments. Chemosphere 194:579-587.

Beusch, C. 2021. Biochar as a Soil Ameliorant: How Biochar Properties Benefit Soil Fertility–A Review. Journal of Geoscience and Evironment Protection, 9(10): 28–46. https://doi.org/10.4236/gep.2021.910003.

Das, S.K., Ghosh, G.K., Avasthe, R.K. & Sinha, K. 2021. Compositional heterogeneity of different biochar: Effect of pyrolysis temperature and feedstocks. Journal of Environmental Management, 278(2). https://doi.org/10.1016/j.jenvman.2020.111501.

Deb D, Kloft M, Lässig J, Walsh S (2016) Variable effects of biochar and P solubilizing microbes on crop productivity in different soil conditions. Agroecology and Sustainable Food Systems 40(2):145-168.

Ding Y, Liu Y, Liu S, Li Z, Tan X, Huang X, Zeng G, Zhou L, Zheng B (2016) Biochar to improve soil fertility. A review. Agronomy for sustainable development 36(2):36.

El-Sharkawy, M., El-Naggar, A.H., AL-Huqail, A.A. & Ghoneim, A.M. 2022. Acid-Modified Biochar Impacts on Soil Properties and Biochemical Characteristics of Crops Grown in Saline-Sodic Soils. Sustainability, 14(13): 8190. https://doi.org/10.3390/su14138190

Gomez JD, Denef K, Stewart CE, Zheng J, Cotrufo MF (2014) Biochar addition rate influences soil microbial abundance and activity in temperate soils. European Journal of Soil Science 65(1):28-39.

Hu, T., Wei, J., Du, L., Chen, J. & Zhang, J. 2023. The effect of biochar on nitrogen availability and bacterial community in farmland. Annals of Microbiology, 73:4. https://doi.org/10.1186/s13213-022-01708-1.

Ippolito, J.A., Cui, L., Kammann, C., Wrage-Mönnig, N., Estavillo, J.M., Fuertes-Mendizabal, T., Cayuela, M.L. et al. 2020. Feedstock choice, pyrolysis temperature and type influence biochar characteristics: a comprehensive meta-data analysis review. Biochar, 2(4): 421–438. http://dx.doi.org/10.1007/s42773-020-00067-x.

Lehmann J, Rillig MC, Thies J, Masiello CA, Hockaday WC, Crowley D (2011) Biochar effects on soil biota–a review. Soil biology and biochemistry 43(9):1812-1836.

Mandal S, Sarkar B, Bolan N, Novak J, Ok YS, Van Zwieten L, Singh BP, Kirkham MB, Choppala G, Spokas K, Naidu R (2016) Designing advanced biochar products for maximizing greenhouse gas mitigation potential. Critical Reviews in Environmental Science and Technology 46(17):1367-1401.

Mukherjee, A. & Lal, R. 2013. Biochar impacts on soil physical properties and greenhouse gas emissions. Agronomy, 3(2) : 313–339.

Nogues, I., Miritana, V.M., Passatore, L., Zacchini, M., Peruzzi, E., Carloni, S., Pietrini, F. et al. 2023. Biochar soil amendment as carbon farming practice in a Mediterranean environment. Geoderma Regional, 33(5). http://dx.doi.org/10.1016/j.geodrs.2023.e00634.

Parmar A, Nema PK, Agarwal T (2014) Biochar production from agro-food industry residues: a sustainable approach for soil and environmental management. Current Science 107(10):1673-1682.

Pullagurala VL, Rawat S, Adisa IO, Hernandez-Viezcas JA, Peralta-Videa JR, Gardea-Torresdey JL (2018) Plant uptake and translocation of contaminants of emerging concern in soil. Science of the Total Environment 636:1585-1596.

Rousk J, Bååth E, Brookes PC, Lauber CL, Lozupone C, Caporaso JG, Knight R, Fierer N (2010) Soil bacterial and fungal communities across a pH gradient in an arable soil. The ISME journal 4(10):1340-1351.

Samantarai SK and Achakzai AKK (2014) Application of nanotechnology in agriculture and food production: opportunity and challenges. Middle East Journal of Scientific Research 22(4):499-501.

Sandhu SS, Ussiri DA, Kumar S, Chintala R, Papiernik SK, Malo DD, Schumacher TE (2017) Analyzing the impacts of three types of biochar on soil carbon fractions and physiochemical properties in a corn-soybean rotation. Chemosphere 184:473-481.

Singh, H., Northup, B.K., Rice, C.W. & Vara Prasad, P.V. 2022. Biochar applications influence soil physical and chemical properties, microbial diversity, and crop productivity: a metaanalysis. Biochar, 4(1): 3. http://dx.doi.org/10.1007/s42773-022-00138-1.

Sohi SP, Krull E, Lopez-Capel E, Bol R (2010) A review of biochar and its use and function in soil. In: Advances in agronomy. Academic Press, pp. 47-82.

Sun Z, Sänger A, Rebensburg P, Lentzsch P, Wirth S, Kaupenjohann M, Meyer-Aurich A (2017) Contrasting effects of biochar on N2O emission and N uptake at different N fertilizer levels on a temperate sandy loam. Science of the Total Environment 578:557-565.

VenkateshG,Suliman W, Harsh JB, Abu-Lail NI, Fortuna AM, Dallmeyer I, Garcia-Pérez M (2017) The role of biochar porosity and surface functionality in augmenting hydrologic properties of a sandy soil. Science of the Total Environment 574:139-147.

Venkatesh G, Gopinath KA, Reddy KS, Reddy BS, Prasad JV, Rao GR, Pratibha G, Srinivasarao C, Chary GR, Prabhakar M, Kumari VV (2018) Biochar for enhancing the soil, water and crop productivity in rainfed areas. In: Krishna Rao B, Sammi Reddy K, Visha Kumari V, Nagarjuna kumar R and Rejani R. (eds.) Rainwater Management for Climate Resilient Agriculture in Drylands. pp 523.

Woolf D, Lehmann J, Lee DR (2016) Optimal bioenergy power generation for climate change mitigation with or without carbon sequestration. Nature Communications 7(1):1-11.

Zhang M, Cheng G, Feng H, Sun B, Zhao Y, Chen H, Chen J, Dyck M, Wang X, Zhang J, Zhang A (2017) Effects of straw and biochar amendments on aggregate stability, soil organic carbon, and enzyme activities in the Loess Plateau, China. Environmental Science and Pollution Research 24(11):10108- 10120. DOI: https://doi.org/10.1007/s11356-017-8505-8.

Zhang, Q., Xiao, J., Xue, J. & Zhang, L. 2020. Quantifying the Effects of Biochar Application on Greenhouse Gas Emissions from Agricultural Soils: A Global Meta-Analysis. Sustainability, 12(8): 3436; http://dx.doi.org/10.3390/su12083436.

Zhang, F., Zhang, G. & Liao, X. 2021. Negative role of biochars in the dissipation and vegetable uptake of polycyclic aromatic hydrocarbons (PAHs) in an agricultural soil: Cautions for application of biochars to remediate PAHs-contaminated soil. Ecotoxicology and Environmental Safety, 213: 112075. https://doi.org/10.1016/j.ecoenv.2021.112075.

TRENDS IN AGRICULTURE SCIENCE
Vol.3 Special Issue 01 January 2024, Page: 77-82

# A Review- *Arthrospira platensis* - Nutritional Benefits and Value-added Products

**Leenasree. R[1] and Sanjaikannan. A[2]**
[1]Assistant Professor, Bharath Institute of Higher Education and Research, Selaiyur, Chennai.
[2]Assistant Professor, RVS Agricultural College, Thanjavur.
https://doi.org/10.5281/zenodo.10551052

***Abstract***

One source of all important elements and vitamins, spirulina is a single-cell protein that can be used to make functional meals. Actually, among the most significant. The usage of artificial food additives that raise the risk of cancer is one of the industry's issues. As a result, attempts are being made globally today to separate novel and secure antioxidants from their natural sources. Among these, cyanobacteria's natural products are a significant source of novel pharmaceutical molecules. In addition to their own medical usefulness, natural bioactive compounds are also employed as building blocks to make synthetic analogues. Protein makes up 70–55% of Spirulina's chemical composition, followed by carbs (25-25%), essential fatty acids (18%), vitamins, minerals, and pigments including phycocyanin, carotene, and chlorophyll A. Of course, the introduction of cyanobacteria's beneficial traits Many antibacterial substances and synthetic antioxidants can be effectively replaced with spirulina, which not only poses no risk to the user but also enhances their health. We have covered the key nutrients, bioactive characteristics, and immunological uses of Spirulina in this review. According to recent study, spirulina supplements are recognized as a safe dietary and nutritional supplement by international accreditation.
***Key words***: Spirulina, cookie, cyanobacteria, value added product.

## INTRODUCTION

Spirulina is categorised under the Cyanobacteria phylum. This Cyanobacterium, which is often found in food and nutritional supplements, can be found as either blue-green algae or bacteria. A particular kind of blue-green vegetable micro-algae, spirulina is becoming more and more well-known around the world due to its exceptional nutritional value, which is frequently praised by health-conscious consumers. The nutritional properties of spirulina are genuinely unique. Spirulina is the highest known natural source of protein, with over 71 percent of its total protein composition found in its structure. Its protein content is five times higher than that of meat and almost three times more than that of the ubiquitous soybean. Apart from its remarkable amino acid composition, spirulina also includes a variety of other health-promoting elements, such as carotenoids, essential fatty acids, vitamin E, B complex vitamins, copper, manganese, magnesium, iron, selenium, and zinc. The nutrients and growth factor properties of spirulina are actually second only to those of milk and evening primrose oil. Spirulina preparations are also utilised for their medicinal qualities in the treatment of numerous illnesses, such as atherosclerosis and hypercholesterolemia, as well as for weight loss in obese people. It is believed that chemicals with antioxidant capabilities, such as phycocyanin, phenolics, and polyunsaturated fatty acids, are what give spirulina its medicinal qualities.

Spirulina can be grown in a variety of methods; the two most well-known ones are raceways and photobioreactors. Raceways are often rectangular with rounded corners, require a lot of water, and are weather- and season-dependent. Since photobioreactors are closed systems for cultivation, they shield Spirulina strains from outside contamination. In these systems, cultivation parameters including pH, temperature, and light may be easily adjusted. Locals near the lakes where it grows naturally have long utilised it as an addition to their diet. It has been made industrially for human consumption and distributed as a protein supplement in many Asian nations. Pregnant ladies frequently believe that consuming cakes will protect their unborn child from magicians' gaze. Certain disorders can also be treated by poulticing sparingly with spirulina. Additionally, Spirulina has been recommended by. Subsequently, numerous animal and human clinical investigations have been conducted to ascertain its beneficial effects when taken as a supplement. As a cheap nutritional supplement, spirulina hasn't been shown to have any notable adverse effects.

**SPIRULINA ITS VALUE-ADDED PRODUCTS**

**SPIRULINA AS A WONDERFUL FUTURE FOOD SOURCE**

Spirulina has the amazing capacity to be utilised in the preparation of concentrated, high-quality food. The diet and Agriculture Organisation (FAO) of the United Nations now declares that spirulina is the ideal diet and nutritional supplement for the twenty-first century. Food processors are extremely concerned about food ingredient authentication because dishonest suppliers may exploit the purity of their supplies. Spirulina has been utilised gradually as an additional protein and vitamin source in aqua feeds, as well as a supplemental nutritional element for fish, prawns and poultry. China is using microalgae to supplement imported fodder in part to boost prawn viability, growth, and immunity. Additionally, comprehensive studies on the application of spirulina. Numerous vitamins and nutrients can be found in spirulina. It contains beta-carotene, gamma-linolenic acid, vitamin B, trace minerals, and all of the essential amino acids. It has 3100% more beta carotene than carrots, 670% more protein than tofu, 5100% more iron than spinach, and 180% more calcium than milk. More antioxidant and anti-inflammatory activity is shown by three grammes of spirulina than by five more fruits and vegetables. Spirulina is 60 times more effective than spinach, 31 times more potent than blue berries, and 700 times more potent than apples in terms of phytonutrients. It has many oxidative and neutralising actions on heavy metals and free radicals. Making cookies that are enhanced with spirulina Among the goods that can be enhanced and combined with spirulina, cookies are an excellent choice because they can be easily moved and has an extended storage life. It actually seems promising to use cyanobacteria as an unconventional source of food and protein. Cookies that have been developed and combined with 0, 5, 10, and 15% S. platensis to enhance their nutritional value. When compared to cookies made exclusively with refined wheat flour, the rise in S. platensis percentage in the cookies corresponded to an increase in protein percentage. In terms of protein and mineral percentages, cookies with 15% S. platensis stood out. In terms of lipids, minerals, and maximal energetic value, these cookies were comparable to the entire batch. The results showed a stunning response: cookies with 5% S. platensis and regular cookies produced the same approval scores.

**Tab 1.** Nutrients & Minerals present in Spirulina

| **Mineral** | **mg 100g$^{-1}$** |
|---|---|
| Calcium | 700 |
| Chromium | 0.28 |
| Copper | 1.2 |
| Iron | 100 |
| Magnesium | 400 |
| Manganese | 5 |
| Phosphorous | 800 |
| Potassium | 1400 |
| Sodium | 900 |
| Zinc | 3 |
| **Vitamins** | **mg 100g$^{-1}$** |
| Pro vitamin A | 2.330.000 IU kg$^{-1}$ |
| Carotene | 140 |
| Vitamin E | 100 a-tocopherol |
| Thiamine $B_1$ | 3.5 |
| Riboflavin $B_2$ | 4 |
| Niacin $B_3$ | 14 |
| Vitamin $B_6$ | 0.8 |
| Vitamin $B_{12}$ | 0.32 |
| Folic Acid | 0.01 |
| Biotin | 0.01 |
| Phantothenic acid | 0.1 |
| Vitamin K | 2.2 |


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

**PRODUCTION OF COOKIES ENRICHED WITH SPIRULINA**

Among the items that can be enhanced and combined with spirulina, cookies are an excellent choice because they are easily transportable and have a long shelf life. It actually seems promising to use cyanobacteria as an unconventional source of food and protein. Cookies that have been developed and combined with 0, 5, 10, and 15% S. platensis to enhance their nutritional value. When compared to cookies made exclusively with refined wheat flour, the rise in S. platensis percentage in the cookies corresponded to an increase in protein percentage. In terms of protein and mineral percentages, cookies with 15% S. platensis stood out. In terms of lipids, minerals, and maximal energetic value, these cookies were comparable to the entire batch. mixed cookies

**USAGE OF SPIRULINA PLATENSIS ON SOFT CHEESE AND ICE CREAM**

Based on the product's sensory and physical attributes, the highest concentration of S. platensis that can be added has been determined. They showed that the highest concentrations of S. platensis were added to ice cream and soft cheese, respectively, at 1% and 1.2%. The addition of S. platensis significantly affected the following: total sugar, overrun, melting point, total solid, fat, protein, β carotene, water, fat, and sensory (ice cream).

**SPIRULINA BISCUIT FORMULATION WITH COCONUT CREAM**

The shelf life of the spirulina biscuit is assessed, and its chemical makeup is contrasted with that of the commercial biscuit. The sensory test revealed that while the commercial biscuit had more fat, the Spirulina biscuit with coconut cream had less fat and more protein. Additionally, it was determined that 2.4 months was the shelf life of spirulina biscuits kept at room temperature.

**PROBIOTIC PROPERTY OF SPIRULINA**

As a digestible food, spirulina supports healthy gut flora. After feeding rats 5% spirulina for 100 days, the lactobacillus and vitamin B1 lengths increased by 32.7 and 20.7 percent, respectively. Furthermore, lactic acid bacteria like Lactococcus lactis, Streptococcus thermophilus, Lactobacillus casei, Lactobacillus acidophilus, and Lactobacillus bulgaricus grew noticeably more when exposed to extracellular products made by Spirulina platensis.

**SPIRULINA FOR EYESIGHT**

Zeaxanthin, a xanthophyll found in human eyes, is abundant in spirulina and reduces the risk of cataract development and age-related macular degeneration. Dried Spirulina powder has 74000 µg of zeaxanthin, and when taken as a dietary supplement, it raises human serum zeaxanthin levels. Relevant function of Spirulina platensis extract: inhibits mice's ocular neovascularization caused by NaOH.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

## IMMUNOLOGICAL APPLICATIONS

NASA made a lot of noise about spirulina's nutritional benefits for astronauts on space missions, including its ability to suppress mast cell histamine release and its potential to alleviate a wide range of allergy symptoms. Chronic tiredness is not affected by spirulina. Zinc and spirulina extract have potential benefits for treating chronic arsenic poisoning that causes keratosis and melanosis. The first study on feeding humans demonstrated Spirulina's protective properties against allergic rhinitis. Spirulina aids in protecting the body from specific dietary deficiencies.

It plays a major part in the function of the medulla and inhibits the growth of cancer, infectious disorders, cellular ageing, and decreased immune system efficiency. Spirulina extract protects against free radical-induced apoptotic cell death. Chlorella was less effective as an inhibitor than Spirulina. The hepatic stellate cell (HSC) extract caused apoptosis after 12 hours of treatment, according to Annexin-V staining. Moreover, the Spirulina extract induced an arrest in the G2/M phase of the HSC cell cycle. Through the activation of macrophage activities, IL-1 production, phagocytosis, and especially the primary response, Spirulina platensis improves the immune response.

## CONCLUSION

The current analysis comes to the conclusion that spirulina is utilised in the food business and may be a useful supplement for human health. It is the best dietary source for malnutrition and a superfood. It strengthens the immune system, decreases cholesterol, inhibits the buildup of fat in the liver, stops the development of tumours, and safeguards the kidneys. It is well recognised that S. platensis is a great source of proteins, carbs, vital fatty acids, minerals, vitamins, calcium, potassium, and carotenes as well as chlorophyll a and phycocyanin. As a result, spirulina may be used as a daily nutrient supplement or as medication for illnesses.

## REFERENCE

Abd El-Baky, H. H., & El-Baroty, G. S. (2020). Spirulina maxima L-asparaginase: Immobilization, Antiviral and Antiproliferation Activities. Recent Patents on Biotechnology, 14(2), 154–163. https://doi.org/10.2174/1872208313666191114151344.

Abdel-Daim, M. M., Ahmed, A., Ijaz, H., Abushouk, A. I., Ahmed, H., Negida, A., … Bungau, S. G. (2019). Influence of Spirulina platensis and ascorbic acid on amikacin-induced nephrotoxicity in rabbits. Environmental Science and Pollution Research, 26(8), 8080–8086. https://doi.org/10.1007/s11356-019-04249-4.

Braga, V. da S., Mastrantonio, D. J. da S., Costa, J. A. V., & Morais, M. G. de. (2018). Cultivation strategy to stimulate high carbohydrate content in Spirulina biomass. Bioresource Technology, 269, 221–226. https://doi.org/10.1016/j.biortech.2018.08.105.

Chen, T., & Wong, Y.-S. (2008). In Vitro Antioxidant and Antiproliferative Activities of Selenium Containing Phycocyanin from Selenium-Enriched Spirulina platensis.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

Journal of Agricultural and Food Chemistry, 56(12), 4352–4358. https://doi.org/10.1021/jf073399k.

Chen, T., Yang, Tang, Zhong, Bai, Zhang, … Zheng. (2012). Surface decoration by Spirulina polysaccharide enhances the cellular uptake and anticancer efficacy of selenium nanoparticles. International Journal of Nanomedicine, 835. https://doi.org/10.2147/IJN.S28278.

Chia, S. R., Chew, K. W., Show, P. L., Xia, A., Ho, S.-H., & Lim, J. W. (2019). Spirulina platensis based biorefinery for the production of value-added products for food and pharmaceutical applications. Bioresource Technology, 289, 121727. https://doi.org/10.1016/j.biortech.2019.121727.

Nagaoka, S.; Shimizu, K.; Kaneko, H.; Shibayama, F.; Morikawa, K.; Kanamaru, Y.; Otsuka, A.; Hirahashi,T.; Kato, T. (2005). A novel protein Cphycocyanin plays a crucial role in the hypocholesterolaemia action of Spirulina platensis concentrate in rats: Journal of Nutrition, 135, 2425- 2430. 9.

H.-N. Yang, E.-H. Lee and H.-M. Kim, ―Spirulina platensis inhibits anaphylactic reaction,‖ Life Sciences, vol. 61, no. 13, pp. 1237–1244, 1997.

S. Ayehunie, A. Belay, T. W. Baba, and R. M. Ruprecht, ―Inhibition of HIV-1 replication by an aqueous extract of Spirulina platensis (Arthrospira platensis),‖ Journal of Acquired Immune Deficiency Syndromes and Human Retro virology, vol. 18, no. 1, pp. 7–12, 1998. 17.

N. Nakaya, Y. Homa, and Y. Goto, ―Cholesterol lowering effect of Spirulina, ‖ Atherosclerosis, vol. 37, pp. 1329–1337, 1988.

TRENDS IN AGRICULTURE SCIENCE

Vol.3 Special Issue 01 January 2024, Page: 83-89

# Path coefficient studies for Quantitative Traits in Greengram [*Vigna radiata (L.)*Wilczek] Genotypes

**Anandhi Lavanya.S, G.Vaidehi, V.Prakash and S.Malarvannan**
Associate Professor, School of Agriculture,
Bharath Institute of Higher Education and Research, Selaiyur, Chennai- 600 0073.
https://doi.org/10.5281/zenodo.10551134

***Abstract***

Mungbean is one of the leading pulse crops in india.it is one of the important food legumes of many tropical and subtropical parts of the world. Path studies give an idea about the contribution of different characters to seed yield. The path analysis in respect of various desirable characters in for 40 greengram germplasm for 10 quantitative traits *viz.,* days to 50 per cent flowering, number of branches per plant, plant height (cm), number of clusters per plant, number of pods per plant, number of pods per cluster, number of seed per pod, pod length (cm), single plant yield (g) and hundred seed weight (g) were evaluated at two different centers *viz.,* Agricultural College and Research Institute, TNAU, Madurai and Agricultural Research Station, TNAU, Vaigai Dam. It will help in isolating promising lines for hybridization programmes and to explore yield potential and quality of mung bean.

**Key words:** Path analysis, Germplasm, Mungbean, Quantitative characters

## Introduction

Pluses are extensively grown in tropical regions of the world as a major protein rich crop bringing considerable improvement in human diet. It is one of the important food legumes of many tropical and subtropical parts of the world. India is considered as its land of orgin (Lawn and Ahn, 2002) .It is grown almost all over the country and has the potential to make up the gap of protein shortage. But yield per acre in the country is still marginal. Mungbean is a short duration grain legume crops with wide adaptability and deep root system, low input requirements, and suitable for crop rotations, intercropping, relay cropping and as catch crop (Devendra payasi *et al*., 2010). Path studies give an idea about the contribiution of different characters to seed yield (VAndana and Dubey, 1993). Direct and indirect effects of economically useful traits with seed yield were also investigated. Genetic diversity analyses can be performed on both qualitative and quantitative data


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

or on a combination of both. Path analysis will establish the extent of association between yield and yield components and bring out relative importance of their direct and indirect effects and these give a clear understanding of their association with yield.

Path coefficient analysis permits the separation of the direct effects from the indirect effects through other related characters by partitioning the genotypic correlation coefficients, providing a clear picture of the characters that can be relied upon in a selection programme for improvement of grain yield. So far very limited work has been done for the improvement of barnyard millet crop. Therefore, an attempt has been made in the present study to estimate their direct and indirect contributions through path coefficient analysis.

**Material and Methods**

The present investigation was carried out in 40 mungbean genotypes. The trials were laid out in randomized block design with three replications at three different environments *viz.,* Agricultural College and Research Institute (ACRI) , TNAU, Madurai (E1), Agricultural Research Station, TNAU, Vaigai Dam (E2) and ACRI, TNAU, Madurai (E3). In this study, genotypic correlation for 10 quantitative traits *viz.,* days to 50 per cent flowering, number of branches per plant, plant height, number of clusters per plant, number of pods per plant, number of pods per cluster, number of seed per pod, pod length, single plant yield and hundred seed weight were analyzed. Path coefficient analysis was carried out as suggested by Dewey and Lu (1959).

**Results and discussion**

Path coefficient analysis would be useful, as it permits the separation of direct effect from indirect effects through other related traits by partitioning the genotypic correlation coefficient (Dewey and Lu, 1959). A character like seed yield is dependent on several mutually associated component characters and change in any one of the components is likely to affect the whole network of cause-and-effect relationship. This in turn might affect the true association of component characters, both in magnitude and direction and tend to vitiate association of yield and yield components. Hence it is necessary to partition the phenotypic correlations of component characters into direct and indirect effects (Biradar *et al*., 2007).

In the present study, direct and indirect effects of yield contributing components on seed yield were worked out.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

**Table 1. Direct and indirect effects of different yield attributing traits with grain yield in AC &RI, Madurai, *Kharif* 2012 (E1)**

| Trait | Days to fifty percent flowering | Number of branches per plant | Plant height | Number of clusters per plant | Number of pods per plant | Number of pods per cluster | Number of seeds per pod | Pod length | Hundred Seed weight |
|---|---|---|---|---|---|---|---|---|---|
| Days to fifty percent flowering | **0.366** | -0.482 | 0.398 | -0.239 | -0.014 | -0.015 | -0.123 | -0.033 | -0.051 |
| Number of branches per plant | 0.274 | **-0.646** | 0.493 | 0.209 | -0.045 | -0.003 | -0.262 | -0.040 | 0.080 |
| Plant height | 0.241 | -0.525 | **0.606** | 0.104 | -0.082 | -0.005 | -0.270 | -0.042 | 0.095 |
| Number of clusters per plant | -0.058 | -0.090 | 0.042 | **1.507** | -0.180 | -0.023 | -0.408 | 0.121 | 0.118 |
| Number of pods per plant | 0.013 | -0.071 | 0.124 | 0.670 | **-0.404** | -0.013 | 0.008 | -0.013 | 0.208 |
| Number of pods per cluster | 0.062 | -0.022 | 0.032 | 0.373 | -0.060 | **-0.091** | -0.193 | 0.041 | 0.011 |
| Number of seeds per pod | 0.066 | -0.247 | 0.240 | 0.898 | 0.005 | -0.026 | **-0.684** | 0.170 | 0.117 |
| Pod length | -0.065 | 0.140 | -0.138 | 0.996 | 0.029 | -0.020 | -0.632 | **0.184** | 0.081 |
| Hundred Seed weight | -0.044 | -0.124 | 0.138 | 0.426 | -0.200 | -0.002 | -0.192 | 0.036 | **0.419** |

**Residual effect: 0.471**


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

**Table 2. Direct and indirect effects of different yield attributing traits with grain yield in ARS, Vaigai Dam, *Kharif* 2012 (E2)**

| Trait | Days to fifty percent flowering | Number of branches per plant | Plant height | Number of clusters per plant | Number of pods per plant | Number of pods per cluster | Number of seeds per pod | Pod length | Hundred Seed weight |
|---|---|---|---|---|---|---|---|---|---|
| Days to fifty percent flowering | **0.039** | -0.020 | 0.056 | 0.013 | 0.330 | 0.001 | -0.050 | -0.086 | -0.084 |
| Number of branches per plant | 0.009 | **-0.085** | 0.102 | -0.013 | 0.172 | 0.003 | -0.095 | -0.093 | -0.003 |
| Plant height | 0.015 | -0.061 | **0.143** | -0.011 | 0.015 | -0.009 | -0.130 | -0.072 | 0.037 |
| Number of clusters per plant | 0.003 | 0.007 | -0.010 | **0.152** | 0.469 | 0.006 | -0.244 | 0.054 | -0.137 |
| Number of pods per plant | 0.012 | -0.014 | 0.002 | 0.066 | **1.072** | 0.055 | -0.179 | -0.036 | -0.214 |
| Number of pods per cluster | 0.001 | -0.002 | -0.013 | 0.010 | 0.648 | **0.091** | -0.164 | -0.066 | -0.059 |
| Number of seeds per pod | 0.003 | -0.014 | 0.031 | 0.062 | 0.320 | 0.025 | **-0.600** | 0.090 | -0.005 |
| Pod length | -0.013 | 0.030 | -0.039 | 0.031 | -0.146 | -0.023 | -0.204 | **0.264** | -0.013 |
| Hundred Seed weight | 0.010 | -0.001 | -0.017 | 0.066 | 0.725 | 0.017 | -0.009 | 0.011 | **-0.316** |

**Residual effect: 0.475**


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

**Table 3. Direct and indirect effects of different yield attributing traits with grain yield in AC & RI, Madurai, *Rabi* 2012 (E3)**

| Trait | Days to fifty percent flowering | Number of branches per plant | Plant height | Number of clusters per plant | Number of pods per plant | Number of pods per cluster | Number of seeds per pod | Pod length | Hundred Seed weight |
|---|---|---|---|---|---|---|---|---|---|
| Days to fifty percent flowering | **-0.288** | 1.328 | -0.702 | 0.113 | 0.124 | 0.008 | -0.574 | 0.007 | -0.068 |
| Number of branches per plant | -0.118 | **3.248** | -0.734 | -0.859 | 0.076 | 0.029 | -1.697 | 0.045 | 0.107 |
| Plant height | -0.180 | 2.123 | **-1.124** | 0.581 | 0.013 | 0.013 | -1.189 | -0.002 | 0.021 |
| Number of clusters per plant | -0.007 | -0.567 | -0.132 | **4.926** | -0.169 | 0.068 | -3.195 | -0.031 | -0.473 |
| Number of pods per plant | 0.063 | -0.437 | 0.025 | 1.464 | **-0.568** | 0.103 | -1.292 | -0.097 | 0.957 |
| Number of pods per cluster | -0.005 | 0.221 | -0.035 | 0.795 | -0.138 | **0.422** | -1.429 | -0.024 | 0.505 |
| Number of seeds per pod | -0.034 | 1.153 | -0.279 | 3.293 | -0.153 | 0.126 | **-4.781** | 0.004 | 0.803 |
| Pod length | -0.005 | 0.339 | 0.005 | -0.357 | 0.128 | -0.024 | -0.045 | **0.429** | -0.594 |
| Hundred Seed weight | 0.007 | 0.131 | -0.009 | -0.877 | -0.205 | 0.080 | -1.446 | -0.096 | **2.656** |

**Residual effect: 1.04**


**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

**Direct effect**

The dependent variable taken into consideration for path analysis was single plant yield. Among the ten traits analyzed, five traits showed positive direct effect and the remaining four characters showed negative direct effect on single plant yield.The highest positive direct effect was registered by number of clusters per plant (1.507) followed by plant height (0.606), hundred seed weight (0.419), days to 50% flowering (0.366) and pod length (0.184). Negative direct effect was recorded through number of seeds per pod (-0.684) followed by number of branches per plant (-0.646), number of pods per plant (-0.404) and number of pods per cluster (-0.091) in E1 **AC & RI, Madurai, *Kharif* .**

Among ten quantitative characters studied, six characters showed positive direct effects and the remaining four characters showed negative directs effects on single plant yield. The highest positive direct effect was registered by number of pods per plant (1.072) followed by pod length (0.264), number of clusters per plant (0.152), plant height (0.143), number of pods per cluster (0.091) and days to 50% flowering (0.039). Negative direct effect was recorded through number of seeds per pod (-0.600) followed by hundred seed weight (-0.316) and number of branches per plant (-0.085) in E2 **AC & RI, Madurai, *Kharif* .**

The dependent variable taken into consideration for path analysis was single plant yield. Among the ten traits analyzed, five traits showed positive direct effect and the remaining four characters showed negative direct effect on single plant yield. The highest positive direct effect was registered by number of clusters per plant (4.926) followed by number of seeds per pod (4.781) , number of branches per plant (3.248), hundred seed weight (2.656), number of pods per cluster (0.568) and pod length (0.429). Negative direct effect was recorded through followed by plant height (-1.124), number of pods per plant (-0.422) and days to 50% flowering (-0.288) in E3 **AC & RI, Madurai, *Rabi***

The highest positive direct effect registered by number of clusters per plant and plant height in AC & RI, Madurai, *Kharif* season (E1 location) and ARS, Vaigai Dam, *Kharif* season (E2 location). This was in accordance with the earlier findings Chauhan *et al*. (2007), Luman Hakim (2008), Kousar Makeen *et al*. (2009) and Suresh ***et al.,*** (2010) in greengram. The characters exerting direct effect on seed yield were number of pods per plant, 100 seed weight and days to maturity in Kalpande *et al.* (1998)

**Indirect effects:**

The other characters which had indirect positive effect on single plant yield was number of branches per plant, number of seeds per pod, number of pods per plant at AC & RI, Madurai, *kharif* season (E1 location), number of seeds per pod, hundred seed weight at ARS, Vaigai Dam, *Kharif* season (E2), number of seeds per pod, days to fifty percent flowering in AC & RI, Madurai,


Published: 23 Jan. 2024
ISSN: 2583-7850

*rabi* season (E3). Pod length had high positive direct effect in all the locations. Similar results were reported by Ved Prakash *et al.* (2007) .The characters exerting direct effect on seed yield were number of pods per plant, 100 seed weight and days to maturity in Kalpande *et al.* (1998). It was concluded that characters with positive effects should be significantly considered in selection criteria for yield improvement in mungbean breeding programs.

**Conclusion:**

The seed yield is an important parameter among all the morphological as well as yield traits. That selection for days to 50% flowering, hundred seed weight, number of clusters per plant, number of pods per plant and number of branches per plant should be given importance to increase the seed yield in greengram.

**Reference:**


Biradar KS, PM Salimath and RL Ravikumar (2007) Genetic studies in greengram and association analysis. *Karnataka J. Agric. Sci.,* **20(4)** : 843- 844.

Chauhan MP, AC Mishra and Ashok Kumar Singh (2007) Correlation and path analysis in urdbean. *Legume Res.,* **30(3)** : 205-208.

Devendra payasi, Pandey, SK Nair and RL Pandey (2010) Generation mean analysis for yield and yield components in mungbean (*Vigna radiata* L.Wilczek). *Indian J. Plan. Sci.,***5:** 485-493.

Dewey DR and KH Lu (1959) A correlation and path analysis of components of crested wheat grass seed production. *Agron. J.,* **51:** 515-518.

Lawn and Ahn (2002) Genetic variability as correlation studies in Green gram. *Bioved.* **12**: 102-104.

Luman Hakim (2008) Variability and correlation of agronomic characters of mungbean germplasm and their utilization for variety improvement program. *Indonesian J. Agricultural Science.* **9(1):** 24-28.

Kousar Makeen, G Babu Suresh, GR Lavany and Archana Kumar (2009) Genetic divergence and character association in micro mutants of urdbean (*Vigna mungo* L.) variety T9. *Academic J. Pl. Sci.* **2(3):** 205-208.

Kalpand, SV, JG Patil, RB Deshmukh, AD Dumber and NS Kute (1998) Correlation and path coefficient analysis in greengram under different environments. *Journal of Maharashtra Agricultural University.***22**:281-283.

Suresh S, S Jebaraj, S Juliet Hepziba and K. Theradimani. 2010. Genetic studies in mungbean (*Vigna radiata* (L.)Wilczek). *Electronic J. Pl.Breeding*, **1(6):** 1480- 1482.

Vandana and DK .Dubey (1993) path analysis in Faba bean . *FABIS* News Lett., **32:** 23- 24.

Ved Prakash, RVSingh and OPKhedar(2007) Genetic parameters, correlation and path analysis among yield and yield characters in mungbean. *J. Arid Legumes.* **4(1):** 6-8.

TRENDS IN AGRICULTURE SCIENCE
Vol.3 Special Issue 01 January 2024, Page: 90-98

# Repellent effects of *Rosmarinus officinalis, ocimum tenuiflorum, Cinnamomum verum* essential oil against *Callosobruchus maculates* in Black gram

**V. Sushmetha, Muthuvel, Gowshik bala, Priyavashini**
School of Agriculture,
Bharath institute of higher education and research
https://doi.org/10.5281/zenodo.10551149

***Abstract***

The main aim of the presented study is to assess the potential repellent effect of selected essential oils (EOs) against *Callosobruchus maculates*, which can cause economic losses in storage. Due to the development of pesticide resistance in *Callosobruchus maculates* populations, as well as an attempt to limit extensive use of potentially harmful pesticides in food-related industries, there is a strong need for the development of alternative methods of dealing with Callosobruchus maculates infestations. Because of their cost-effectiveness, availability, and low vertebrate toxicity, EOs are promising agents in pest management. In this test insect is reared under laboratory condition Grains were kept in jars at 28±2 ºC and 65±5% Relative humidity (RH) and covered with muslin cloth to supply adequate humidity to the grains. To establish the stock culture of C.maculatus black gram was used as a host. Grains of black gram were kept in the jars and the jars were covered with muslin cloth and placed at 28.5 ºC and 67.25 RH. Essential oil *Rosmarinus officinalis, ocimum tenuiflorum, Cinnamomum verum* were tested as potential repellents. Moreover, a preference assay, providing an extended analysis of the preference and the locomotor response, was used. The most effective EOs were: *ocimum tenuiflorum, Cinnamomum verum.* A few of the tested EOs caused significant alterations to the locomotor activity, although no direct relation was observed. In conclusion, EOs can be potentially used as repellent agents in Callosobruchus maculates management. Thus, Cinnamomum *verum* oil can be used as an effective option of commercial Repellent for the storage of black gram seeds against *Callosobruchus maculates*.

## Introduction

Pulses are the ancient food crops with evidence of their cultivation for over 8000 years. They are biologically rich source of protein and essential minerals and complement well with cereal-based diet because of high amount of lysine. Indian Council of Medical Research has recommended an average daily consumption of 40 grams of pulses. *Callosobruchus maculatus*, is


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

a key pest that infests both pods in the field and seeds in storage (Stoll, 1988). According to Singh et al. (1978), 100% of pulses seeds are infested after 3±5 months of storage. Tanzubil (1991) found that this insect can damage 100% of stored seeds causing weight losses of up to 60%. After six months of storage, losses in terms of perforated seeds can reach 90% (Seck et al., 1991). The pulse beetle *Callosobruchus maculatus* is reported to be the major pest infesting all types of pulses both in the field and in storage. The differential rate of damage infected by C. maculatus in different pulses was reported to be 68, 56, 49 and 52 per cent in cowpea, bengal gram, red gram and green gram respectively over a storage period of 6 months. The grain damage was as high as 69.93% under storage condition (Seck et al., 1991). This pest is a serious problem at small farmers' level, village traders and average households where storage conditions are poor and inadequate. To control the pulse beetle in storage, a number of synthetic organic insecticides such as malathion and dichlorvos have been recommended. The admixture synthetic insecticide with food grains has more recently been banned in many countries. There are also reports that the pulse beetle is developing resistance to malathion. In contrast, Essential oils used against pulse beetle appear to be quite safe and promising. Several authors have reported the insecticidal action and growth inhibiting effects of plant products on C. maculatus.

Essential oils can be used to keep the stored pulse free from pulse beetle attack. Stored products meet heavy loss in both quality and quantity due to pest attack. The Pulse beetle, Callosobruchus maculatus (F.) (Coleoptera: Bruchidae), a cosmopolitan pest of legumes, is a common throughout the tropics and subtropics of the world. Plants may provide potential alternative to currently used insect-control agents because they constitute a rich source of bioactive chemicals. Aromatic plants are among the most efficient insecticides of botanical origin and essential oils often constitute the bioactive fraction of plant extracts. Plant essential oils have many useful applications beyond those in the fragrance and flavouring industries, among which are their uses as pesticides and insect repellents. An emerging body of scientific literature reports the efficacy of various essential oils for use against pests of public health, stored product pests, and agricultural pests (Isman 2000, 2004; Isman & Machial, 2006). Now a days essential oil is commercial developed Rosemary *Rosmarinus officinalis*, Clove *Syzygium aromaticum*, Thyme *Thymus* w*vulgaris*, Peppermint *Mentha piperita*, Holy basil *(ocimum tenuiflorum*) and Cinnamon *Cinnamomum verum.* In recent years research is increasing to use plant secondary metabolites, particularly essential oils, as natural pesticides for crop protection and storage, because of their


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

low toxicity to human beings and minimal environmental impact, in contrast to some synthetic pesticides. Some plants have received global attention and their secondary metabolites have been formulated as botanical pesticides in plant protection The essential oil composition of O. basilicum varies depending on the environment and the chemotype. Essential oils of Cinnamomum plants are widely used as promising antibacterial agents and the essential oils of C. camphora and C. cassia reverse antibiotic resistance and biofilm formation. Essential oils are volatile secondary metabolites that plants produce for their own needs other than nutrition (i.e., protectant or attractant). In general, they are complex mixtures of organic compounds that give characteristic odour and flavour to the plants.

The evolutionary role of EOs in plants is mainly to be a protective agent against pests, including insects and fungi. *R. officinalis* EO is known to be an effective fumigant agent against various insect pests, such as confused flour beetle, *Tribolium confusum* (du Val.) (Coleoptera: Tenebrionidae) (Isikber, A.A et al., 2006), red flour beetle, *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae), almond moth, *Cadra cautella* (Walker) (Lepidoptera: Pyralidae) (Sim, M.J et al., 2009), and pulse beetle, *Callosobruchus chinensis* (L.) (Coleoptera: Chrysomelidae). Thus, *R. officinalis* is a promising bioinsecticide agent; especially valuable when considering the widely spreading resistance to conventional insecticides (Athanassiou, C.G et al., 2018). Although there are relatively numerous studies on the insecticidal effectiveness of the EO against cowpea weevil, *Callosobruchus maculatus* (F.) (Coleoptera: Chrysomelidae) most of them focus exclusively on mortality assessment omitting behavioral and biochemical parameters (Dayaram, L et al., 2016). The insecticidal effects of EOs are multimodal affecting a broad range of the physiological processes.

The potential uses of *O. basilicum*, *O. canum O. gratissimum* and *O. sanctum* essential oils, particularly as antioxidant and antimicrobial agents have also been explored (AI Hussain et al., 2008) (B Bozin, N et al.,2006). Recently, Mondal *et al*. reviewed the antimicrobial, adaptogenic, antidiabetic, hepato-protective, anti-inflammatory, anti-carcinogenic, radioprotective, immunomodulatory, neuro-protective, cardio-protective and mosquito repellent properties of *O. sanctum* (S Mondal et al., 2009).

Among the essential oils that have been shown to adequately control insect pests, the oils extracted from cinnamon, *Cinnamomum zeylanicu*m (L.), plants have drawn particular interest


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

because of their promising insecticidal activities against various pests of stored products such as the maize weevil *Sitophilus Zeamais* and the red flour beetle *Tribolium castaneum* (Regnault-Roger C. et al., 2012) (Oliveira NN. et al., 2017) In insects, these essential oils have neurotoxic action both as fumigants and or contact insecticides and their metabolites can act upon variety of molecular targets including inhibition of acetylcholinesterase or disturbing the functions of GABAergic and aminergic systems (Jankowska M. et al., 2017).

Hence, the present study was undertaken to investigate the repellent effect *Rosmarinus officinalis,ocimum tenuiflorum, Cinnamomum verum* of Essential oil against C. maculatus on black gram.

**Materials and methods:**

**Insect Rearing:**

Starting new cultures requires no more than containers to contain black gram and beetles. Virtually any closable containers will work successfully with lidded plastic Petri dishes, screen covered glass jars, snap lid vials, and cotton plugged shell vials are all suitable containers. We prefer to use disposable plastic containers in our teaching laboratories to minimize breakage and to keep cultures relatively small but replicated. Although beetles are the easiest of insects to successfully culture, sometimes a culture will fail if adults were very old when introduced to the new culture container or too few adults were introduced for adequate numbers of eggs to be laid. It is always a good practice to check a new culture a few days after it is started to see if numerous eggs have been laid. Plastic Petri dishes 150 x 25 mm are ideal containers can easily view cultures and remove selected adults. Although the lids fit loosely on the plates, Petri dishes will confine adults and permit adequate ventilation without any modification. Covering the bottom of a Petri dish with a single layer of black gram (approximately 50 ml volume) and introducing 10 adults males and 10 adult females is sufficient to 7 produce a dense culture. Cultures established in this manner will typically sustain two or three sequential generations without adding additional black gram and without inducing the production of dispersal morph adults. Cultures older than three generations on the same set of black grams should be discarded. We also have had good results using plastic snap-lid containers with pin-holes punched in the lid for ventilation. As with the Petri dishes, we use only 50 ml of black grams in each 300 ml snap-lid container. Raising beetles on black gram is best done in 150 mm petri dishes, which minimizes mould growth on the black gram. We prefer to use organically grown black gram to minimize pesticide problems in our cultures, but it is not essential for successful culturing of beetles. Black gram and adult beetles in a container


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

that keeps the beetles from escaping are all that you need. Keep the cultures at temperatures between 22° - 30°C (not in direct sunlight and away from radiators).

**Essential Oils:**

The essential oils used in the experiment were obtained from local vendors *Rosmarinus officinalis, ocimum tenuiflorum, Cinnamomum verum*. The oils were tested separately and as mixtures. The mixtures were formulated by mixing equal parts of the tested EOs. For each oil and mixture, a series of dilutions was prepared in ultrapure deionised water of the following concentrations: 8, 16, 24 and 32 µ. The obtained suspensions were stirred until emulsified and poured into the respective bubbler before phase separation occurred. The bubbler, controlling the airstream, was filled with an equal volume of ultrapure water.

**Repellency bioassay with choice chamber method**

Repellency of selected essential oil on test insect C. maculatus was tested by using area preference test described by Mc Donald et al. (1970). The entire tests of repellency were carried out in a 'choice chamber'. It consists of Whatman No.1 filter paper placed in the petri dish, cut in to 2 halves. Different test solutions of 8, 16, 24, and 32µl from 1% of essential oil preparation were applied on the half portion of filter paper disc as uniformly as possible with micropipette. Other half is treated with acetone as control. Each half is dried to evaporate the solvents and placed in the petri dish of experimental set up. Lower part of filter paper disc was pasted in the petri dish in order to prevent the escape of insects to underneath the filter paper. Then 10 adults of mixed sex of C. maculatus were released at the center of the filter paper disc and made a closed set up by using another petri dish, where the insects are allowed to move on to any direction of test half or control half. Then number of insects present in test half and control half were counted and recorded periodically after 1,2,4,8 and 16 hours to find out the percentage of repellency. Each dose of treatment was replicated for 4 times. The mean value of 4 replications of each dose at above-described intervals were taken and percentage of repellency (PR) was calculated using the following formula adopted by Obeng-Ofori (1995)

**Percentage Repellency:**

**(PR) = [(NC – NT) / (NC+NT)] x 100**

(Where, NC is number of insects present in control half and NT is number of insects present in test half)


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

**Repellency classes** assigned according to scale described by Mc Govern et al. (1977),

Class I - range of % repellency 0.1-20

Class II - range of % repellency 20.1- 40

Class III = range of % repellency 40.1 - 60

Class IV - range of % repellency 60.1- 80

Class V- range of repellency 80.1-100

**Result and Discussion:**

Repellent effects of different doses 8, 16,24 and 32µl of Rosemary, Holy basil and Cinnamon essential oil against C. maculatus in varying duration of exposure. Essential oils exhibiting insecticidal activities are extensively used as botanical pesticides as an alternative to chemical pesticides. As an attempt to assess the pesticidal properties of Rosemary, Holy basil and Cinnamon essential oils, present study tried to elucidate the repellent activity of on *Callosobruchus maculatus*. In repellency bioassay essential oil of Rosemary showed its potency the control of *C. maculatus* Essential oil imparts higher rate of repellency from 36% -86% with 8 - 32µl of concentration. The highest repellency rate of 86% was observed for the concentration of 32µl at 4 hours of duration. Essential oil of Holy basil showed it impart higher rate of repellency from 43%-98% with 8-32 µl of concentration and highest repellency rate of cinnamion oil against C. maculatus is from 55% to 100% with same 8-32µl of concentration. The highest repellency rate 100% was observed for the concentration of 32µl.

In the Repellency bioassay, the higher rate of repellency was found to increase with an increase in concentration of essential oils indicating that the response was concentration dependent and the time of exposure of the insect. Compare with rosemary, Holy basil and cinnamon essential oil though higher concentration of each essential oil show's significant repellent effect the highest 100% repellency was observed in 32µl of cinnamon essential oil and 98% repellency observed in 32µl holy basil essential oil and comparative less in rosemary essential oil 86% was observed


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

**Table: 1 Repellent activity of *Rosmarinus officinalis* Essential oil**

| Percentage Repellence of varying duration of exposure (hrs)/Dose | 1 | 2 | 4 | 8 | 16 | Overall average percentage Repellence | Repellence class |
|---|---|---|---|---|---|---|---|
| 16 µl | 28±6.12 | 33±10.33 | 38±10.22 | 55±10.23 | 47±6.33 | 40.2 | Class III |
| 24 µl | 44±5.2 | 58±6.41 | 62±10.42 | 74±6.32 | 59±4.22 | 59.4 | Class III |
| 36 µl | 48±10.3 | 60±8.32 | 86±10.33 | 76±6.21 | 58±8.33 | 65.6 | Class IV |

**Table: 2 Repellent activity of *ocimum tenuiflorum* Essential oil**

| Percentage Repellence of varying duration of exposure (hrs)/Dose | 1 | 2 | 4 | 8 | 16 | Overall average percentage Repellence | Repellence class |
|---|---|---|---|---|---|---|---|
| 16 µl | 52±6.32 | 67±9.66 | 75±4.32 | 65±10.32 | 46±10.32 | 61 | Class IV |
| 24 µl | 74±4.32 | 84±9.66 | 89±10.32 | 84±6.32 | 65±6.32 | 79.2 | Class IV |
| 36 µl | 84±5.33 | 89±9.32 | 98±1.41 | 79±9.66 | 72±10.32 | 84.4 | Class V |

**Table: 3 Repellent activity of *Cinnamomum verum* Essential oil**

| Percentage Repellence of varying duration of exposure (hrs)/Dose | 1 | 2 | 4 | 8 | 16 | Overall average percentage Repellence | Repellence class |
|---|---|---|---|---|---|---|---|
| 16 µl | 61±6.33 | 78±10.32 | 75±4.32 | 87±6.45 | 55±8.61 | 71.2 | Class IV |
| 24 µl | 80±8.53 | 89±6.36 | 62±10.23 | 84±6.32 | 100±0.00 | 83 | Class V |
| 36 µl | 89±10.11 | 95±4.22 | 65±10.81 | 79±9.66 | 100±0.00 | 85.6 | Class V |

The present findings were in accordance with the findings of N Subekti, et al., (2019) described that those essential oils produced a significant range of biological effect on *Tribolium castaneum* and C. maculatus. However, cinnamon oil was the most effective making it suitable botanical extract to develop repellency *Tribolium castaneum* and C. maculatus with less environmental hazards.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

Sushmita, *et al*., (2019) stated that volatile oils of *Cinnamomum zeylanicum, Pogostemon cablin* and *Zingiber officinale* caused fumigant and contact toxicity against bruchid adults. In the toxicity assay, the mortality rate was found to increase with an increase in concentration of plant volatile oils indicating that the response was concentration dependent.

Mohammad Mahmoudvand, *et al*., (2011) explained that percentage of insect mortality was increased with the concentration and the time of exposure. In the other hand, toxicity depends on concentration, type of essential oil and exposure time. Dadang, et al., (2016) described that those essential oils produced a significant range of biological effect on *Tribolium castaneum* and C. maculatus. However, cinnamon oil was the most effective making it suitable botanical extract to develop repellency *Tribolium castaneum* and C. maculatus with less environmental hazards. Mehrdad Ahmadi and Saeid Moharramipour, et al., (2016) stated that there was a significant difference in the mortality of the adults at different levels of concentration of essential oils. Mortality was increased with the increasing concentration. The results indicated that the doses higher than 300 caused complete mortality (100%)

**Conclusion:**

The present experimental results suggested that *ocimum tenuiflorum, Cinnamomum verum* oil are effective in all the immature stages and have the efficiency to reduce the pulse beetle. It is therefore required to study about Cinnamon and Zinger oil as it reduce environmental problems, chemical pesticides and maintain a balance in agro ecosystem.

**Reference:**


Athanassiou, C.G.; Arthur, F.H. *Recent Advances in Stored Product Protection*; Springer: Berlin/Heidelberg, Germany, 2018; ISBN 9783662561256.

Dayaram, L.; Khan, A. Repellent, Fumigant and Contact Toxicity of Salvia Officinalis, Rosmarinus Officinalis and Coriandrum Sativum Against Callosobruchus Maculatus ( Fab.) ( Coleoptera: Bruchidae). *Int. J. Trop. Agric.* **2016**, *34*, 893–902.

Isikber, A.A.; Alma, M.H.; Kanat, M.; Karci, A. Fumigant toxicity of essential oils from Laurus nobilis and Rosmarinus officinalis against all life stages of Tribolium confusum. *Phytoparasitica* **2006**, *34*, 167–177.

Mehrdad Ahmadi1, Saeid Moharramipour 2, 2016, 5 (4): 519-527; Interaction between essential oil of Rosmarinus officinalis and gamma radiation against Callosobruchus maculatus

N Subekti, H Nur2, A Fanidya1, S Susanti1, R Saputri1 ,P Indrawati1, 1402 (2019; Chlorpyrifos organophosphate and essential oils activities against Callosobruchus maculatus (F.) warehouse pests.

Sim, M.-J.; Choi, D.-R.; Ahn, Y.-J. Vapor Phase Toxicity of Plant Essential Oils to *Cadra cautella* (Lepidoptera: Pyralidae). *J. Econ. Entomol.* **2009**, *99*, 593–598



Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

Singh, S.R., Luse, R.A., Leuschner, K., Nangju, D., 1978. Groundnut oil treatment for the control of Callosobruchus maculatus (F.) during cowpea storage. Journal of Stored Products Research 14, 77±80.

Stoll, G. 1988. Protection naturelle des veÂgeÂtaux en zones tropicales. CTA; AGRECOL, 177 pp

Sushmita TH, MK Gupta, KI Singh,Karthik S, 2019; 7(1): 597-599; Contact toxicity of some plant volatile oils against pulse beetle, Callosobruchus maculatus (Coleoptera: Bruchidae).


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

TRENDS IN AGRICULTURE SCIENCE
Vol.3 Special Issue 01 January 2024, Page: 99-101

# A Study on Consumer Behaviour of Egg in India

**A. Mouna**

Associate Professor, School of Agriculture,
Bharath Institute of Higher Education and Research, Selaiyur, Chennai -73
https://doi.org/10.5281/zenodo.10551165

***Abstract***

The present study focuses on buyer behaviour in Egg market and offers suggestions for the increase of egg consumption, which plays a pivotal role for the survival of the poultry Industry. The aim of marketing is to identify and satisfy target customers' needs and wants. Marketers must study their target customers wants, perceptions, preferences, and shopping and buying behaviour. Such a study will provide clues for developing new products, product features, prices, channels, messages and other marketing mix elements. It is very important for marketing and future marketers to recognize why and how individuals make their consumption decisions so that they can make better marketing decisions. No doubt, marketers who understand buyer behaviour have a great competitive advantage in the market place

***Key words*: Consumer Behaviour, Egg, Marketing**

## Introduction

The most egg consumption and manufacturing occur in Asia's densely inhabited regions, where this protein acts as a fantastic food. In this region, there is a wide range of production, processing, and pricing for eggs and egg products. This region is made up of 16 countries, each with its own culture, religion, welfare system, eating customs, and so on. Another difference between these countries is their level of industrial activity. There are clear variances in egg prices across the region as a result of feed, production methods, and efficiency in production.

Consumers gives dually importance on a balanced diet, brand consciousness, higher education levels,healthfulness,superior quality ,convenience and valued animal welfare are certain


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

factors through which consumers are decided whether they buy the egg products or not. There are lots of factors which affects the choices of consumer like

Environmental factors
Cultural factors
Consumer taste and preferences
Income level of consumer
Buying behaviour
Price of the product

**Material and methods**

With the conceptual background, an attempt was made to study the consumer behaviour in egg market in the area under study covering various socio-economic factors – income of the consumer, family size, food habits, occupational pattern, etc., which influence the purchasing pattern of the consumers. The views of consumer over prices and sources of price information are examined

**Result and Discussion**

Industry and retailers, who wish to succeed in food category. They would do well if they understand these factors and strengthen the food products, which they are offering to their customers. According to survey conducted, for large section of respondents, taste and nutrition are the most important factors while shopping for food. 40% of the respondents consider cost of food important. While purchase food, people are not keen about convenience of purchasing food. It is seen that 100% of respondents buy nutritionally enriched food to stay healthy whereas other important reasons are for children and to avoid medical treatment. Factors such as maintaining attractiveness, interest, curiosity, retarding age are not encouraging them to buy nutritionally enriched food. In the survey, a correlation was found between the lifestyle changes to increase nutritionally enriched food in the diet with the gender, age & qualification of the respondents.

There is a growing concern that many Indians are going through an unbalanced diet due to lifestyle changes which has led to health problems with increasing age. Respondents are ready to change their lifestyle by increasing consumption of nutritionally enriched food, irrespective of their age. However, the acceptance of lifestyle change is found to be more in the age group of 40-60 than 21-40. A diet built on nutrient-dense foods can provide a solid foundation for better health. The shift to positive nutrition guidance and education based on a consistently determined standardized nutrient density index or score can help people implement the lifestyle changes. From the study it is also seen that education of respondents affect the decision regarding lifestyle change


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

to increase consumption of nutritionally enriched food. Such acceptance of is found to be more in respondents with post graduate degree.

**Conclusion**

Egg is the most cost-effective source of protein; the rural or low-income population consumes the most poultry meat. The focus might be on building quality brands and creating a revolution by selling highest quality chicken meat, meat products and eggs to the country's most remote areas at a competitive price. It is not only the business, but also the style of doing business that will determine the future success of an enterprise.

**Reference**

Ayim-Akonor, M., & Akonor, P. T. (2014). Egg consumption: Patterns, preferences and perceptions among consumers in Accra metropolitan area. International Food Research Journal, 21(4), 1457– 1463. Baba, Y., Kallas, Z., & Realini, C. (2017). Application of the analytical hierarchy process to evaluate consumer acceptance and preferences for omega-3 enriched eggs. British Food Journal, 119(7), 1459–1472.

Borrelli, L., Coretti, L., Dipineto, L., Bovera, F., Menna, F., Chiariotti, L., Fioretti, A. (2017). Insect- 21 based diet, a promising nutritional source, modulates gut microbiota composition and SCFAs production in laying hens. Scientific Reports, 7(1), 1–11.

Chang, J. B., Lusk, J. L., & Norwood, F. B. (2010). The price of happy hens: A hedonic analysis of retail egg prices. Journal of Agricultural and Resource Economics, 35(3), 406–423. De Pelsmaeker, S., Dewettinck, K., & Gellynck, X. (2013). The possibility of using tasting as a presentation method for sensory stimuli in conjoint analysis. Trends in Food Science & Technology, 29(2), 108–115.

Koch, G., & Elbers, A. R. W. (2006). Outdoor ranging of poultry: A major risk factor for the introduction and development of High-Pathogenecity Avian Influenza. NJAS - Wageningen Journal of Life Sciences, 54(2), 179–194.

Montossi, F., Cazzuli, F., Brito, G., Realini, C., Luzardo, S., Rovira, P., & Font-I-Furnols, M. (2018). The challenges of aligning consumer preferences and production systems: Analysing the case of a small beef meat exporting country. International Journal of Agricultural Policy and Research, 6(9), 144–159. Napolitano, F., Girolami, A., & Braghieri, A. (2010). Consumer liking and willingness to pay for high welfare animal-based products. Trends in Food Science & Technology, 21(11), 537–543.


Published: 23 Jan. 2024
ISSN: 2583-7850

TRENDS IN AGRICULTURE SCIENCE
Vol.3 Special Issue 01 January 2024, Page: 102-105

# A Review on Environmental Impact of Pesticide Usage and Its Agronomic Management Strategies

***J. Sivanantha*, C. Sai Durga and S. G. Suriya***
Post Graduate Students, Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar – 608002, Tamil Nadu, India
https://doi.org/10.5281/zenodo.10551188

***Abstract***

The Sustainability and long-term welfare of farmers and lands depends on good quality water, soil, air and other natural resources available. Pesticides are crucial in agricultural production. This study provides an overview of negative effect of the pesticides on the environment, particularly when the pesticide escaped outside of the intended application area. The study clearly highlights the serious consequences of pesticide use on various environmental components and also ways to protect the environment by agronomic remedial practices. I intend to acknowledge that, there are some fine-tunings and adjustments are to be made to wean farmers from pesticide reliance. Also, Biopesticides should also be developed alongside synthetic pesticides to minimize farmers reliance on synthetic pesticides and the pollution caused in the environment. Subsequently, the environmental protection is a global concern, it is high time we need to understand the gravity of the situation and create awareness among the manufacturers, policy makers, government agencies, common men and farmers especially for safety pesticide handling and application.

***Keywords***: Agronomic practices, biopesticides, environmental impacts, pesticides

## Introduction

Pesticides are crucial and one of the most important chemicals used in agricultural production. They have been used by farmers to control insects and weeds, and there have been reports of a remarkable increase in their use in agricultural products. The expansion in the total populace in the twentieth century could never have been conceivable without an equal expansion in food production. Tudi *et al.,* (2021) stated that around 33 percent of agricultural commodities are created relying upon the use of pesticides. There would be a 78 percent decline in fruit production, 54 percent decline in vegetable production, and a 32 percent decline in cereal production if pesticides were not used. However, the use of pesticides can also have negative effects on the environment, particularly if the pesticide is spread outside of the intended application area. Sharma *et al.*, (2019) reported that many procedures are influence what befalls pesticides in the ecosystem. These procedures incorporate adsorption, breakdown, degradation and transfer, that


**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

incorporates processes that move the pesticide away from the intended site of the subjected area and spray drift, leaching, volatilization, runoff, crop removal and absorption are all reasons for main causes of pollution or non-target damage.

**History and its classifications**

The historical backdrop of pesticide use can be isolated into three timeframes (Tudi *et al.,* 2021). During the first-time frame before the 1870s, pests were constrained by utilizing different natural compounds. The first recorded utilization of insect sprays was around quite a while back by Sumerians. They utilized sulfur mixtures to control mites and insects. Pyrethrum is acquired from the dried blossoms of the *Chrysanthemum Cinerariafolium*, "pyrethrum daisies", and has been utilized as an insecticide spray for more than 2000 years. During the subsequent period, somewhere in the range of 1870 and 1945, peoples started to utilize inorganic manufactured materials. The third time frame began after 1945, addressed by the utilization of engineered synthetic pesticides with the revelation of the impacts of aldrin, Dichlorodiphenyltrichloroethane (DDT), endrin, β-Hexachlorocyclohexane (BHC), 2,4-D, dieldrin, parathion, chlordane, and captan. In present day agriculture, researchers are attempting to foster genetically engineered crops intended to deliver their own insect sprays or display protection from expansive range herbicide items or irritations. Gill and Garg, (2014) reported that pesticides are arranged by various order terms like functional groups, chemical classes, toxicity and modes of action. First and foremost, pesticides are arranged by various focuses of pests, including rodenticides, insecticides, fungicides and herbicides.

**Pesticide use impact on environmental**

Pesticides are utilized to kill harmful insects and control weeds as a component of their chemical compounds, in this manner, they can be poisonous to different organisms in the environment, including beneficial insects, fish, birds, and nontarget plants, as well as various ecological media, including crops, water, air, soil (Gill and Garg, 2014). Such chemical residue deposits influence human wellbeing through the climate and food defilement or contamination. In addition, pesticide defilement gets away from the target objective plants, bringing about ecological pollution. At the point when pesticides are applied to a target objective plant or discarded, they can possibly enter the ecological system. On entering the ecological system, pesticides can go through cycles like degradation and transfer (or movement). Pesticide degradation in the environment delivers new synthetics. Pesticides move from the objective site to other natural media or non-


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

target plants by move processes including leaching, spray drift, adsorption, runoff, and volatilization. The various kinds of synthetic compounds demonstrate their disparities in natural way of behaving (Tudi *et al.,* 2021).

**Agronomic Management Practices**

Combining pesticide use with agronomic management techniques, the application of typical agronomic techniques (solarization and bio solarization) to speed up the breakdown of these pesticide degradation of bifenthrin, tolclofos-methyl, and endosulfan in contaminated soil (Fenoll *et al.,* 2011). Models should better account for mulching, such as plastic, crop residues and related crops, as well as other cutting-edge techniques. The Root Zone Water Quality Model (RZWQM) models pretends pesticide interruption by mulch during application of pesticide (Mottes *et al.,* 2014).

**Biopesticides**

As a safer method to control pest populations such weeds, plant diseases, and insects while causing less damage to humans and the environment, biopesticides are generating interest on a worldwide basis. Biopesticides are efficient, biodegradable, and leave no environmental residues behind. As a promising alternative to chemical pesticides, the use of biopesticides as a supplement is becoming more and more popular throughout the world (Tijjani *et al.,* 2016). Kumar and Singh, (2015) reported that only 2% of plant protectants used globally now are biopesticides, but their growth rate has been on the rise over the past 20 years. Over 3,000 tons of biopesticides are thought to be produced year globally, and this number is rising quickly. Some of the major factors driving the biopesticide market include rising consumer demand for agricultural produce free of residues, a booming organic food industry, and easier registration than chemical pesticides. The usage of biopesticides is rising rapidly worldwide, at 10 percent a year.

**Future research needs**

As conclusion to control pesticide use, new systems and methods are required in surveying the impact of far and wide utilization of pesticides on environment and steps ought to be made to give awareness among public to limit the use of harmful risk pesticides. Yet the above discussion clearly highlights the serious consequences of pesticide use on various environmental components. Further studies focus on both industrial and environmental revelations and their related health risk evaluation of pesticides to more readily comprehend pesticide use and the executives later on. Regarding agronomic pesticide practices, there are fine-tuning and adjustments are needed to be


Published: 23 Jan. 2024
ISSN: 2583-7850

made to wean farmers from pesticide reliance. Also, Biopesticides should also be developed alongside synthetic pesticides to minimize pesticide pollution in the environment. Subsequently, the environmental protection is a global concern, we need to create an awareness and to convey the logical scientific results of the exposure and occupational and ecological wellbeing risk evaluations among the manufacturers, policy makers, government agencies, farmers, and the common men to for safety pesticide application, the avoidance of adverse human wellbeing impacts by improper pesticide utilization, and also switch-over to biopesticides for the pest management requirements.

**Reference**

Fenoll, J., Ruiz, E., Flores, P., Hellín, P. and Navarro, S., 2011. Reduction of the movement and persistence of pesticides in soil through common agronomic practices. *Chemosphere*, **85(8)**, pp.1375-1382.

Gill, H.K. and Garg, H., 2014. Pesticide: environmental impacts and management strategies. *Pesticides-toxic aspects*, **8(187)**, pp.10-5772.

Kumar, S. and Singh, A., 2015. Biopesticides: present status and the future prospects. *J. Fertil. Pestic*, **6(2)**, pp.1-2.

Mottes, C., Lesueur-Jannoyer, M., Le Bail, M. and Malézieux, E., 2014. Pesticide transfer models in crop and watershed systems: a review. *Agronomy for sustainable development*, **34**, pp.229-250.

Sharma, A., Kumar, V., Shahzad, B., Tanveer, M., Sidhu, G.P.S., Handa, N., Kohli, S.K., Yadav, P., Bali, A.S., Parihar, R.D. and Dar, O.I., 2019. Worldwide pesticide usage and its impacts on ecosystem. *SN Applied Sciences*, **1**, pp.1-16.

Tijjani, A., Bashir, K.A., Mohammed, I., Muhammad, A., Gambo, A. and Musa, H., 2016. Biopesticides for pests' control: A review. *Journal of Biopesticides and Agriculture*, **3(1)**, pp.6-13.

Tudi, M., Daniel Ruan, H., Wang, L., Lyu, J., Sadler, R., Connell, D., Chu, C. and Phung, D.T., 2021. Agriculture development, pesticide application and its impact on the environment. *International journal of environmental research and public health*, **18(3)**, p.1112.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

TRENDS IN AGRICULTURE SCIENCE
Vol.3 Special Issue 01 January 2024, Page: 106-108

# Application of Drone Technology in Horticulture

**Dr. G.Vaidehi**
Associate Professor, School of Agriculture,
Bharath Institute of Higher Education and Research
https://doi.org/10.5281/zenodo.10551193

***Abstract***

The population is increasing tremendously and with this increase the demand of food. The traditional methods which were used by the farmers were not sufficient enough to fulfil these requirements. Thus, new automated methods (Drone technology) were introduced. These new methods satisfied the food requirements and also provided employment opportunities to billions of people. Drones' technologies save the excess use of water, pesticides, and herbicides, maintains the fertility of the soil, also helps in the efficient use of man power and elevate the productivity and improve the quality. The objective of this paper is to review the usage of Drones in Horticulture applications. Based on the literature, we found that a lot of agriculture applications can be done by using Drone. In the methodology, we used a comprehensive review from other researches in this world. This paper summarizes the current state of drone technology for agricultural uses, including crop health monitoring

## Introduction

An industry of value, Agriculture sets the livelihood of 65% of the population of India, directly or indirectly. The vitality of the Agricultural Industry is so deep-rooted in our systems that its growth heavily affects the Gross Domestic Product (GDP) of our country by about 17%. Heightening this growth factor has become ever-so-crucial to generate more revenue, income, and employment. The dynamic and speedy nature of technology brings convenience and advancement to its applied industries. Drone technology and the

Soil Health Monitoring The robust capabilities of drones help in the primitive operation of analysing soil health. In essence, UAVs collect and process data received from monitoring that can help check, control, and maintain the soil's health and nature.

Drone technology can also provide the essential nutrients to the soil to improve their health and well-being. Through its operations of 3D mapping and data processing, drones achieve this operation of analysing soil health. Seeding Process By its virtue, agriculture is a highly cumbersome and exhaustive industry because it requires skilful abilities to perform its operations. Seeding, especially, requires manual labour as it is a time-consuming procedure.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

To ease this tiring process, drone technology is employed to sow the seeds of the copious varieties of crops. As instilled in drones, the lasers, sensors, tanks, etc., allow them to quickly yet smoothly plant seeds.

**Analyzing**

**Deficiencies**

Another incredible merit of adopting drones for crop fertilization comes with their feature to analyze, identify, and survey the crops for any deficiencies. Their high-resolution cameras and sensors, additionally instilled with lasers, help to perform these operations quickly. Unmanned Aerial Vehicles can also map these deficiencies in real-time, and the data collected and processed can be used to make further determinations regarding the crops.

Drones for Crop Fertilization In its entirety, drones and their applications have helped ease the cumbersome process attributed to crop fertilization. Their enterprising and potent nature helps farmers a great deal with bountiful tasks and operations.

**Plantation**

Drones can help in planting trees and crops, which was done by farmers before. This technology will not only save labor but also help in saving fuels. Soon, it is expected that budget friendly drones will be used instead of huge tractors, as they emit harmful gases and pollute the environment in the process.

**Benefits of Horti-drones**

Security: The drones are operated by trained drone pilots. So, there are no chances of their misuse. High efficiency: Drones do not have any operational delays and can work double the speed of human labor

Drones, for starters, are great for monitoring and sensing techniques because they can quickly cover territory to check crop development and soil health. Drones are mostly used for this purpose since their sensors can detect the absorbance of a specific wavelength, resulting in a color contrast image that visibly reflects possibly problematic locations. Ranchers have also employed drones to track livestock on ranches and check for any damaged fences, demonstrating that this monitoring capability not only provides for rapid processing of spatiotemporal information. Rangers have also employed night cameras and thermal imagers to locate any animals disturbing or attacking herds to better monitor cattle.


**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

The second major use of drones in agriculture is to keep crops healthy by dispersing water, fertilizer, and pesticides. Drones coupled with spectroscopic and thermography technology can detect dry areas and address problems that traditional watering equipment may have missed. Drones, on the other hand, can detect equipment leaks and irrigation problems. Drones can stitch thermographic photos together over time to detect the direction of water flow and locate geographical features that may affect water dispersion. Drones' accuracy and speed allow fertilizer to be delivered to precise locations if crops aren't growing well enough, as well as the elimination of pests and pathogens by spraying pesticides from the drones themselves.

A third significant benefit of drones is that they can operate as mechanical pollinators. Although insect vectors are still the most important pollinators, drones may one day replace bees as the most essential pollinators. Although further research is needed in this area, researchers are optimistic that drones will be able to another important aspect of drone application is the use of drones for agricultural research. Drones can cover broad areas damaged by natural catastrophes to find the reasons and implications of incidents, from infections to insurance claims.

Drones are already being used to confirm claims in agricultural insurance surveys, and the quick response paired with high-resolution imaging allows for the collection of data on huge scales, which is difficult, if not impossible, to do on the same timescale with manual labor. Drones are a good contender for enhancing agricultural techniques at a low cost because of these advantages. Aside from the financial benefits, optimizing fertilizer, pesticide, and water usage in important areas has various ecological and environmental benefits that would not be feasible otherwise.

**References**

Zhang C, Kovacs JM. The Application of Small Unmanned Aerial Systems for Precision Agriculture: A Review (2012). Precision Agriculture, Springer.; 13(6):693-712.

Aditya S Natu, Kulkarni SC. Adoption and Utilization of Drones for Advanced Precision Farming: A Review (2016). International Journal on Recent and Innovation Trends In Computing And Communication,4(5):563-565.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

TRENDS IN AGRICULTURE SCIENCE

Vol.3 Special Issue 01 January 2024, Page: 109-114

# The Effect of Organic and Inorganic Fertilizers on Soil Fertility and Crop Production - A Review

**M. G. Arun Kumar*, J. Sivanantha and J. B. Shubhiksha**
Post Graduate Students, Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar – 608002, Tamil Nadu, India.
https://doi.org/10.5281/zenodo.10551404

***Abstract***

Now a days, with the present rate of population growth and the scarcity of food, it is imperative to boost soil fertility and agricultural output. For crop plants to sustain their normal physiological processes, they need nitrogen, phosphorus, and potassium. Fertilizers include all the components needed to grow plants while enhancing the soil's chemical, physical, and biological qualities. The organic fertilizers were highly effective, cost-effective, and easy to carry around in large quantities. Similarly, inorganic fertilizers were known for their high cost and negative environmental impact if improperly managed. The impacts of both organic and inorganic fertilizers on crop productivity and soil fertility were reviewed in the current study. Combining organic and inorganic fertilizers builds soil health, increases the effectiveness of recommended inorganic fertilizer use, and minimizes the cost of the latter type of fertilizer. Continuous research and field trials are necessary to refine our understanding and practices, ensuring the development of effective, environmentally friendly, and economically viable fertilization strategies for sustainable agriculture.

***Keywords***: Organic, inorganic, soil fertility, crop production and balanced application

**Introduction:**

Now a days, with the present rate of population growth and the scarcity of food, it is imperative to boost soil fertility and agricultural output. One of the primary issues in crop production is less soil fertility (Javed *et al*., 2022). Using both organic and inorganic fertilizers can increase soil fertility; however, using inorganic fertilizers in excessive amounts might decrease soil fertility.

The organic fertilizers were highly effective, cost-effective, and easy to carry around in large quantities. Similarly, inorganic fertilizers were known for their high cost and negative environmental impact if improperly managed. According to Assefa and Tadesse (2019), the use of inorganic fertilizers is advantageous in a shorter amount of time but has more adverse effects, such as soil compaction, erosion, and decreased soil fertility. Enhancing soil fertility and agricultural yield can be achieved by several methods, such as applying fertilizers and beneficial bacteria. The microbial population in soil functions as a bioindicator of crop productivity, soil biome, sustainability, and sensitive pointer of soil quality.


**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

Combining organic and inorganic fertilizers builds soil health, increases the effectiveness of recommended inorganic fertilizer use, and minimizes the cost of the latter type of fertilizer (Roba, 2018; Verma *et al*., 2020). It also has a greater positive impact on microbial biomass. According to Kugbe *et al*., (2019), the idea of soil fertility is based on physical, chemical, and biological characteristics and will increase crop productivity. The impacts of both organic and inorganic fertilizers on crop productivity and soil fertility were reviewed in the current study.

**Importance of Fertilizers:**

Fertilizers are substances that include one or more nutrient components in the form of both organic and inorganic chemical molecules. For crop plants to sustain their normal physiological processes, they need nitrogen, phosphorus, and potassium (Wang *et al*., 2021). These micronutrients are intended to meet the plants lesser but still essential needs, which is why these fertilizers are designed to supply tiny amounts of nutrients. These macronutrients are extremely important for the healthy and non-restrictive growth of any plant, and they also significantly increase yields (Hazra, 2016). Fertilizers include all the components needed to grow plants while enhancing the soil's chemical, physical, and biological qualities (Sharma and Chetani, 2017).

**Organic Fertilizers:**

According to Assefa and Tadesse (2019), organic fertilizers are substances with a specific chemical composition and high analytical value that provide plant nutrients in an accessible form. Organic fertilizers are natural materials of either plant or animal source, including livestock manure, green manures, crop residues, household waste, compost, and works directly as a source of plant nutrients and indirectly influences the physical, chemical and biological properties of soil (Bhatt *et al*., 2019).

Applying organic fertilizers will increase the soil's organic matter, soil water retention, soil nitrogen content, nutrient mobilization, and enhanced nutrient availability. They will also shield the soil from wind and rain erosion and release nutrients more gradually. A significant amount of organic fertilizer must be applied because improperly processed organic fertilizers contain pathogens that are harmful to humans and plants. Additionally, because the composition of organic fertilizers is highly variable, it is challenging to apply nutrients accurately to match plant production (Roba, 2018).

**Inorganic Fertilizers:**

Inorganic agricultural fertilizers are defined as those that are made up of inorganic chemical compounds. Most of these fertilizers do not biodegrade. Because they are produced in factories utilizing modern technologies, these fertilizers are sometimes known as artificial or synthetic fertilizers (Hazra, 2016).


Published: 23 Jan. 2024
ISSN: 2583-7850

When inorganic fertilizer is applied in a balanced manner, it can increase soil organic matter, boost crop yield, and improve soil fertility. Since these nutrients are already soluble in water, the effects are often immediate and the plant grows quickly because it has all the nutrients it needs. Little amounts of inorganic fertilizers are needed for productivity because they have a high nutrient content (Bhatt *et al*., 2019).

Overuse of chemical fertilizers can alter soil quality parameters, diminishing the amount of organic matter and humus in the soil, slowing plant development, frustrating beneficial organisms, changing the PH value of the soil, increasing pests, and increasing greenhouse gas emissions. According to Ilahi *et al*., (2020), using inorganic fertilizers exclusively can be hazardous and over time can contaminate the soil.

**Effect of organic and inorganic fertilizers on soil fertility:**

A key factor that influences crop plant yield, nutritional value, and capacity for reproductive growth is soil fertility. According to Bodruzzaman *et al*., (2010), there was a substantial response in the soil's pH, % OM, %total N, accessible P, exchangeable K, and available S content when organic and inorganic fertilizers were applied. The buildup of organic carbon in soils under a rice–rice cropping system was 40, 60, and 58 kg $t^{-1}$ of rice straw, cow dung, and poultry manure, respectively, during five rice-growing seasons, according to research by Rahman *et al*., (2016). This could vary depending on the initial carbon contents of residues applied to soil.

It has been demonstrated that chemical fertilizers directly and efficiently increase soil fertility in low-fertility fields. On the other hand, the N in organic fertilizers breaks down more slowly and is more readily held in the soil, while the inorganic N in chemical fertilizers breaks down quickly and is easily lost (Ma *et al*., 2023). Thus, in areas with differing fertility levels, combining organic and inorganic fertilization is a long-term successful approach.

**Conclusion:**

In conclusion, the impact of organic and inorganic fertilizers on soil fertility and crop production is a complex interplay of various factors. While both types of fertilizers contribute essential nutrients to the soil, organic fertilizers promote long-term soil health, microbial activity, and sustainability. They also enhance soil structure and water retention. On the other hand, inorganic fertilizers provide readily available nutrients and can lead to higher short-term crop yields.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

**Effect of organic and inorganic fertilizers on crop production:**

| S. No | Crop | Type of fertilizer | Result | Place of research | Reference |
|---|---|---|---|---|---|
| 1. | Rice | Both Organic and Inorganic | The results revealed that the application of enriched poultry manure compost on equal N basis (2.3 t $ha^{-1}$) recorded higher growth parameters, yield attributes and grain yield of 4953 kg $ha^{-1}$. | Ethiopia | Redda and Abay (2015) |
| 2. | Wheat | Both Organic and Inorganic | It found that the Treatment $T_9$ (100% NPK + 5 t $ha^{-1}$ FYM + 5t $ha^{-1}$ vermicompost + PSB), was found best in the terms of plant population, growth parameters, grain yield, straw yield, harvest index and B:C ratio. | Kanpur, India | Kumar and Niwas (2022) |
| 3. | Maize | Both Organic and Inorganic | The combined application of FYM, vermicompost and chemical fertilizers (50% Recommended dose of NPK + 25% FYM + 25% Vermicompost) gives significantly higher results in growth parameters and yield attributes as well as yield as compared to rest of treatments as well as control. | Punjab, India | Singh and Misal (2022) |
| 4. | Sorghum | Organic | The highest rate of Sorghum physiological growth indexes root and net assimilation rate were belonged to the co-inoculation of mycorrhiza + Nitroxin treatment ($T_2$). | Iran | Kamaei *et al.*, (2019) |
| 5. | Pearl millet | Both Organic and Inorganic | The significantly higher grain yield (3.18 t/ha), stover yield (6.39 t/ha) and harvest index (33.22%) were recorded with the application of 75% RDN with 50% Poultry manure compared to all other treatments. | Uttar Pradesh, India | Amarghade and Singh (2021) |
| 6. | Groundnut | Organic | The results of this investigation revealed that the application of 50 % N (FYM) + 25 % N (Vermicompost) + Rhizobium + PSB (Seed treatment) ($T_3$) had significant effect on haulm yield of groundnut (4622 kg $ha^{-1}$). | Gujarat, India | Kulkarni *et al.*, (2018) |
| 7. | Sunflower | Both Organic and Inorganic | The Result indicated that the treatment 100 % RDF + FYM @ 5 t/ha ($T_2$) recorded significantly higher growth & yield attributes. | Maharashtra, India | Dambale *et al.*, (2017) |
| 8. | Mung bean | Both Organic and Inorganic | it can be concluded that 50% vermicompost mixed with 50% recommended fertilizers showed excellent results in growth and yield parameters. | Pakistan | Aslam *et al.*, (2024) |
| 9. | Barely | Both Organic and Inorganic | The combined application of vermicompost @ 4.5 t $ha^{-1}$ + 40kg N gave higher grain yield (5.59 t $ha^{-1}$) and straw yield (7.06 t $ha^{-1}$) over rest of other combinations of organic manure and nitrogen. | Rajasthan, India | Kumawat *et al.*, (2006) |


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

A balanced and integrated approach, combining the strengths of both organic and inorganic fertilizers, tailored to specific soil and crop needs, appears to be a promising strategy. It is crucial to consider environmental sustainability and the long-term health of the soil, striving for a harmonious coexistence of agricultural productivity and ecological balance. Continuous research and field trials are necessary to refine our understanding and practices, ensuring the development of effective, environmentally friendly, and economically viable fertilization strategies for sustainable agriculture.

**Reference:**


Amarghade, N. and Singh, R., 2021. Effect of inorganic and organic sources of nutrient on growth and yield of pearl millet (*Pennisetum glaucum* L.). *The Pharma Innovation Journal*, 10(**10**), pp.507-509.

Aslam, Z., Ahmad, A., Mushtaq, Z., Liaquat, M., Hussain, T., Bellitürk, K., Awad Alahmadi, T., Ansari, M.J., Ur Rahman, S. and Du, Z., 2024. Evaluating the integration of vermicompost with synthetic fertilizer and compost on mung bean (*Vigna radiata* L.). *Archives of Agronomy and Soil Science*, pp.1-14.

Assefa, S. and Tadesse, S., 2019. The principal role of organic fertilizer on soil properties and agricultural productivity-a review. Agri Res and Tech: *Open Access J*, 22(**2**), p.556192.

Bhatt, M.K., Labanya, R. and Joshi, H.C., 2019. Influence of long-term chemical fertilizers and organic manures on soil fertility-A review. *Universal Journal of Agricultural Research*, 7(**5**), pp.177-188.

Bodruzzaman, M., Meisner, C.A., Sadat, M.A. and Hossain, M.I., 2010, August. Long-term effects of applied organic manures and inorganic fertilizers on yield and soil fertility in a wheat-rice cropping pattern. **In Proceedings of** the 19th World Congress of Soil Science, Brisbane, Australia (pp. 142-145).

Dambale, A.S., Shinde, R.S. and Bochare, A.D., 2017. Effect on Growth and Yield of Sunflower (*Helianthus annuus* L.) as Influenced by Organic and Inorganic Fertilizers. *Trends In Biosciences*, 10(**24**), pp.5062-5065.

Hazra, G., 2016. Different types of eco-friendly fertilizers: An overview. *Sustainability in Environment*, 1(**1**), p.54.

Ilahi, H., Hidayat, K., Adnan, M., Rehman, F.U., Tahir, R., Saeed, M.S., Shah, S.W.A. and Toor, M.D., 2020. Accentuating the impact of inorganic and organic fertilizers on agriculture crop production: A review. *Ind. J. Pure App. Biosci*, **9**, pp.36-45.

Javed, A., Ali, E., Afzal, K.B., Osman, A. and Riaz, S., 2022. Soil fertility: Factors affecting soil fertility, and biodiversity responsible for soil fertility. *International Journal of Plant, Animal and Environmental Sciences*, 12(**1**), pp.21-33.

Kamaei, R., Faramarzi, F., Parsa, M. and Jahan, M., 2019. The effects of biological, chemical, and organic fertilizers application on root growth features and grain yield of Sorghum. *Journal of Plant Nutrition*, 42(**18**), pp.2221-2233.

Kugbe, J.X., Wuni, M., Alhassan, M.H. and Maganoba, C., 2019. Increase in the use of organic fertilizers as complements to inorganic fertilizers in maintenance of soil fertility and environmental sustainability. *World Journal of Agriculture and Soil Science*, 4(**1**), pp.1-4.



Published: 23 Jan. 2024
ISSN: 2583-7850

Kulkarni, M.V., Patel, K.C., Patil, D.D. and Pathak, M., 2018. Effect of organic and inorganic fertilizers on yield and yield attributes of groundnut and wheat. *International J. of Chemical Studies*, 6(**2**), pp.87-90.

Kumar, G. and Niwas, R., 2022. Effect of organic and inorganic fertilizers on growth and yield of wheat (*Triticum aestivum* L.).

Kumawat, P.D., Jat, N.L. and Yadav, S.S., 2006. Effect of organic manure and nitrogen fertilization on growth, yield and economics of barley (*Hordeum vulgare*). *The Indian Journal of Agricultural Sciences*, 76(**4**).

Ma, G., Cheng, S., He, W., Dong, Y., Qi, S., Tu, N. and Tao, W., 2023. Effects of Organic and Inorganic Fertilizers on Soil Nutrient Conditions in Rice Fields with Varying Soil Fertility. *Land*, 12(**5**), p.1026.

Rahman, F., Rahman, M.M., Rahman, G.M., Saleque, M.A., Hossain, A.S. and Miah, M.G., 2016. Effect of organic and inorganic fertilizers and rice straw on carbon sequestration and soil fertility under a rice–rice cropping pattern. *Carbon Management*, 7(**1-2**), pp.41-53.

Redda, A. and Abay, F., 2015. Agronomic performance of integrated use of organic and inorganic fertilizers on rice (*Oryza sativa* L.) in Tselemti District of North-Western Tigray, Ethiopia. *Journal of Environment and Earth Science*, 5(**9**), pp.2224-3216.

Roba, T.B., 2018. Review on: The effect of mixing organic and inorganic fertilizer on productivity and soil fertility. *Open Access Library Journal*, 5(**06**), p.1.

Sharma, A. and Chetani, R., 2017. A review on the effect of organic and chemical fertilizers on plants. *Int. J. Res. Appl. Sci. Eng. Technol*, 5, pp.677-680.

Singh, S. and Misal, N.B., 2022. Effect of different levels of organic and inorganic fertilizers on maize (*Zea mays* L.). *Indian Journal of Agricultural Research*, 56(**5**), pp.562-566.

Verma, B.C., Pramanik, P. and Bhaduri, D., 2020. Organic fertilizers for sustainable soil and environmental management. *Nutrient dynamics for sustainable crop production*, pp.289-313.

Wang, Y., Chen, Y.F. and Wu, W.H., 2021. Potassium and phosphorus transport and signaling in plants. *Journal of Integrative Plant Biology*, 63(**1**), pp.34-52.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

TRENDS IN AGRICULTURE SCIENCE

Vol.3 Special Issue 01 January 2024, Page: 115-126

# Examining the impact of zinc in combination with organic manures on the yield and growth characteristics of chilli

**S.Nagaraj[1]*, P. Saravana Pandian[2], P. Christy Nirmala Mary[3], R. Geetha[4], A.Gurusamy[5]**

[1]Assistant Professor, Department of Soil Science and Agricultural Chemistry, Institute of Agriculture Research & Technology, Aruppukottai, Tamil Nadu, India

[2&3]Professor, Department of Soils and Environment, Agricultural College and Research Institute, Madurai, Tamil Nadu, India

[4]Professor, Department of Seed Science and Technology, Agricultural College and Research Institute, Madurai, Tamil Nadu, India

[5]Professor, Department of Agronomy, Agricultural College and Research Institute, Madurai, Tamil Nadu, India

https://doi.org/10.5281/zenodo.10551470

***Abstract***

Chilli (*Capsicum annuum L.*) is a vegetable, spice cum cash crop belong to the family of Solanaceae. It is called as the universal spice of India and orginated from South America. It has a significant role in agricultural economics of the nation. A field experiment was conducted in a farmer's field located in Kaveripattinam village of the Mudukulathur block, Ramanathapuram district to evaluate the response of chilli to foliar and soil application of zinc combination with organic manures on the growth and yield attributes and yield of chilli fruits in zinc deficient soil. The soil was categorized as Fine, mixed isohyperthermic Vertic Haplustept, and low N, medium P and high K content, in a randomized block design with twelve treatments and three replications. The results relvealed that the application of $ZnSO_4$ @ 37.5 kg $ha^{-1}$ incubated with 188 kg vermicompost along with N, $P_2O_5$ and $K_2O$ on STCR basis registered maximum plant height at all three stages (45 DAT, 90 DAT and harvest) of crop growth (37.4, 60.4 and 100.0 cm), number of branches $plant^{-1}$ (3.8, 24.3 and 33.3) and chilli fruit yield (133.9 q $ha^{-1}$). This was followed by treatment application of $ZnSO_4$ @ 37.5 kg $ha^{-1}$ incubated with 375 kg FYM along with N, $P_2O_5$ and $K_2O$ on STCR basis and the lowest treatment receiving the recommended dose of N, $P_2O_5$ and $K_2O$ alone (120:60:30 kg $ha^{-1}$). It was revealed that natural chelated fertilizer prepared from $ZnSO_4$ incubated with organic manures for 30 days significantly improved the growth and yield of chilli.

**Keywords:** Chilli; *Capsicum annum L.*,; Zinc; vermicompost; yield;

## Introduction

Chilli (*Capsicum annuum* L.) is a remunerative vegetable, spice cum cash crop belong to the family of Solanaceae. It is called as the universal spice of India and orginates from South America. India is the largest area (7.81 lakh ha) cultivating and producing (41.6 lakh tonnes) chilli and ranks first globally but 38$^{th}$ position in productivity (2312 kg $ha^{-1}$). In Tamil Nadu,


**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

the total cultivated area under chilli was 0.46 lakh ha with a production of 0.21 lakh tonnes and the productivity of 410 kg $ha^{-1}$ (India stat, 2020). In Tamil Nadu major area under chilli cultivation is at Ramanathapuram (22441 ha) followed by Thoothukudi, Sivagangai, Virudhunagar, Thirunelveli and Ariyalur districts. Despite a larger area being used for chilli cultivation, the yield and profitability of chilli are declining because of poor management. In terms of chilli production, Indian soils produce a significantly lower yield, which may be the result of improper fertilization and deficiencies of micronutrients (Bose and Tripathi, 1996). One of the problems faced by chilli growing farmers is flower, fruit drop and zinc deficiency which drastically reduces the yield. Zinc play a vital role in the growth and productivity of different vegetable crops including chilli (Shil *et. al.,* 2013). Zinc involved in the biosynthesis of auxin (Indole-3-acetic acid) and it is also the metabolic activator of many cellular enzymes in plants. The information of the role of Zn on morphological, physiological and biochemical traits in chilli is meagre. Hence it is important to study the influence of Zn on morpho-physioloogical and yield components in chilli to boost the productivity potential. Application of organic manures in crop production is in vogue for several years. Addition of well decomposed FYM not only supply plant nutrients but also acts as a binding material and improves the soil physical properties. Beneficial effects of earthworms and their cast were known as early as in Darwin's era. But the potential of vermicompost to supply nutrients and to support beneficial microbes has been recognized recently. Organics alone do not produce spectacular increase in crop yields due to their low nutrient status. Therefore, to maintain soil productivity on a sustainable basis, blending of organic and inorganic sources of nutrients needs to be adopted. Particularly chilli needs heavy manuring for better growth and high yield. Use of judicious combinations of organic and inorganic fertilizer sources are essential not only to maintain the soil health but also sustain productivity (Malewar *et al.,* 1998). Keeping these points in view, the present study was conducted to evaluate the effect of zinc sulphate alone and incubation with various organic manures on the growth, yield attributes and chilli fruit production in Zn deficient soils of Ramanathapuram district, Tamil Nadu.

## Materials and Methods

***Experimental site:*** The field experiment was carried out to understand the response of Zn to the growth and yield of chilli in a farmer field located in Kaveripattinam village of the Mudukulathur block, Ramanathapuram district, Tamil Nadu, during the *kharif* season from 28$^{th}$ September 2021 to 15$^{th}$ March 2022. The mean annual temperature and mean annual rainfall in the Ramanathapuram district was is 29.1°C and 770 mm respectively.


Published: 23 Jan. 2024
ISSN: 2583-7850

***Enrichment of organics fortified with Zn:*** The organic sources employed in the incubation of Zn are vermicompost and farmyard manure. The enrichment process included $ZnSO_4$ @ 25 kg $ha^{-1}$ incubated with 250 kg FYM for 30 days (1:10 ratio), $ZnSO_4$ @ 37.5 kg $ha^{-1}$ incubated with 125 kg FYM for 30 days (1:10 ratio), $ZnSO_4$ @ 25 kg $ha^{-1}$ incubated with 125 kg Vermicompost for 30 days (1:5 ratio), $ZnSO_4$ @ 37.5 kg $ha^{-1}$ incubated with 188 kg Vermicompost for 30 days (1:5 ratio).

***Experimental details:*** The field experiment was conducted in a randomized block design with twelve treatments and three replication 20 $m^2$ (5 m X 4 m). The details of the treatments are given in Table 1.

**Table 1. Treatment details of the experiment**

| | |
|---|---|
| $T_1$ | N, $P_2O_5$, $K_2O$ @ 120:60:30 kg $ha^{-1}$ |
| $T_2$ | N, $P_2O_5$, $K_2O$ on STCR basis |
| $T_3$ | $T_2$ + Basal application of $ZnSO_4$ @ 25 kg $ha^{-1}$ |
| $T_4$ | $T_2$ + Basal application of $ZnSO_4$ @ 37.5 kg $ha^{-1}$ |
| $T_5$ | $T_2$ + $ZnSO_4$ @ 25 kg $ha^{-1}$ incubated with 250 kg FYM for 30 days (1:10 ratio) |
| $T_6$ | $T_2$ + $ZnSO_4$ @ 37.5 kg $ha^{-1}$ incubated with 125 kg FYM for 30 days (1:10 ratio) |
| $T_7$ | $T_2$ + $ZnSO_4$ @ 25 kg $ha^{-1}$ incubated with 125 kg Vermicompost for 30 days (1:5 ratio) |
| $T_8$ | $T_2$ + $ZnSO_4$ @ 37.5 kg $ha^{-1}$ incubated with 188 kg Vermicompost for 30 days (1:5 ratio) |
| $T_9$ | $T_2$ + Foliar application of $ZnSO_4$ @ 0.5 % on 20, 40, 60 DAT |
| $T_{10}$ | $T_3$ + Foliar application of $ZnSO_4$ @ 0.5 % on 20, 40, 60 DAT |
| $T_{11}$ | $T_2$ + Basal application of ZnEDTA @ 2 kg $ha^{-1}$ |
| $T_{12}$ | $T_2$ + Foliar application of ZnEDTA @ 0.5 % on 20, 40, 60 DAT |

***Data Collection and Analysis***

Before the experimentation, soil samples were collected at randomly at 0-30 cm depth across the experimental site and made in a single composite. The composite soil sample was processed and used for the analysis of physico-chemical characteristics viz., soil reaction (pH)(Potentiometry, Jackson, 1973), electrical conductivity (EC) (Conductometry, Jackson, 1973), soil organic carbon (Dichromate wet digestion method, Walkley and black, 1934), available nitrogen (Alkaline permanganate method, Subbaiah and Asija, 1956), available phosphorus (Olsen method, Olsen et al., 1954), available potassium (neutral normal $NH_4OAc$


Published: 23 Jan. 2024
ISSN: 2583-7850

method, Stanford and English, 1949), DTPA extractable Zn, Fe, Cu, Mn (Atomic Absorption Spectrophotometer, Lindsay and Norvell, 1978). From each plot, five plants were selected randomly and tagged and the following growth and yield parameters were observed. Plant height was measured from the ground level to the tip of the terminal bud and expressed in cm. The number of branches per plant was counted from the selected tagged plants and the mean number of fruits, was determined and expressed in numbers. The yield data were collected at physiological maturity and after the crop was harvested. Analysis of variance (ANOVA) was used to examine the growth and yield (kg $ha^{-1}$) obtained in the research, as recommended by Panse and Sukhatme (1967).

**Results and Discussion**

The present study showed that chilli (Capsicum annum L.), samba variety, the plant growth and yield attributes were highly influenced by the soil application of Zn and enriched organics along with STCR based N, $P_2O_5$ and $K_2O$.

***Initial properties:*** The data of various physico-chemical properties of the initial soil are presented in Table 2. The soil texture was sandy clay in nature with a bulk density (1.18 Mg $m^{-3}$) and particle density (2.45 Mg $m^{-3}$). The pH of the experimental soil was moderately alkaline (8.32). The soil was low in alkaline Alk.$KMnO_4$ – N (200.5 kg $ha^{-1}$), medium in Olsen's- P (13.7 kg $ha^{-1}$), high in $NH_4OAc$- K (362 kg $ha^{-1}$), low in organic carbon content (3.7 g $kg^{-1}$) and CEC of 26.2 c mol ($p^+$) $kg^{-1}$. The total nutrient status of the soil was 0.075, 0.031 and 0.420 per cent of N, P and K respectively. The exchangeable calcium and magnesium were 7.21 and 8.32 c mol (p+) $kg^{-1}$ respectively. The DTPA extractable Zn was found to be deficient (0.63 mg $kg^{-1}$). The soil was categorized as "Fine, mixed isohyperthermic *Vertic Haplustept"* by the United State Department of Agriculture (USDA) soil taxonomy.

**Table 2. Initial soil parameters of the experimental site**

| Particulars | | Vertic Haplustept (Kadaladi) |
|---|---|---|
| **A.** | **Mechanical composition** | |
| | Clay (%) | 31.30 |
| | Silt (%) | 7.8 |
| | Fine Sand (%) | 31.50 |
| | Coarse Sand (%) | 28.40 |
| | Textural class | Sandy clay |
| **B.** | **Physical Properties** | |
| | Bulk density (Mg $m^{-3}$) | 1.18 |
| | Particle density (Mg $m^{-3}$) | 2.45 |


Published: 23 Jan. 2024
ISSN: 2583-7850

| | | |
|---|---|---|
| | Porosity (%) | 45.43 |
| **C.** | **Physico-chemical properties** | |
| | pH | 8.32 |
| | EC (dSm$^{-1}$) | 0.40 |
| | AEC (c mol (p+ ) kg$^{-1}$) | 2.80 |
| | CEC (c mol (p+ ) kg$^{-1}$) | 26.2 |
| **D.** | **Chemical properties** | |
| | Free $CaCO_3$ (%) | 6.73 |
| | Sesquioxide (%) | 6.45 |
| | Total nitrogen (%) | 0.075 |
| | Total phosphorus (%) | 0.031 |
| | Total potassium (%) | 0.420 |
| | Organic carbon (g kg$^{-1}$) | 3.7 |
| | Alk- $KMnO_4$ –nitrogen (kg ha$^{-1}$) | 200.5 |
| | Olsen – phosphorus (kg ha$^{-1}$) | 13.7 |
| | $NH_4OAc$ - potassium (kg ha$^{-1}$) | 362 |
| | Exchangeable calcium (c mol (p+ ) kg$^{-1}$) | 7.21 |
| | Exchangeable magnesium (c mol (p+) kg$^{-1}$) | 8.32 |
| | CaCl2–S (mg kg-1) | 8.7 |
| | Available iron (mg kg$^{-1}$) | 10.8 |
| | Available manganese (mg kg$^{-1}$) | 11.6 |
| | Available zinc (mg kg$^{-1}$) | 0.63 |
| | Available copper (mg kg$^{-1}$) | 1.89 |

***Effect of Zn and fortified organic manures on growth attributes :*** The application of Zn significantly influenced the growth attributes of chilli, as shown in Table 3. The plant height, number of branches were significantly (P = 0.05) higher in the treatment receiving $ZnSO_4$ @ 37.5 kg ha$^{-1}$ incubated with 188 kg vermicompost along with N, $P_2O_5$ and $K_2O$ on STCR basis than in the other treatments. Thus, this result might be due to the increased availability of Zn for chilli during the critical stages, as Zn starvation greatly reduces the growth and development of chilli.

**Table 3. Effect of zinc fertilization on plant height (cm) and number of branches at various growth stages of chilli**

| Treatment | Plant height (cm) | | | Number of branches | | |
|---|---|---|---|---|---|---|
| | 45 DAT | 90 DAT | At harvest | 45 DAT | 90 DAT | At harvest |
| **T1** | 26.8 | 46.0 | 78.8 | 1.8 | 11.1 | 20.1 |
| **T2** | 28.4 | 47.8 | 81.0 | 2.2 | 12.9 | 21.9 |
| **T3** | 30.5 | 51.1 | 86.9 | 2.8 | 16.0 | 25.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **T4** | 33.2 | 54.4 | 91.4 | 3.1 | 18.6 | 27.6 |
| **T5** | 34.5 | 56.4 | 94.2 | 3.2 | 20.8 | 29.8 |
| **T6** | 36.6 | 59.3 | 97.4 | 3.7 | 22.9 | 31.9 |
| **T7** | 35.0 | 57.3 | 95.1 | 3.4 | 21.9 | 30.9 |
| **T8** | 37.4 | 60.4 | 100.0 | 3.8 | 24.3 | 33.3 |
| **T9** | 29.4 | 49.3 | 83.7 | 2.6 | 13.7 | 22.7 |
| **T10** | 32.1 | 52.9 | 89.1 | 3.0 | 17.4 | 26.4 |
| **T11** | 34.0 | 55.6 | 93.1 | 3.6 | 19.4 | 28.4 |
| **T12** | 30.1 | 50.3 | 85.3 | 2.7 | 15.2 | 24.2 |
| **Mean** | **32.3** | **53.4** | **89.7** | **3.0** | **17.9** | **26.9** |
| **SEd** | **0.71** | **0.94** | **1.71** | **0.11** | **0.45** | **0.45** |
| **CD (P = 0.05)** | **1.48** | **1.96** | **3.55** | **0.23** | **0.94** | **0.94** |

***Plant height:*** The application of vermicompost incubated with zinc sulphate exhibited favourable results on plant height. Among the various treatments, application of 37.5 kg ha$^{-1}$ $ZnSO_4$ incubated with 188 kg of vermicompost along with N, $P_2O_5$ and $K_2O$ on STCR basis ($T_8$) was significantly superior on improving the plant height by recording 37.4, 60.4 and 100.0 cm followed by $T_6$ ($ZnSO_4$ @ 37.5 kg ha$^{-1}$ incubated with 375 kg FYM along with N, $P_2O_5$ and $K_2O$ on STCR basis). The treatment $T_8$ was statistically on par with $T_6$ which was applied with $ZnSO_4$ @ 37.5 kg ha$^{-1}$ incubated with 375 kg FYM along with N, $P_2O_5$ and $K_2O$ on STCR basis. The lowest plant height of 26.8, 46.0 and 78.8 cm at 45, 90 DAT and at harvest stages respectively were recorded in the treatment receiving RDF alone (120: 60: 30 kg ha$^{-1}$). In experimental field investigation, enriched $ZnSO_4$ outperformed the control in terms of boosting growth metrics such as plant height, with 39.5 % during 45 DAT, 31.3 % during 90 DAT and 26.9 % at harvest. An increase in plant height due to the application of Zn irrespective of its levels were observed. This may be attributed to the enhanced photosynthetic and other metabolic activity which leads to an increase in various plant metabolites responsible for cell division and elongation as opined by Hatwar *et al.* (2003) which leads to produced the tallest plant. Ghosh *et al.* (2020) reported that increased plant height obtained from application of zinc may be due to role of Zn in auxin biosynthesis, which plays important role in apical dominance of plants.

***Number of branches per plant:*** The number of branches per plant was also enhanced by the application of Zn with vermicompost. The treatment 37.5 kg ha$^{-1}$ $ZnSO_4$ incubated with 188 kg vermicompost along with N, $P_2O_5$ and $K_2O$ on STCR basis ($T_8$) registered the maximum number of branches per plant at all the stages of crop growth (3.8, 24.3 and 33.3) followed by the treatment receiving 37.5 kg ha$^{-1}$ $ZnSO_4$ incubated with 375 kg FYM along with N, $P_2O_5$ and $K_2O$ on STCR basis ($T_6$). The lowest number of branches per plant (1.8, 11.1 and 20.1) was registered in the treatment receiving RDF alone (120: 60: 30 kg ha$^{-1}$). This might be due to the increased nutrient supply with the addition of fertilizer along with organic manures. Angami *et al.* (2017) also reported increase in number of branches of chilli by application of Zinc ($ZnSO_4$). It may be ascribed due to sufficient availability of zinc to plant which might have enhanced catalytic or stimulatory effect on most of the physiological and metabolic processes of plant. It also helps in enhances the absorption of essential elements via increasing the cation exchange capacity of roots, plant root formation, carbohydrate metabolism, protein synthesis and growth promoters activations which ultimately produces healthy plant with the maximum productive branches of the crop. Zn was found to increase the photosynthetic activity and the rate of respiration which results in improved the growth (Martin *et al.,* 1966). These present findings also are in conformity with earlier workers of Abbasi *et al.* (2010), Elayaraja and Dhanasekaran (2016). The control treatment (RDF alone) recorded the lowest growth characters viz., plant height, number of branches per plant compared to other treatments. Similar results obtained with earlier workers Elayaraja and Dhanasekaran (2016).

***Effect of Zn and fortified organic manures on yield attribute:*** Incubation of Zn with vermicompost showed a significant (P = 0.05) impact on the number of fruits plant$^{-1}$, fruit length, single fruit weight and 100 seed weight. Among the various treatments, the combined application of $ZnSO_4$ @ 37.5 kg ha$^{-1}$ incubated with 375 kg FYM along with N, $P_2O_5$ and $K_2O$ on STCR basis was found to be effective in increasing the number of fruits plant$^{-1}$ (82.6), fruit length (9.10 cm), single fruit weight (5.10 g) and 100 seed weight plant$^{-1}$ (0.60 g), followed by the treatment receiving 37.5 kg ha$^{-1}$ $ZnSO_4$ incubated with 375 kg FYM along with N, $P_2O_5$ and $K_2O$ on STCR basis ($T_6$) with 79.5 fruits per plant, 8.87 cm of fruit length, 4.83 g of single fruit weight and 0.60 g of 100 seed weight plant$^{-1}$. The lowest number of fruits plant$^{-1}$ (51.6), fruit length (6.17 cm), single fruit weight (3.10 g) and 100 seed weight plant$^{-1}$ (0.52 g) were recorded in the RDF treatment ($T_1$). This might be due to the improved production of phyto-hormones prompted by Zn fertilization, which in turn increased the fruit development and production (Elizabath *et al.,* 2017). The most important effect of including Zn applications to chilli is that it can improve yield and yield components and growth characteristics (Hatwar *et al.,* 2003) as its application increases endogenous hormones like auxins, gibberellins, and melatonin which


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

will benefit growth, development and fruit production (Zhu *et al.,* 2020). Followed by it, fruit length the treatment received with 37.5 kg ha$^{-1}$ of $ZnSO_4$ incubated with 188 kg vermicompost along with N, $P_2O_5$ and $K_2O$ on STCR basis was found to have highest fruit length and lowest fruit length obtained in the treatment receiving RDF. This might be due to more accumulation of photosynthesis was probably due to more vigor, growth (Iyenger and Raja, 1998) and significantly enhance both the size and number of cells in plant (Natesh *et al.,* 2005).

The increment in fruit weight must be due to the timely application of Zn as it plays a vital role in accumulation of other nutrients including N, P, K and Ca. zinc application boosts chilli weight because of increasing cells and cell division and work in the volume of intercellular space in mesocarpic cells in addition to rapid metabolite translocation and sink fruits (Brahmachari and Rani, 2001) and also aid in the preparation of tryptophan, which is an amino acid that aids in the manufacture of proteins, as well as auxins, which are plant growth regulators that result in improved fruit growth (Wojcik and Wojcik, 2003). Followed by it, the increment in 100 seed weight also followed the same trend with the application of 37.5 kg ha$^{-1}$ of $ZnSO_4$ incubated with 188 kg vermicompost along with N, $P_2O_5$ and $K_2O$ on STCR basis was registering the highest 100 seed weight compared to other treatments. Naga *et al.,* (2013) reported that application of micro nutrient mixture in tomato increase 100 seed weight as compared to the control. The similar findings with the application of zinc have also been recorded by Dongr *et al.* 2000 in vary vegetable crops those various concentrations of zinc treatments significantly influenced the 1000 seed weight of lentil.

***Effect of Zn and fortified organic manures on chilli fruit yield:*** Chilli fruit yield is a direct correlation between growth and development of various morphological components. The data defined in table revealed that application of $ZnSO_4$ @ 37.5 kg ha$^{-1}$ incubated with 188 kg vermicompost along with N, $P_2O_5$ and $K_2O$ on STCR basis delivered the highest chilli fruit yield (133.9 q ha$^{-1}$) followed by $T_6$ - $ZnSO_4$ @ 37.5 kg ha$^{-1}$ incubated with 375 kg FYM along with N, $P_2O_5$ and $K_2O$ on STCR basis (127 q ha$^{-1}$) and it was statistically on par with $T_7$ - $ZnSO_4$ @ 25 kg ha$^{-1}$ incubated with 125 kg vermicompost along with N, $P_2O_5$ and $K_2O$ on STCR basis (125.1 q ha$^{-1}$). Treatment $T_1$ - RDF (N:$P_2O_5$:$K_2O$ @ 120:60:30 kg ha$^{-1}$) had the lowest chilli fruit yield (90 q ha$^{-1}$). While Behera and Chitdeshwari (2021) also supported these findings that highest fruit per plant recorded in the treatment soil test based NPK+ 37.5 kg $ZnSO_4$ ha$^{-1}$. This might be due to the improved production of phyto-hormones prompted by Zn fertilization, which in turn increased the fruit development and production (Elizabath *et al.,* 2017). The most important effect of including Zn applications to chilli is that it can improve yield and yield components and growth characteristics (Hatwar *et al.,* 2003) as its application increases endogenous hormones like auxins, gibberellins, and melatonin which will benefit growth, development and fruit production (Zhu *et al.,* 2020). This result is also similar to Ali *et al.,* (2008) reported that the effect of zinc which is essential for the carbonic enzyme and photosynthesis, resulting in increase in translocation of photosynthesis in fruits and decrease in flowers and fruits abscission (Graham *et al.,* 2000). The zinc increases the number of fruits per plant by increasing IAA synthesis (Shnain *et al.,* 2014) as well as carbonhydrates translocation (Singh and Tawari, 2013).

**Table 4. Effect of zinc fertilization on yield parameters of chilli at harvest stage**

| Treatment | Yield attributes | | | |
|---|---|---|---|---|
| | No. of fruits plant$^{-1}$ | Fruit length (cm) | Single fruit weight (g) | 100 seed weight plant$^{-1}$ (g) |
| **T1** | 51.6 | 6.17 | 3.10 | 0.52 |
| **T2** | 54.3 | 6.37 | 3.30 | 0.53 |
| **T3** | 63.3 | 7.37 | 3.37 | 0.55 |
| **T4** | 68.9 | 7.83 | 3.53 | 0.56 |
| **T5** | 74.5 | 8.47 | 4.57 | 0.58 |
| **T6** | 79.5 | 8.87 | 4.83 | 0.59 |
| **T7** | 77.8 | 8.67 | 4.63 | 0.59 |
| **T8** | 82.6 | 9.10 | 5.10 | 0.60 |
| **T9** | 57.2 | 6.70 | 3.37 | 0.54 |
| **T10** | 66.7 | 7.53 | 3.80 | 0.56 |
| **T11** | 72.4 | 8.13 | 4.33 | 0.57 |
| **T12** | 60.5 | 7.00 | 3.53 | 0.55 |
| **Mean** | **67.4** | **7.68** | **3.96** | **0.56** |
| **SEd** | **1.791** | **0.171** | **0.121** | **0.009** |
| **CD (P = 0.05)** | **3.715** | **0.355** | **0.252** | **0.020** |

**Table 5. Effect of zinc fertilization on yield of chilli fruit at harvest stage**

| S.No | Treatment | Fruit yield (q ha$^{-1}$) |
|---|---|---|
| **1** | $T_1$ - RDF ($N:P_2O_5:K_2O$ @ 120:60:30 kg ha$^{-1}$) | 90.0$^{k}$ |
| **2** | $T_2$ - N, $P_2O_5$ and $K_2O$ on STCR basis | 96.9$^{j}$ |
| **3** | $T_3$ - $T_2$ + Basal application of $ZnSO_4$ @ 25 kg ha$^{-1}$ | 109.7$^{gh}$ |
| **4** | $T_4$ – $T_2$ + Basal application of $ZnSO_4$ @ 37.5 kg ha$^{-1}$ | 115.8$^{ef}$ |
| **5** | $T_5$ - $T_2$ + $ZnSO_4$ @ 25 kg incubated with 250 kg FYM for 30 days (1:10 ratio) | 121.6$^{cd}$ |


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

| | | |
|---|---|---|
| **6** | $T_6$ - $T_2$ + $ZnSO_4$ @ 37.5 kg incubated with 375 kg FYM for 30 days (1:10 ratio) | 127.0[b] |
| **7** | $T_7$ - $T_2$ + $ZnSO_4$ @ 25 kg incubated with 125 kg VC for 30 days (1:5 ratio) | 125.1[bc] |
| **8** | $T_8$ - $T_2$ + $ZnSO_4$ @ 37.5 kg incubated with 188 kg VC for 30 days (1:5 ratio) | 133.9[a] |
| **9** | $T_9$ - $T_2$ + Foliar spray of $ZnSO_4$ @ 0.5% three times | 102.8[i] |
| **10** | $T_{10}$ – $T_3$ + Foliar spray of $ZnSO_4$ @ 0.5% three times | 112.5[fg] |
| **11** | $T_{11}$ - $T_2$ + Basal application of Zn EDTA @ 2 kg $ha^{-1}$ | 119.4[de] |
| **12** | $T_{12}$ - $T_2$ + Foliar spray of Zn EDTA @ 0.5% three times | 107.6[h] |
| | **CD** | 4.64 |
| | **SEd** | 2.24 |

## Conclusion

The application of Zn in conjuction with organic manures significantly (p = 0.05) increased growth and yield parameters in chilli. The results concluded that soil application of $ZnSO_4$ @ 37.5 kg $ha^{-1}$ incubated with 188 kg vermicompost along with N, $P_2O_5$ and $K_2O$ on STCR basis significantly increased the growth and yield of chilli in Zn deficient soils. Thus, the application of $ZnSO_4$ along with organic manures is recommended for better crop growth and yield of chilli.

## References

Abbasi, F.F., M. A. Baloch, Zia-Ul-Hassan, K. H. Wagan, A. N. Shah and I. Rajput, (2010). Growth and yield of okra under foliar application of some new multinutrient fertilizer products. *Pak. J. Agri. Agril. Engg. Vet. Sci.,* 26(2): 11-18.

Ali, S., K.A. Riaz, G. Mairaj, M. Arif, M. Fida and S. Bibi. (2008). Assessment of different crop nutrient management practices for yield improvement. *Aust. J. Crop Sci.,* 2(3): 150-157.

Angami, T., Chandra, A., Makdoh, B., Raghav, C.S., Assumi, S.R., Baruah, S., Bam, B., Sen, A., Kalita, H., (2017). Promising Influence of Micronutrients on Yield and Quality of Chilli Under Mid Hill Conditions of Arunachal Pradesh. *The Bioscan,* 12(3): 1633−1636.

Behera PR, Chitdeshwari T. (2021). Response of capsicum hybrids to zinc (Zn) fertilization under protected cultivation. *Curr J Appl Sci Technol.,* 40(41): 1-10.

Brahmachari, V.S and Rani, R. (2001). Effect of growth substances on fruit drop, yield and physico-chemical composition of litchi fruits. *Prog Hort* 32: 50-55.

Bose, U. S. and S. K. Tripathi. (1996). Effect of micronutrients on growth, yield and quality of tomato cv. Pusa Ruby in M. P. *Cro. Res.* 12: 61-64.

Dongr, S.M, Mahorkar, V.K, Joshi, P.S. and Deo, D.D. (2000). Effect of micronutrients spray on yield and quality of chilli (Capsicum annuum L.) var. Jayanti. *Agric Sci Digest*, 20(2): 106-107.

Elayaraja, D. and K. Dhanasekaran, (2016). Effect of Zinc Fertilization on the Growth, Yield and Nutrients Uptake by Bhendi in Coastal Sandy Soil. *International Journal of Agriculture Innovations and Research,* 5(3): 422-426.

Elizabath, A. Vijay, B., Pragathi, M., Vipin, M. P., T. Thomas, (2017). Effect of different concentrations of iron oxide and zinc oxide nanoparticles on growth and yield of carrot (Daucus carota L.). *Journal of Pharmacognosy and Phytochemistry,* 6(4): 1266-1269

Ghosh, A., Mondal, S., and D. Panda. (2020). Morpho-physiological Responses of Chilli (Capsicum annuum L.) to Foliar Application of Micronutrients and Growth Regulators. *International Journal of Bio-resource and Stress Management*, 11(1), 095-102

Graham, R.D., R.M. Welch and H.E. Bouis. (2000). Addressing micronutrient nutrition through enhancing the nutritional quality of staple foods. *Adv. Agron.,* 70: 77-161. https://doi.org/10.1016/S0065-2113(01)70004-1

Hatwar, G. P., S.V. Gondane, S. M. Urkude and O.V. Gahukar. (2003). Effect of micronutrients on growth and yield of chilli. *J. Soil Crop.,* 13:1239- 1254

Iyenger, B.R.V and M.E Raja (1988). Response of some vegetable crops to different sources and methods of application of zinc. *Indian J Agri Sci.,* 58(7): 565-567.

Jackson, M. (1973). Soil chemical analysis. Prentice Hall of India Pvt. Ltd., New Delhi, India.

Lindsay, W. L. and W. A. Norvell. (1978). Development of a DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of America Journal,* 42: 421-428

Martín G., Leivar P., Ludevid D., Tepperman J. M., Quail P. H., Monte E. (2016). Phytochrome and retrograde signalling pathways converge to antagonistically regulate a light-induced transcriptional network. *Nat. Commun.* 7:11431 10.1038/ncomms11431

Natesh N, Vyakarnahal BS, Shekargouda S and Deshpande VK. (2005). Effect of Micronutrients and Organics on Growth, Seed Yield and Quality of Chilli. Karnataka *J. Agric. Sci.,* 18(2): 334-337.

Olsen, S. R., C. V. Cole., F. S. Watanable and L. A. Dean. (1954). Estimation of available phosphorus in soils by extraction with sodium carbonate. Circular, United States, Department of Agriculture, 939**.**

Panse, V.G. and Sukhatme, P.V. (1954). Statistical methods for agricultural workers. Indian Council of Agricultural Research, New Delhi.

Shil KNC, Naser HM, Brahma S, Yousuf MN, Rashid MH. (2013). Response of chilli (*Capsium annuum L.*) to Zinc and Boron application. *Bangladesh Agricultural Research Unit* 38(1), 49-59.

Standford, S. and L. English. (1949). Use of flame photometer in rapid soil tests of potassium and calcium. *Agronomy Journal*, 41: 446-447.


**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

Subbiah, B. V. and G. L. Asija. (1956). A rapid procedure for the estimation of available nitrogen in soils. *Current Science,* 25: 259-260.

Malewar, G.U., Syed Ismail and Rudraksha, G.B. (1998). Integrated nitrogen management in chilli (*Capsicum annum L.*). *Bull. Indian Inst. Soil Sci.,* 2: 156-163.

Naga, S. K., Swain, S. K., Raju, B. and Sandeep, V. (2013). Effect of micronutrients foliar application on seed yield in tomato (*Lycopersicon esculentum* MILL.) *Int. J. Dev. Res.,* 3(11):191-195.

Shnain, R.S., V.M. Prasad and S. Saravanan. (2014). Effect of zinc and boron on growth, yield and quality of tomato (*Lycopersicon esculentum* Mill) cv. Heem Sohna, under protected cultivation. *Eur. Acad. Res.* (3): 4572-4597.

Singh, H.M. and J.K. Tiwari. (2013). Impact of micronutrient spray on growth, yield and quality of tomato (*Lycopersicon esculentum* Mill). *Hort. Flora. Res. Spectrum*. 2(1): 87-89.

Walkley, A. J. and C. A. Black. (1934). An estimation of declare methods for determining soil organic matter and a proposed modification of the chromic acid titration methods. *Journal of Soil Science*, 37: 29-38.

Wojcik P, and Wojcik M. (2003). Effects of boron fertilization on 'Conference' pear tree vigor, nutrition, and fruit yield and storability. *Plant Soil.,* 256:413-421.

Zhu T, Li L, Feng L, Ren AM. (2020). StABI5 involved in the regulation of chloroplast development and photosynthesis in potato. *Int. J. Mol. Sci.,* 21: 1068


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

TRENDS IN AGRICULTURE SCIENCE
Vol.3 Special Issue 01 January 2024, Page: 127-139

# Evaluation of Variability Resistance for Yellow Mosaic Virus between in Blackgram and Greengram

**Anandhi Lavanya, C.Gurumoorthy***
School of Agriculture Sciences
*Centre of Excellence in Applied Nuclear Research
Bharath Institute of Higher Education and Research
Selaiyur, Chennai
https://doi.org/10.5281/zenodo.10551560

***Abstract***

Mungbean yellow mosaic virus (MYMV) is a whitefly-transmitted major destructive virus affecting Blackgram and Green gram productivity in India. The objective of this research was to identify Blackgram and Green gram genotypes resistant against MYMV based on the phenotypic reaction and genotypic analysis. These results were confirmed through genotyping based on MYMV-resistance tagged molecular markers CEDG013, CEDG056, CEDG180 and CYR1. In addition to biochemical analysis on genotype resistance in the genotypes of each category (R-HS), effect of gamma irradiation on biochemical characteristics was studied. Results showed that the percentage of disease infection recorded positive significant association with phenol and total chlorophyll at both level, protein at genotypic level and negative significant association with sugars at both genotypic and phenotypic level. The new identified genotypes (resistant sources) can be utilized in the Blackgram and Green gram breeding programme for improving resistance to MYMV.

## Introduction

Pulses, supplemented with cereals, provide a perfect mix of vegetarian protein of high biological value. India is the largest producer, importer and consumer of pulses, accounting for 25% of global production from 35% of global area under pulses. The productivity of pulses in India is less than half of the productivity levels in the USA and Canada, as the pulses are mainly grown under rain fed condition in India in the areas with high rainfall variability. The persistent and growing demand- supply gap is putting pressure on prices and this good source of vegetarian protein is turning in accessible to the poor. The production of pulses in India is caught in the vicious cycle of low and uncertain yields, poor per hectare returns resulting in farmers' least preference to grow pulses on irrigated and fertile parcel of land, thereby leading to unstable and low yields. Inadequate adoption of production technology, higher price volatility, production risk and low level of irrigation are the important influencing factors responsible for stagnation in the productivity of these crops.


**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

The country would require 39 million tonnes of total pulses by 2050, which will require pulses production to grow at an annual rate of 2.2%. To fulfill the growing requirement, the country has to produce enough pulses as well as remain competitive to protect the domestic production. It is imperative to develop and adopt more efficient crop

production technologies along with favourable policies and market support to encourage farmers to bring more area under pulses. In order to provide nutritional security to the poor masses relying on a vegetarian diet, making pulses affordable through boosting domestic production of pulses is the best alternative. In order to augment the supply of pulses to poor masses, under the current scenario supply through a public distribution system will not only distribute pulses to poor at affordable prices and enhance nutritional security, but will also lead to stabilize prices and provide a boost to the farmers through assured procurement. The lack of an assured market is one of the major issues in the poor performance of pulses.

As a result of significant increase in the area coverage and productivity of all major Pulses, total production of pulses during 2016-17 was estimated at 22.95 million tonnes which was higher by 3.70 million tonnes (19.22%) than the previous record production of 19.25 million tonnes achieved during 2013-14. Production of Pulses during 2016-17 was also higher by 5.32 million tonnes (30.16%) than their five years' average production. However the actual production in 2016-2017 was higher by 6.61 million tonnes (40.41%) than the previous year's production (22.95 million tonnes).

India is producing 14.76 million tons of pulses from an area of 23.63 million hectare, which is one of the largest pulses producing countries in the world. However, about 2-3 million tons of pulses are imported annually to meet the domestic consumption requirement. Thus, there is a need to increase production and productivity of pulses in the country by more intensive interventions.

To achieve target of additional production of pulses, it is necessary to concentrate efforts on five most important pulse crops depending upon their contribution in national production *viz.*, chickpea (39%), pigeonpea (21%), mungbean (11%), urdbean (10%), and lentil (7%).

Blackgram (*Vigna mungo* L. Hepper) also called urdbean is a member of the Asian *Vigna* crop group. It is a staple crop in central and South East Asia; however it is extensively used only in India and now grown in the Southern United States, West Indies, Japan and other tropics and subtropics.

In India, black gram occupies 12.7 percent of total area under pulses and contributes 8.4 per cent of total pulses production. India is the largest producer and consumer of black


Published: 23 Jan. 2024
ISSN: 2583-7850

gram which is cultivated in an area about 3.26 million hectares with a production of 1.76 million tonnes. Blackgram is a short duration, self-pollinated, diploid grain legume (2n = 22) with a small genome size estimated to be 0.56pg/1C (574 Mbp) (Gupta *et al*., 2008).

The productivity of blackgram remains low due to biotic (mungbean yellow mosaic virus, powdery mildew and cercospora leaf spot) and abiotic stresses (drought, heat and preharvest sprouting). Among the various diseases limiting the blackgram and green gram productivity, Mungbean yellow mosaic virus (MYMV) was given special attention because of its severity and ability to cause yield loss up to 85% (Nene, 1972; Varma and Malathi, 2003).

Mungbean *(Vigna.radiata* (L.)Wilczek) is the most important (Rahman *et al.,* 2003). Besides being a rich source of protein, it maintains soil fertility through biological nitrogen fixation in soil and thus plays a vital role in furthering sustainable agriculture. It has gained importance mainly because of its wide use as a pulse crop with cheapest source of high quality easily digestible protein and also as a good source of green manure. It is consumed in the form of split pulse as well as whole pulse, which is an essential supplement of cereal based diet. The moong dal Khichdi is recommended to the ill or aged person as it is easily digestible and considered as a complete diet (Singh *et al.,* 2009). Likewise other pulse crops mungbean is a short duration grain legume crop with wide adaptability , low input requirements and deep root system, and proved an ideal for different crop rotations, intercropping, relay cropping and as catch crop (Devendra payasi *et al*., 2010).

The area under pulses in India is around 1.38 lakh hectares with a production of 0.47 lakh tones. Greengram (*vigna radiata),* which is the third important pulse crop of India in terms of area cultivated and production next to gram and pigeon pea. In Tamil Nadu, greengram is cultivated in an area of 1.71 lakh hectares with an annual production of 0.55 lakh tones and productivity 321.64 kg $ha^{-1}$.

**Area production and productivity of major pulses in India**

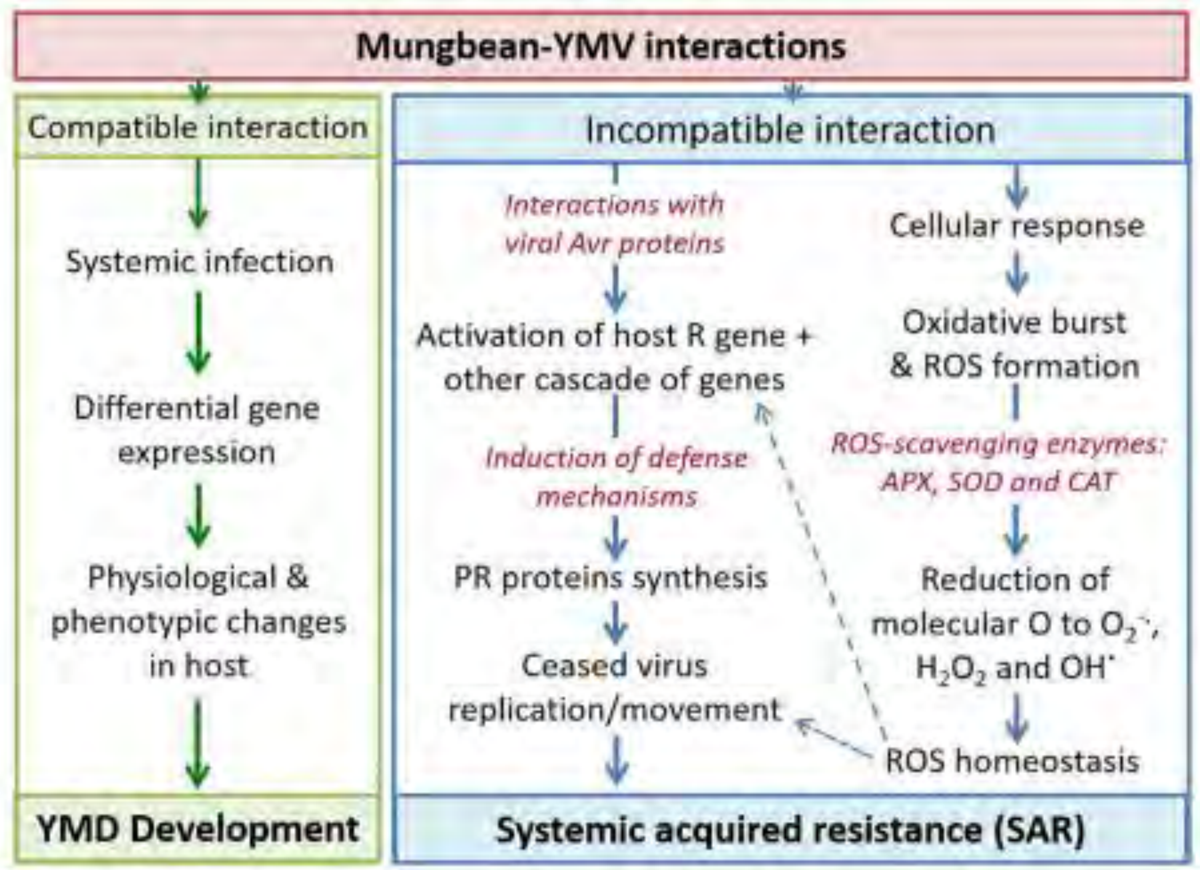
**(Area: lakh ha, Production: Lakh tonnes, Productivity: kg/ha)**

| **Particulars** | **Area** | **Per cent** | **Production** | **Per cent** | **Productivity** |
|---|---|---|---|---|---|
| Chickpea | 73.7 | 38.71 | 58.9 | 48.28 | 799.19 |
| Pegionpea | 36.3 | 19.07 | 27.6 | 22.62 | 760.33 |
| Mungbean | 34.4 | 18.07 | 14 | 11.48 | 406.98 |


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

| | | | | | |
|---|---|---|---|---|---|
| Uradbean | 31 | 16.28 | 14 | 11.48 | 451.61 |
| Lentil | 15 | 7.88 | 9.5 | 7.79 | 633.33 |
| **Total** | **190.4** | **100.00** | **124** | **101.64** | **651.2** |

Many factors are responsible for the low productivity of blackgram ranging from plant ideotype to various biotic and abiotic stresses. Among the various diseases, Yellow Mosaic Disease (YMD) is given special attention because of its severity and ability to cause damage up to 100 percent. Among different gemini viruses, Mungbean Yellow Mosaic Virus (MYMV) is extensively studied as it infects five major leguminous crops e.g. black gram, green gram, french bean, pigeon pea and soybean. Whitefly-transmitted bipartite begomoviruses named as *Mungbean Yellow Mosaic India Virus* (MYMIV), *Mungbean Yellow Mosaic Virus* (MYMV), *Horsegram Yellow Mosaic Virus* (HgYMV) and *Dolichus Yellow Mosaic Virus* (DoYMV) are four distinct etiological agents of this disease in legume crops in India and other South Asian countries. Yield loss due to this disease varies from 5 to 100 percent depending upon disease severity, susceptibility of cultivars and population of whitefly (Nene, 1972: Singh, 1980; Rathi, 2002).




It has been confirmed that two virus species causing YMD are prevalent in Indian sub continent *viz*., Mungbean Yellow Mosaic India Virus (MYMIV) is commonly occurring in northern part of India and Mungbean Yellow Mosaic Virus (MYMV) is confined to Southern India. Existence of different species of yellow mosaic viruses changes the crop behaviour on nature of resistance exhibited by blackgram genotypes from southern to northern parts of India. The development of YMD resistant varieties along with disease screening is curtailed by the complexities of the viral strains, vector population, crop biology and environmental factors (Malathi and John, 2008).

Recently, it was reported that *Vigna mungo var. silvestris,* a wild species of black gram, was infected with YMV disease. The incidence of this wild species is reported to be 100% (Naimuddin *et al.,* 2011). Therefore identification of the etiological agent of YMD and making available genetic stock of *Vigna* spp. resistance to YMD, which is a prerequisite for breeding programmes for varietal improvement to achieve the effective and practical management of this disease at farmer's field, is the most important goal.

Screening may be either on natural field conditions or through forced inoculation employing virulent vectors. In both the situations, vector population remains specific for the disease spread. Practical difficulties include climatic conditions that greatly affect the building


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

up of the vector population. If optimal conditions occur throughout the year, vector population will be present continuously. There is lack of uniform screening procedures and in many cases resistance is governed by recessive genes and hence significant delay in introgression of YMV resistance gene in elite blackgram lines .The efficacy of transmission and behaviour of the whiteflies varies with the host genotypes, vector biotypes and growth conditions. Screening based on natural occurrence in the hot spot areas has not given consistent results. Hence, the plant breeders and pathologists are in need of biotechnological and molecular tools that can lead to the identification of MYMV resistant and susceptible genotypes.

In India, the virus causes more severe yellow mosaic disease in black gram than in mung bean in all of South Asia. Disease incidence as high as 100% in farmers fields is common in the Indian subcontinent, often resulting in considerable yield losses (Varma *et al.*, 1992). Soybean, blackgram, mung bean, moth bean, cowpea and a few other leguminous species have also been reported to be hosts of this virus. Singh (1980) reported that susceptibility was dominant over resistance with two recessive genes required for resistance.

**GENETIC INHERITANCE OF MUNGBEAN YELLOW MOSAIC VIRUS**

Inheritance of YMD resistance studies revealed that the resistance was controlled by two recessive genes (Verma, 1988, Ammavasai *et al.,* 2004 and Singh *et al.,* 2006), a single recessive gene (Singh, 1977, Thaku., 1977, Saleem, 1998, Malik, 1986 Reddy, 1995 and Reddy, 2012) and complementary recessive genes (Shukla, 1985) and a dominant gene (Sandhu., *1985,* Gupta *et al.*, *2005).* Cayalvizhi *et al.* (2017) studied ninety $F_2$ genotypes developed from the cross made between KMG189 (MYMV-resistant) and VBN(Gg)2 (MYMV-susceptible), segregated in the mendelian single cross ratio 3S:1R; susceptibility of all the $F_1$s to MYMV suggested that the MYMV resistance in mungbean is governed by a single recessive gene.

**EFFECT OF GAMMA IRRADIATION ON BIOCHEMICAL CHARACTERISTICS**

Different types of electromagnetic radiation are available such as gamma irradiation, X irradiation, visible light UVirradiation. Radiation has a different range of energies and frequencies. Compared to other radiations, gamma irradiation is considered as more energetic form of radiation nearly 10 KeV to several 100 KeV and it has more penetrable power compared to alpha and beta irradiation. The relationship between growth of irradiated plants and dose of gamma irradiation has been manifested by investigating the morphological changes and seedling growth of the irradiated plants. No significant morphological aberrations were observed (Yasmin et. Al., 2022) in the phenotype of the plants irradiated with relatively


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

low doses (1–5 Gy) of gamma rays. Gamma radiation affects the plant growth and induces change in genetic level, physiological, biochemical and morphological nature of the cells. Gamma radiation induces biochemical changes and breaks the bond in between chains, cross-linking in DNA molecules and protein molecules. Protein, carbohydrate and vitamins are necessary for the seedling development. Based on the gamma radiation doses, various morphological and biochemical characters alter and induce and stimulate seedling growth and enhanced germination.65 In plants, gamma irradiation effects are determined based on the amino acids changes and are essential for human diets. Increased gamma radiation affects the quality of reducing sugar, starch content, carotenoids and other organic nature of the plant cell commonly used in understanding the plant growth and

development. Carotenoids are generally present in plant chloroplast and are also useful to protect the chlorophyll from photo-damage and also interlink with other major metabolic function.

**ANALYSES OF BIOCHEMICAL ALTERATIONS INDUCED BY GAMMA IRRADIATION BY FTIR SPECTROSCOPY**

Alteration and changes of biochemical profiles are commonly characterized by the Fourier transform infrared spectroscopy (FTIR). FTIR is also useful to identify the functional groups and it may be used to identify the unknown structure and composition of chemical groups and intensity of absorption spectra which associate with molecular composition of chemical compositions. Generally, FT-IR method is used to measure the vibrations of chemical bonds and functional groups and it generates the spectrum for biochemical and metabolite of the samples based on the “fingerprint”. Based on the infrared spectrum of plant samples, the minor and major changes present in primary and secondary metabolites are also detected.

FTIR spectroscopy is useful to monitor the modification in the structural and properties of biomolecules such as DNA, RNA, protein, carbohydrate, lipids and other plant cell and tissues.FTIR spectroscopy is the emerging technique for understanding and studying the biochemical alterations in plants. FTIR micro spectroscopy with multivariate data analysis is used to differentiate the spectral fingerprint of biochemical changes in plant tissues. Gamma irradiation induces oxidative stress due to the over production of reactive oxygen species(ROS) including superoxide radicals, hydroxyl radicals and hydrogen peroxides. Due to the overproduction of ROS, it reduces the antioxidants in plant tissues. Biotic and abiotic stresses induce ROS by the action of NADPH oxidase which triggers plant defence mechanism against various stress conditions and it enhances the tolerance capacity of plants to different stress environment and pathogens. Gamma irradiation induced more free radicals at increasing doses of gamma irradiation on seeds which affect the growth in black gram. Effect of mutagens on quantitative (agronomic) traits of crop plants: Due to gamma irradiation stress, M1generation results reduced rate of seedling germination, meanwhile in M2 generation, low rate of mutation effects was noticed in seed germination. This reduced seedling germination rate in M2 generation mainly due to the reduced effect of mutation in second generation as well as in DNA repair mechanism in plant tissues.74In M1 generation, the increased gamma irradiation doses reduce the agronomic and morphological traits. However, inM2, M3 and M4 generations, significant enhancements were recorded in morphological and yield traits reported in various crops. The yield parameters such as number of clusters per plant, seed per plant and seed yield per plant were moderate to higher at higher gamma radiation.

**GENETIC DIVERSITY IN BLACKGRAM**

At Annamalai University the genetic divergence was estimated on the basis of $D^2$ values and 40 genotypes of blackgram under study were grouped into six clusters by Tocher's method. The relative contribution of individual characters towards the expression of genetic diversity was estimated over character wise $D^2$value. The inter-cluster distances were greater than intra-cluster distances, revealing that considerable amount of genetic diversity existed among the accessions. The characters namely single plant seed yield, percentage disease infection, number of clusters per plant and number of pods per plant contributed more than 90% towards divergence. Hence, these characters appeared most important for check indices.

Among this Character which expressed higher genetic advance may be exploited as they respond better for selection (Malarkodi, 2018) (Unpublished).

**MARKER ASSISTED ELUCIDATION OF VARIABILITY FOR YMV IN BLACKGRAM**

Marker assisted indirect selection of resistant genotypes using linked markers has been reported as an effective breeding approach for developing YMV resistant cultivars in blackgram. It is assuming increased importance due to lack of uniform field screening procedure as well as difficulty in direct selection due to complex virus, vector, host and environmental interaction (Souframanien and Gopalakrishna, 2006). Few molecular markers linked with YMD resistance were identified (Basak *et al.*, 2004; Souframanien and Gopalakrishna, 2006; Maiti *et al.*, 2011). Yet, validation of such markers becomes an essential criterion with regard to the intricate disease nature.

Among various DNA marker systems, SSR markers are considered the most ideal marker for genetic studies because they are multi-allelic, abundant, randomly and widely


Published: 23 Jan. 2024
ISSN: 2583-7850

distributed throughout the genome, co-dominant that could differentiate plants with homozygous or heterozygous alleles, simple to assay, highly reliable, reproducible and could be applied across laboratories, and amenable for automation. Microsatellites or Simple Sequence Repeats (SSR) are DNA sequences with repeat lengths of a few base pairs. Variation in the number of repeats can be detected with PCR by designing primers for the conserved DNA sequence flanking the SSR. As molecular markers, SSR combine many desirable marker properties including high levels of polymorphism and information content, unambiguous designation of alleles, even dispersal, selective neutrality, high reproducibility, co-dominance, rapid and simple genotyping assays. Microsatellites have become the molecular markers of choice for a wide range of applications in genetic mapping and genome analysis paternity determination and pedigree analysis, gene and quantitative trait locus analysis and marker-assisted breeding.

Investigations at Annamalai University using molecular Markers for YMV resistance on blackgram revealed that nine out of fifteen markers (63.2%) showed polymorphic bands among the genotypes tested. Out of the remaining six markers five markers were bi-allelic producing two distinct alleles among the genotypes while one marker was mono-allelic showing a dominant allele pattern. Polymorphic information content of the nine polymorphic markers ranged from 0.30 to 0.65. Four markers namely CEDG013, CEDG056, CEDG180 and CYR1 had PIC values above 0.5 and hence can be considered as informative markers for YMV screening (Malarkodi, 2018) (Unpublished).

In another study involving twenty six genotypes of blackgram we concluded that twelve out of nineteen markers (63.2%) showed polymorphic bands among the genotypes tested. Eight markers were bialleic producing two distinct alleles among the genotypes while four markers were mono-allelic showing a dominant allele pattern. Percentage polymorphism was highest in CEDG 059 (55.8%). The genetic distance estimated using DICE dissimilarity co-efficient indicated highest divergence of 1.0 between VBN 8 and AUBG 17 and between VBN 8 and AUBG 19. The dendogram showed four apparent clusters based on marker allele distribution. Single marker analysis with CEDG092 revealed that genotypes AUBG 6, VBN4 and VBN8 carried the positive alleles for YMV resistance and the allele for susceptibility was present in AUBG12, AUBG15, AUBG17, AUBG19.

**MUNGBEAN**

**$D^2$ ANALYSIS**

The Mahalanobis $D^2$analysis as a potent tool for estimating the genetic diversity and it


Published: 23 Jan. 2024
ISSN: 2583-7850

provides a rational basis for selection of parents for hybridization programme. The present investigation, eleven economic traits were studied in forty five genotypes were subjected to $D^2$analysis. By the application of non–hierarchical clustering technique the genotypes grouped into five clusters in S1, eight clusters in S2 and pooled analysis.

Among the clusters the maximum numbers of genotypes were recorded in cluster I and II in S1 and cluster in S2 followed by in cluster in pooled analysis.

The intra cluster distance was maximum in cluster IV in S1 and pooled analysis; while it was cluster III in S2. The divergence within the cluster indicates the divergence among the genotypes in the same cluster. The minimum intra cluster distance in cluster V and VI in S1,While it was cluster IV in S2 and cluster III in pooled analysis.

The inter cluster distance was maximum between cluster III and V and minimum between clusters I and VI in S1. In S2, the maximum inter cluster distance was exhibited by cluster V and VI and minimum between cluster VI and V. In pooled analysis the maximum inter cluster distance was observed in between cluster III and VII and it was minimum between cluster II and III. The inter cluster distance was higher than intra cluster distance.

**CLUSTER MEAN**

The maximum cluster mean value for single plant seed yield was exhibited by cluster IV in S1, while it was cluster VIII in S2 and cluster VII in pooled analysis. Days to 50% flowering recorded lowest mean value in cluster VI in S1, cluster IV in S2 and cluster in VIII in pooled analysis. Cluster II recorded minimum plant height in S1, S2 and pooled analysis. The maximum number of branches per plant was exhibited by cluster III in S1, cluster V in S2 and cluster I in pooled analysis. Number of clusters per plant was higher in cluster III in S1, cluster VIII in S2 and cluster VI in pooled analysis. Cluster III recorded higher number of pods per cluster in S1, cluster VIII in S2 and cluster in VI in pooled analysis. The maximum number of pods per plant was exhibited by cluster III in S1 followed by cluster V in S2 and cluster VI in pooled analysis. Pod length recorded highest mean value in cluster VI in S1 and cluster VIII in S2 and pooled analysis. Cluster IV showed highest cluster mean value in S1, followed by cluster III in S2 and cluster II pooled analysis. Minimum value of percentage of disease infection was recorded in cluster I in S1, cluster VI in S2 and cluster VII in pooled analysis. Cluster VI recorded highest hundred seed weight in S1 and pooled analysis, while it was cluster VIII in S2.

**VARIATION BASED ON BIOCHEMICAL MARKERS**

**BIOCHEMICAL MARKER**

Among the forty five genotypes, twenty five genotypes scored and selected based on


Published: 23 Jan. 2024 ISSN: 2583-7850

percentage of disease infection from pooled analysis.

**PROTEIN**

Protein content of genotypes varied from 0.18 to 0.31 mg/g. The minimum was observed in genotype G6 (0.18 mg/g) and the maximum was observed in genotype G39 (0.31 mg/g). Out of twenty five genotypes, four genotypes recorded higher significant mean value than the general mean of 0.23 mg/g. The protein content is higher in susceptible genotype than the resistant genotype.

**PHENOLS**

The phenol content of genotypes ranged from o.75 to 4.67 mg/g. The minimum phenol content was observed in G3 (0.75 mg/g). The maximum was observed in genotype G20 and G39 (4.67 mg/g). Out of twenty five genotypes, twelve genotypes registered higher significant mean value than the general mean of 2.60 mg/g. The phenol content is higher in susceptible genotype than resistant genotype.

**SUGARS**

The sugar content was ranged from 2.70 to 8.67 mg/g. The minimum sugar content was observed in genotype G15 (2.70 mg/g) and the maximum was observed in genotype (8.67 mg/g). Out of twenty five genotypes, seven genotypes recorded higher significant mean value than the general mean of 4.83 mg/g. The sugar content is higher in resistant than the susceptible genotype.

**TOTAL CHLOROPHYLL**

Total chlorophyll content of genotypes varied from 1.40 to 2.13 mg/g. The minimum was observed in genotype G20 (1.40 mg/g) and the maximum total chlorophyll G19 (2.13 mg/g). Out of twenty five genotypes, seven genotypes registered higher significant mean value than the general mean of 1.80mg/g. Increased in total chlorophyll in resistant genotype than susceptible genotype.

**CORRELATION STUDIES**

Estimates of correlation between percentage of disease infection and isozymes component characters in greengram are presented in the table.

The protein had significant positive association with phenol (0.402), total chlorophyll (0.470) and percentage of disease infection (0.456) at genotypic level. The phenol recorded positive and significant association with percentage of disease infection (0.768 and 0.787) and negative significant association with sugars (-0.473 and -0.486) at both phenotypic and genotypic levels. The sugars had negative significant association with percentage of disease infection (-0.454 and -0.456) at both levels. The total chlorophyll recorded positive significant


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

association with percentage of disease infection (0.513 and 0.553) at both levels.

The percentage of disease infection recorded positive significant association with phenol and total chlorophyll at both level, protein at genotypic level and negative significant association with sugars at both genotypic and phenotypic level.

**REFERENCES**


Ammavasai, S., D.S. Phogat and Solanki, I.S. 2004.Inheritance of Resistance to Mungbean Yellow Mosaic Virus (MYMV) in Greengram (*Vigna radiata* L. Wilczek). ***The Indian Journal of Genetics.*** **Vol. 64, No. 2**, p.146.

Devendra payasi, Sudhanshu Pandey, S.K. Nair and R.L. Pandey. 2010. Generation mean analysis for yield and yield components in mungbean (*Vigna radiata L. Wilczek*). **Indian. J. Plant. Sci., 5(2) :** 485-493.

Basak J, Kundagrami S, Ghose TK and Pal A. 2004. Development Of Yellow Mosaic Virus (YMV) Resistance Linked DNA Marker In *Vigna mungo* From Populations Segregating For YMV-Reaction, ***Molecular Breeding***. **14**: 375–383.

Cayalvizhi, B., P.Nagarajan, M.Raveendran, R.Rabindran, J.R.KannanBapu and N.Senthil. 2017. Understanding the inheritance of mungbean yellow mosaic virus (MYMV) resistance in mungbean (*Vigna radiata* L.) Wilczek. ***Molecular Breeding.*****37:** 63.

Gupta, S.K and T.Gopalakrishna . 2008. Molecular markers and their application in grain legumes breeding. ***Journal of Food Legumes***. **21**: 1-14.

Gupta, S.K., R.A.Singh and S.Chandra .2005.Identification of a single dominant gene for resistance to mungbean yellow mosaic virus in blackgram (*Vigna mungo* (L.)Hepper).SABRAO ***Journal of Breedingand Genetics***.**37(2)**: 85-89.

Maiti S, Basak J, Kundagrami S, Kundu A, Pal A. 2011. Molecular marker-assisted genotyping of mungbean yellow mosaic India virus resistant germplasms of mungbean and urdbean, ***Mol Biotechnol***.**47**:95–104.

Malathi.V.G., and P. John, 2008.Geminiviruses infecting legumes, In G.P. Rao, P. Lava Kumar and R.J. Holguin-Pena (Eds.). Characterization, Diagnosis and Management of Plant Viruses: ***Vegetables and Pulses Crops*** (pp. 97–123). Houston, TX: Stadium Press, LLC.

Malik, I.A., G.Sarwar and Y.Ali. 1986. Inheritance of tolerance to *MungbeanYellow Mosaic Virus* (MYMV) and some morphological characters. ***Pakistan Journal of Botany***. **Vol. 18, No. 1**, pp. 189-198.

Naimuddin, M., A. Akram, A. Pratap, B.K. Chaubey and K.J. Joseph, 2011. PCR based identification of the virus causing yellow mosaic disease in wild *Vigna* accessions. ***Journal of Food Legumes,*** **24(i):** 14-17.

Nene, Y.L. 1972. A survey of viral diseases of pulse crops in Uttar Pradesh.***Research Bulletin***. *Uttar Pradesh Agricultural University*, Pantnagar.191.

Rahman, M., A.S.M. Iqbal Hussain, A.Saykhal, Z.Akhter and M.hassanuzzaman. 2003 b. Gentic Variability, correlation and path analysis in mungbean. **Asian J. Plant Sci., 2(17-24):** 1209-1211.

Rathi, Y.P.S. 2002. Epidemology, Yield losses and management of major diseases of Kharif pulses in India, ***Plant Pathology and Asian congress of Mycology and Plant Pathology***, University of Mysore, Mysore

Reddy, K.R and Singh, D.P. 1995.Inheritance of resistance to Mungbean Yellow Mosaic Virus.***The Madras Agricultural Journal,*** 88(2): 199-201.

Reddy, K.S. 2012. A new mutant for Yellow Mosaic Virus resistance in Mungbean (*Vigna radiata* L. Wilczek) variety SML-668 by recurrent Gamma-ray irradiation," In: Q. Y. Shu, Ed., ***Induced Plant Mutation inthe Genomics Era***, Food and Agriculture



**Published**: 23 Jan. 2024
**ISSN: 2583-7850**

Organization of the UnitedNations, Rome, pp. 361-362.

Saleem, M., W.A.Haris and I.A.Malik, 1998.Inheritance of yellow mosaic virus resistance in mungbean.***Pakistan Journal of Phytopathology*.10**: 30-32.

Sandhu, T.S., J.S.Brar , S.S.Sandhu and M.M.Verma .1985. Inheritance of resistance to Mungbean Yellow Mosaic Virus in greengram.***Journal ofResearch Punjab Agri cultural University***. **Vol. 22, No. 1**, pp. 607-611.

Shukla, G.P and B.P.Pandya .1985.Resistance to yellow mosaic in greengram. ***SABRAO Journal of Genetic and Plant Breeding*.17**: 165.

Singh, J.P., 1980. Effect of virus diseases on growth component and yield of mungbean and urdbean, ***Indian phyto- pathology***, 8: 405-408.

Singh, J.P., 1980. Effect of virus diseases on growth component and yield of mungbean and urdbean, ***Indian phyto- pathology***, 8: 405-408.

Singh, R.K and B.D.Chaudhary .1977.Biometric methods in quantitative genetics analysis.***Kalyani Publishers***. Ludhiana. India.

Singh, S.K and M.N.Singh .2006.Inheritance of resistance to mungbean yellow mosaic virus in mungbean.***Indian Journal of Pulses Research***. 19: 21.

Singh, S.K., I.P. Singh, B.B. Sing and Onkar Sing. 2009 . Stability analysis in mungbean (*Vigna radiata (L.) Wilczek*) **Legume Res., 32 (2):** 108 -112

Souframanien, J and T. Gopalakrishna. 2004. A comparative analysis of genetic diversity in blackgram genotypes using RAPD and ISSR markers. ***Theoretical and Applied Genetics,* 109:** 1687–1693.

Souframanien, J. and T. Gopalakrishna. 2006, ISSR and SCAR markers linked to the mungbean yellow mosaic virus (MYMV) resistance gene in blackgram (*Vigna mungo* (L.) Hepper).***Plant Breeding,* 125:** 619-622.

Varma, A. and V.G. Malathi. 2003. Emerging geminivirus problems: A serious threat to crop production. **Ann. Appl. Biol. 142:** 145-164.

Varma, P and D. K.Garg. 2003. Estimation of genetic parameters among a set of mungbean (*Vigna radiata* (L.) Wilczek) genotypes. ***Annals of Agricultural Research*, 24(1):** 156-158.

Verma, R.P.S and D.P. Singh. 1988. Inheritance of resistance to mungbean yellow mosaic virus in Greengram. ***Annals of Agricultural Research*, 9(3):** 98-100.

Yasmin K.1 and Arulbalachandran, 2022, Gamma irradiation effects on crop plants, Res. J., Vol. 17 (8), 126-135.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

TRENDS IN AGRICULTURE SCIENCE
Vol.3 Special Issue 01 January 2024, Page: 140-142

# The Crucial Role of Insects as Soil Pollinators

**Surya Prakash S**
IV Year Students, School of Agriculture,
Bharath institute of Higher Education and Research Selaiyur, Tambaram, Chennai – 073
https://doi.org/10.5281/zenodo.10551720

***Abstract***
This abstract provides a concise overview of the article exploring the emerging concept of insects as soil pollinators. The adaptations and mechanisms that facilitate soil pollination are discussed, shedding light on the unique strategies evolved by both plants and insects in this hidden ecosystem. The implications for conservation and the potential paradigm shift in our understanding of plant reproduction make this exploration of insects as soil pollinators a captivating avenue for further research and consideration in ecological studies.

***Key word:*** Soil pollination, Ecosystem, Insects.

**Introduction:**

When we think of pollinators, our minds often turn to the buzzing bees and graceful butterflies that flit from flower to flower above the ground. However, there exists an equally important but often overlooked group of pollinators that operate in a different realm – beneath the surface of the soil. In this article, we explore the fascinating world of soil pollination and the vital role that insects play in this hidden dance that sustains plant life below ground.

**Insect pollination on ecosystem:**

Climate change is thought to be a principal factor that can influence the activities, distribution, and abundance of insect pollinators dwelling in the forest. Overall, elevated temperature level could affect the insect pollinators present in the forests and the dependence of linked agro-ecosystems on the forest, and various indicators of climate change with the species present in the forest. (Apoorva IS Kataria, Advait Edgaonkar ,2023)

**Honeybees and insect polinators of cultivatable crops:**

The total pollination activities, over 80% is performed by insects and bees contribute nearly 80% of the total insect pollination, and therefore, they are considered the best pollinators. Management of wide diversities of honeybees and other beneficial insects and flowering plant species occurring in Nepal help to maintain diversity of flora and bee fauna, pollination and reward hive products in the service of mankind. (RB Thapa J).


**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

**Plant Partnerships Below Ground:**

Many plant species have evolved to depend on soil-dwelling insects for their reproductive success. These plants often have inconspicuous flowers that may not attract above-ground pollinators. We delve into the specific adaptations of these plants and the intricate relationships they form with their subterranean pollinators.

**Insect pollinators and sustainable agriculture:**

The economic value of insects to pollination, seed set, and fruit formation greatly outweighs that suggested by more conventional indices, such as the value of honey and wax produced by honeybees. (Peter G Kevan, E Ann Clark, Vernon G Thomas 1990)

**Benefit on organic farming from insect pollination:**

Organic farming is one of the important ways to increase agriculture. The question that raised from this study is whether the benefits of organic agriculture on weed and pollinators By observing the plant pattern were consistent with the hypothesis with regards to the pollinators The pollination type and the plants species were respectively increased in organic comparatively than conventional fields and higher at the field edge than in the field center, whereas the relative number of non-insect pollinated species was higher in conventional fields and in the field center. (Doreen Gabriel, Teja Tscharntke 2007)

**The Impact of Human Activities**:

Human activities, such as habitat destruction, land-use changes, and the use of pesticides, can significantly impact soil pollinator populations. We discuss the potential consequences of these actions on the delicate balance of below-ground ecosystems and the importance of conservation efforts.

**The Future of Soil Pollination Research:**

As scientists uncover more about soil pollination, new avenues for research and conservation emerge. We explore the latest advancements in the field and the potential implications for agriculture, ecosystem health, and biodiversity.

**Conclusion:**

In the intricate tapestry of ecological interactions, soil pollinators play a vital role in shaping the diversity and resilience of our planet's ecosystems. As we deepen our understanding of this hidden world, it becomes increasingly clear that the conservation of soil pollinators is not only crucial for the health of subterranean ecosystems but also for the interconnected web of life that sustains us all.


**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

**Reference:**

Apoorva IS Kataria, Advait Edgaonkar. 2023. Journal of Entomology and Zoology Studies 11 (4), 19-24, 2023.

Peter G Kevan, E Ann Clark, Vernon G Thomas. 1990. American Journal of Alternative Agriculture 5 (1), 13-22.

A review RB Thapa. 2006. J. Inst. Agric. Anim. Sci 27, 1-23.

Doreen Gabriel, Teja Tscharntke. 2007. Agriculture, Ecosystems & Environment 118 (1-4), 43-48.


**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

TRENDS IN AGRICULTURE SCIENCE
Vol.3 Special Issue 01 January 2024, Page: 143-145

# Exploring the Symbiotic Dance of Insect and Soil Bio-Diversity

**Deepika D**
IV-year student, School of Agriculture,
Bharath Institute of Higher Education and Research,
Selaiyur, Tambaram, Chennai – 073.
https://doi.org/10.5281/zenodo.10551729

***Abstract***
This study investigates the intricate relationships between insect and soil biodiversity, aiming to provide a comprehensive understanding of their interdependence in terrestrial ecosystems. Employing a multidisciplinary approach, we analyze the intricate web of interactions between insect species and soil microorganisms, exploring the reciprocal influences that shape both communities. Through field surveys, molecular analyses, and ecological modeling, our research unveils the nuanced mechanisms driving biodiversity in these crucial components of ecosystems. By unraveling these connections, our findings contribute to a deeper comprehension of the ecological processes that sustain terrestrial life and inform conservation strategies for maintaining and enhancing insect and soil biodiversity.

**Introduction**:

Insects play a crucial role in maintaining soil biodiversity, contributing significantly to the intricate web of life beneath our feet. From decomposing org contributions to ecosystems and the delicate balance that exists within the ground beneanic matter to enhancing nutrient cycling, these tiny creatures exert a profound influence on soil health. The soil system is dynamic, highly heterogeneous and extremely complex. Soil itself consists of a mineral portion containing mainly silica and a mixture of trace metals, and an organic matter portion containing a large variety of different organic compounds, as well as water and vast array of different organisms. Soil can exist as a variety of textures; with the texture being a product of changes in the relative proportions of sand, silt and clay. It can contain areas of relative dryness, and includes micropores which are almost always water filled apart from in times of extreme drought. The proportion and type of organic matter varies both with depth, and spatially.

**Soil biodiversity:**

What is biodiversity? Biodiversity has different meanings depending on the situation being discussed and the target audience. For example, the Oxford English Dictionary defines


**Published**: 23 Jan. 2024
**ISSN**: 2583-7850

biodiversity as being "The variety of plant and animal life in the world or in a particular habitat". ( Ciro Gardi, Simon Jeffery ,EUR-OP, 2009).

**Role of soil biodiversity and arthropods in soil fertility:**

The requirement of healthy production for soil is the food requirement of humans and animals. Arthropods have important role in maintaining soil fertility. As much as 20 % of total animal litter input is processed by the activity of collembolans alone. Arthropods also stimulate mineralization of nutrients in soil. Arthropods facilitate soil processes. Hence, understanding soil arthropod communities will prove useful in developing management plans for both wild and cultivated ecosystems. ( DJ Bagyaraj, CJ Nethravathi, KS Nitin-2016)

**The influence of biotic interactions on soil biodiversity**:

Underground communities usually support a much greater diversity of organisms than do corresponding aboveground ones, and while the factors that regulate their diversity are far less well understood, the current studies shows that information related to this data to understand the factors. at higher range the individual specific species effects on the plant production, plant composition and all components of biodiversity. ( David A Wardle-2006 )

**Soil biodiversity and functions**:

This is due to the complex spatial structure of the soil. The sizes of soil organisms range from< 100 μm body width for the microbes (eg bacteria, archaea, and fungi) and microfauna (eg protozoa, nematodes), to mesofauna with body width between 100 μm and 2 mm (eg Collembola, mites), macrofauna with body widths> 2 mm (eg earthworms, myriapods, and insects) and up to megafauna with body width> 2 cm (eg moles, voles). The Soil microbes have body widths of< 100 μm and are amongst the most abundant and diverse groups of soil organisms ( Susanne Wurst, Gerlinde B De Deyn, Kate Orwin ).

**Soil fertility**, **biodiversity and pest management:**

The high organic matter and active soil biological activity generally exhibit good soil fertility as well as complex food webs and beneficial organisms that prevent infection (Magdoff and van Es, 2000). Furthermore, recent research shows how biotic interactions in soil can regulate the structure and functioning of above-ground communities (Harman et al., 2004; Wardle et al., 2004), suggesting that the belowground component of an agroecosystem can be managed through a set of agroecological practices that can exert a substantial influence on pest dynamics (Altieri and Nicholls, 2003). Slowly agroecologists are recognising that aboveground and below-ground biodiversity components of agroecosystems cannot continue to be viewed in isolation from each other (van der Putten et al., 2009). In fact, the otherwise largely separate above-ground and below-ground components of agroecosystems are


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

connected by the plant (Wardle *et al*., 2004). This recognition of the biological linkages between above-ground and below-ground biota constitutes a key step on which a truly innovative ecologically based pest management strategy can be built.

**Conclusion**:

In the intricate tapestry of ecological interactions, soil pollinators play a vital role in shaping the diversity and resilience of our planet's ecosystems. As we deepen our understanding of this hidden world, it becomes increasingly clear that the conservation of soil pollinators is not only crucial for the health of subterranean ecosystems but also for the interconnected web of life that sustains us all.

**Reference**:

David A Wardle , 2006. Ecology letters 9 (7), 870-886.

DJ Bagyaraj, CJ Nethravathi, KS Nitin. 2016. Economic and ecological significance of arthropods in diversified ecosystems: Sustaining regulatory mechanisms, 17-51.

(Ciro Gardi, Simon Jeffery ,EUR-OP, 2009).

Miguel A Altieri, Luigi Ponti, Clara I Nicholls. 2012. Biodiversity and insect pests: key issues for sustainable management, 72-84.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

TRENDS IN AGRICULTURE SCIENCE
Vol.3 Special Issue 01 January 2024, Page: 146-154

# Harnessing AI Technologies for Efficient Soil and Water Management

**T. Geetha Jebarathnam**
Professor, School of Agriculture,
Bharath Institute of Higher Education and Research,
Selaiyur, Tambaram, Chennai. - 073
https://doi.org/10.5281/zenodo.10551761

***Abstract***

Sustainable global economic growth is based primarily on agriculture. With the continued growth of the human population, pressure on the farming systems will intensify, data-intensive methods are used in precision farming and agricultural technology. Recent scientific areas that have emerged and are now referred to as "digital agriculture," to increase agricultural productivity while reducing environmental impacts. Today's agricultural operations generate data from a variety of sensors, which helps to improve decision-making by providing a better understanding of both the process (data from machinery) and the operating environment (the interaction between crop, soil, and weather conditions). In the 20th century, advancements in information technology led to the arrival of artificial intelligence (AI) and the subsequent vision of machines driven by AI. A global source of current information on crop health, soil conditions, and water availability for agricultural production fields is provided by the passive SMO (Social media optimization) and other microwave satellite sensors, which register signals that radiate from the Earth's surface. This passive microwave technology finds solutions for irrigation issues and waterlogging during the dark and through clouds. Water damage to crops and other vegetation can be very expensive and should be prevented. Soil moisture and AI water data are urgently required for hydrological studies and data is vital for improving which will contribute to furthering our knowledge of the Earth's water cycle, and will improve climate, weather, and extreme-event forecasting. These are current trends in water distribution, irrigation management using different Artificial Intelligence (AI) models, wastewater recycling, and rainwater harvesting. The information gathered for these uses is exclusive and varies in kind. Applying a model or algorithm that can be used to provide solutions for all of these applications is therefore desperately needed. An intelligent water management system can be designed for sustainable water use from natural resources with the help of Artificial Intelligence (AI) and Deep Learning (DL) techniques combined with an Internet of Things (IoT) framework.

**Keywords**: digital agriculture, microwave satellite sensors, hydrological studies, water distribution, irrigation management, crop health, soil conditions.

## INTRODUCTION

Sustainable agriculture depends on maintaining the health of the soil. AI-powered systems are able to offer real-time insights and continuously monitor important soil parameters. In order to improve soil structure, fertility, and water retention, this aids farmers in putting suitable soil management techniques into practice, such as crop rotation and cover crops. Crop health and growth can be adversely affected by an incorrect combination of nutrients in the soil. Farmers can quickly make the required adjustments by using AI to identify these nutrients and determine their effects on crop yield. Computer vision models can monitor soil conditions to collect accurate data, while human observation is limited in its accuracy. After that, crop health and yield predictions are made using this data from plant science, along with a flag for any specific problems. In actual use, artificial intelligence (AI) has demonstrated a level of speed and accuracy that surpasses that of humans in tracking the stages of wheat growth and tomato ripeness. Advances in big data analytics, robotics, the internet of things, low-cost sensors and cameras, drone technology, and even widespread internet access on geographically separated fields will make it possible to apply AI to agriculture. AI systems will be able to predict which crop to plant in a given year and when the best dates to sow and harvest are in a particular area, increasing crop yields and reducing the use of water, fertilizers, and pesticides. They will do this by analyzing soil management data sources such as temperature, weather, soil analysis, moisture, and past crop performance. AI technology use has the potential to improve worker safety and lessen its negative effects on natural ecosystems, which in turn will keep food prices down and ensure that the food production will keep pace with the increasing population. Farming entails a great deal of choices and uncertainties Crops become unviable due to weeds suffocating them, pests damaging them, soil deterioration, fluctuating prices of farming supplies, and varied weather from season to season. These uncertainties must be managed by farmers. Successful agriculture depends on healthy soil, which is the origin of the nutrients that are used in crop growth. In agriculture and forestry, soil is the foundation of all production systems and fishing. In order to ensure that crops grow and develop properly, the soil stores proteins, nutrients, and water.

By 2050, it's predicted that there will be more than nine billion people on the planet, meaning that 70% more agricultural output will be needed to feed everyone. Remaining lands may only contribute about 10% of this increased production; the remaining amount should come from intensifying current production. To make farming more efficient in this context, utilizing the most recent technological advancements is still vital. The market wants high-quality food, and current strategies to increase agricultural production call for large energy inputs. Global industries stand to be drastically changed by robotics and autonomous systems (RAS). Agro-food production, or the process of producing food from the farm to the store shelf, is one of the major economic sectors that will be greatly impacted by these technologies. Non-numerical data, including text, audio, video, and image data, can be processed more accurately by artificial intelligence (AI). Therefore, in order to process the decision-making more robustly, it is necessary to match the geophysical influence data on soil quality with artificially intelligent systems (Liu et al. 2014). In order for AI to analyze and recommend a crop management strategy, the data does not even need to be vast enough.

**Soil-Water Interactions:**

The potential of the soil to anchor water might vary depending on the physicochemical texture and climate (Singh and Nair, 2023) various types of soil can hold various amounts of water. But the thorough description of soil-water does not fully explain the scientific concepts guiding field crops' water absorption ( Adhikari et al. 2022). There are various varieties of soil-water, including capillary soil-water (CSW), gravitational soil-water (GSW), and hygroscopic soil-water (HSW). The diverse range of soil-water combinations are susceptible to unique and fluctuating factors that deteriorate the soil (Rayne and Aula 2020). Hydrogen bonding, or more commonly, soil-particle physical interactions, hold the HSW components in vapor form. Because of the tight soil binding, there is very little chance that the crops may strain these contents during growth. Gravity pulls GSW materials firmly to the bigger soil pores to a great depth, frequently raising the water table (Fu et al. 2021). The crops also use this GSW far less frequently because of their shorter root lengths. Generally speaking, crops can only access GSW contents momentarily before being exhausted. The CSW contents that comprise the maximum field capacity are therefore the actual and easily accessible water contents used by crops. Furthermore, the point at which plants are incapable of absorbing any more water is known as the permanent wilting point, and it is reached when the field capacity is inaccessible to them because of the strong bonding of the residual water with the soil (Ben-Noah et al. 2021). The available soil-water, which is often estimated at -15 bar, is now more than the crop's ability to absorb water. As a result, the crop's water draw point is located halfway between field capacity and the point of irreversible withering. Crops' ability to absorb water and nutrients is influenced by the way soil-water interactions with soil particles. Facilitating crop water uptake is determined by the difference in root water potential between the crop and the soil (Vico et al., 2023).

Crop root water potential refers to the force and instantaneous concentration of water generated by the water within the roots of crops. The direction in which water moves into or out of the plant is mostly determined by this factor, as water movement is invariably described as spontaneous from higher to lower potentials. Another way to calculate crop root water potential is to use the pressure potential, turgor pressure, and solute potentials. All the water molecules' interactions with the soil (adhesion) and with each other (cohesion) are actually what control the flow of water. Another important element limiting water movement uphill is


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

gravitational pull. Plants can only absorb soil-water when they are able to resist the adhesion and gravitational pull of water molecules, which are often connected with one another. Because soil textures and porosity vary, it is challenging for plants to absorb water, even at more practical bar pressures. The suction processes described by TACT theory (transpiration, adhesion, cohesion, and tension) justifies the transfer of water from soil to plant roots. Crops absorb nutrients more easily because of the differences in nutrient composition between soil and crop roots. The amount of nutrients contained in a plant's sap is referred to as the plant nutrient concentration, and it is expressed as a mass or molarity ratio per unit volume (Chen et al. 2022). The species, growth stage, and environmental factors all affect the concentration of nutrients in plants. For the best growth and output, crops require sufficient amounts of both water and nutrients. Numerous elements, including soil texture, structure, organic matter, pH, cation exchange capacity, fertilizer application, climate, crop species, growth stage, climatic conditions, root system features, etc., affect how soil-water interacts with soil particles. Soil texture refers to the quantities of sand, silt, and clay in the soil (Barman and Choudhury 2020).

The ability of soils to hold water or modify the capacity for cation exchange is thought to be two ways in which soil texture affects nutrient availability. Since water holding capacity is the most important factor supporting plant nutrient uptake and transport processes, it affects the amount of water held by soil for plant use. Generally speaking, finer-textured soils, or clayey soils, have a larger ability to hold water than coarser-textured soils, or sandy soils. Clayey soils, however, can potentially become anaerobic or wet if drainage is inadequate, which can restrict plant development and nutrient availability (Wang et al. 2021a). Various factors, including soil texture, structure, organic matter content, pH levels, cation exchange capacity, and fertilizer application, influence the variability of soil nutrient concentration. Precipitation is the main source of support for SWCs in most arable land textures, which is essential for arid vegetation support and the eco hydrological cycle (Xu et al., 2023).

Different soil types coexist with diverse microbial communities to preserve their microscale textural variety (Huang et al., 2023). The distribution of soil pores is directly correlated with soil heterogeneity, which determines the majority of soil textures (Rooney et al. 2022).

Clayey soils, however, can become anaerobic or flooded if drainage is inadequate because of their higher matric potential, which inhibits gravitational drainage ( Mulla et al; 2023).Because pore space and pore size distribution vary with soil texture, so do SWCs. Under all moisture levels, clayey soils have a lower hydraulic conductivity and a higher SWC than


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

sandy soils. This impacts the soil's ability to store water and the flow of water through it, which in turn impacts a number of processes like plant development, nutrient cycling, water balance, and soil erosion. For the purpose of efficiently managing soil and water resources, it is crucial to comprehend the link between SWC and soil texture.

**Effective Water Management through the Use of IoT and Artificial Intelligence**

Agriculture productivity, ecosystem health, and sustainable farmland management have all been proven to be significantly impacted by soil texture (Zhai et al. 2006). Planning and managing agricultural land involve making decisions based on a variety of factors, one of which is the texture of the soil. The traditional methods involving agricultural sensors and statistical analysis were discovered to be unreliable, costly, time-consuming, and non-instantaneous. Still, new paths for texture prediction and transformed soil management techniques have been made possible by sophisticated AI processing tools and machine learning applications. Consequently, a great deal of time, specialized equipment, and knowledgeable personnel are needed for all of these laborious tasks. The limits that would otherwise restrict soil management are, however, potentially overcome by AI tools. Predicting soil texture accurately and effectively could be made possible by AI techniques such as machine learning (ML) and deep learning (DL). Geographic, spectral, and compositional data sets—some of which may not be in mathematical form—are the inputs used by these algorithms. In comparison to traditional laboratory techniques, AI processing of these data sets primarily lowers the associated costs, times, and labor. Wang et al. (2021b) state that the ML and DL algorithms facilitate the rapid acquisition and application of the intricacy of relationships among the data sets. The constraints of conventional laboratory-based procedures can be overcome, and real-time decision-making in soil management practices can be enabled, by utilizing artificial intelligence capabilities. Therefore, for AI-based soil texture analysis to be implemented successfully, it will be essential to solve issues with data quality, interpretability, and system integration (Liu et al. 2022). Sustainable land management, agricultural productivity, and environmental conservation can all be greatly enhanced by AI-driven soil analysis with further research, cooperation, and innovation. Together, scientists, engineers, and politicians must develop a seamless integration of AI models into current soil management procedures and decision support.

AI has proven beneficial in several domains, including robotics, medical imaging, disease detection, and flight control systems. Important problems in hydrology, meteorology, and agronomy have also been discovered to be amenable to AI solutions. AI source codes have recently proven beneficial to the science of SWC measurement as well. It has demonstrated excellent performance, correlation, and statistical correctness as a manager of the water and soil states (Gao et al. 2022). This is a very clever addition to sound agricultural decision-making that takes into account a range of environmental considerations.According to Pernet and Ribi Forclaz (2019), the Food and Agriculture Organization (FAO) estimates that agriculture would account for around 70% of freshwater withdrawals worldwide by 2050, with the potential to increase to 15% in order to fulfill the increasing demand for food due to population growth.In order to tackle this issue, numerous scholars and professionals have suggested and executed intelligent irrigation systems, which employ sensors, actuators, controllers, communication networks, and data analysis instruments to monitor and regulate the watering of crops in accordance with their requirements and surrounding circumstances (Jong et al;2021) The high cost of maintenance, the lack of standardization and interoperability across many platforms and devices, the difficulty of processing and interpreting data, and the unpredictable and variable responses of crops to irrigation are some of the drawbacks of smart irrigation systems.

Thus, it is believed that artificial intelligence (AI) significantly contributes to the improved functionality and efficiency of smart irrigation systems.AI can also assist farmers in optimizing the timing and distribution of their irrigations with machine learning algorithms that can foresee future events, learn from past and present data, and adjust to changing circumstances. As such, making effective use of these resources instead of relying solely on traditional statistical methods and thorough data analysis may be the new paradigm for more intelligent agricultural practices, particularly with regard to soil management. Many scientists, engineers, and biologists have been working on various materials related to habitats, agriculture, and biological sciences during the past few years.

**Development of an International Soil Texture and SWC Dataset**

The type and strength of agricultural land determines several biological processes, water availability, and agricultural output. In order to decide on efficient land use, sustainable agriculture, and water management, soil texture and SWC are more important factors (Maino et al. 2022). Nevertheless, it is very challenging to get thorough and trustworthy soil information because of the large surface area of the earth and the geographical variability of the soil (Martinelli and Gasser 2022). Farmers, legislators, and land managers may be able to promptly implement smart agricultural techniques with the use of the worldwide data set of SWC and soil texture information. Important hydrological analysis and climate modeling can also benefit from these data sets. In order to create predictive models based on accessible soil


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

data and auxiliary environmental variables, machine learning algorithms like random forests, support vector machines, and neural networks can be used. By helping to interpolate and extrapolate soil property values to unsampled sites, geostatistical techniques like kriging and co-kriging enhance the dataset's spatial representation (Naimi et al. 2022).

Airborne sensors and satellite pictures are examples of remote sensing technology that can indirectly provide important information on soil conditions. These sensors' spectral signatures can be connected with information gathered from ground-based observations of soil moisture content and texture. A greater amount of soil data is also collected by proximal sensing methods like ground-penetrating radar and electromagnetic induction. Accurately representing the worldwide spatial heterogeneity of soils requires a sufficient distribution of soil samples throughout various land cover categories, soil types, and geographies. It can be difficult to obtain a representative data set due to sampling biases and restricted access to some areas. Standards and harmonization are necessary to guarantee consistency and compatibility for soil data gathered with various protocols, laboratory techniques, and equipment. To combine various data sets into a cohesive global database, strong quality control methods and data harmonization processes must be developed. Developing a complete worldwide data set requires promoting data exchange across academics, institutions, and national soil agencies. In order to fill in data gaps and encourage data exchange, regional and global collaboration can assist produce a dataset that is more comprehensive and trustworthy.

**Conclusion**

Data privacy ethics are becoming more and more important as we enter a new era when Artificial Intelligence is revolutionizing agricultural water management. Many IoT devices, sensors, and real-time monitoring systems generate a lot of data, which begs important concerns about who can access and use this data. A precise balance to make sure AI systems use data to improve farming operations without jeopardizing the privacy of individual farmers is imperative. Achieving this balance calls for strict laws and open policies that protect farmers' rights and promote innovation. For smallholder farmers, the expense of deploying AI-powered devices may be prohibitive. Innovative funding schemes, grants, and partnerships with governmental and non-governmental groups are required to make these technologies accessible to all farmers and to make AI solutions financially feasible. In order to maximize the influence of AI on agricultural water management, cooperation and knowledge sharing are essential. Cross-disciplinary cooperation is necessary for effective solutions, bringing together techies, doctors, problem solvers, and—most importantly—farmers. Holistic, long-term solutions can result from dismantling sectoral silos and encouraging interdisciplinary cooperation. The


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

unique requirements and environments of local communities should be taken into account in designing AI systems. A practical, culturally appropriate, and genuine solution to the problems encountered by the local community is guaranteed when farmers are involved in the development process. Effective innovations can be facilitated by the combination of technology know-how with local understanding. In order to ensure that AI is widely used in agriculture, knowledge sharing platforms must be established. The exchange of best practices, success stories, and lessons learned can be facilitated by these platforms, resulting in a dynamic ecosystem that hastens the beneficial effects of AI on water management throughout the continent. For the effective integration of AI into agricultural practices, which will promote sustainability and resilience in the face of changing environmental and economic conditions, the cooperation of techies, medical professionals, and problem solvers becomes more than just advantageous in navigating these challenges.

**References**

Adhikari S, Timms W, Mahmud MAP (2022) Optimising water holding capacity and hydrophobicity of biochar for soil amendment—a review. Sci Total Environ 851:158043.

Ben-Noah I, Nitsan I, Cohen B, Kaplan G, Friedman SP (2021) Soil aeration using air injection in a citrus orchard with shallow groundwater. Agric Water Manag 245:106664.

Barman U, Choudhury RD (2020) Soil texture classification using multi class support vector machine. Inform Process Agric 7(2):318–332.

Chen X et al (2022) Root physiological adaptations that enhance the grain yield and nutrient use efficiency of maize (Zea mays L) and their dependency on phosphorus placement depth. Field Crops Res 276:108378.

Fu Y, Horton R, Heitman J (2021) Estimation of soil water retention curves from soil bulk electrical conductivity and water content measurements. Soil Tillage Res 209:104948.

Gao L et al (2022) A deep neural network based SMAP soil moisture product. Remote Sens Environ 277:113059.

Huang Q, Zhang H, Zhang L, Xu B (2023) Bacterial microbiota in different types of processed meat products: diversity, adaptation, and co-occurrence. Crit Rev Food Sci Nutr. https://doi.org/10.1080/10408398.2023.2272770.

Jong SC, Ong DEL, Oh E (2021) State-of-the-art review of geotechnical-driven artificial intelligence techniques in underground soil-structure interaction. Tunn Undergr Space Technol 113:103946.

Liu Z, Zhou W, Shen J, Li S, Ai C (2014) Soil quality assessment of yellow clayey paddy soils with different productivity. Biol Fertil Soils 50(3):537–548.

Liu X et al (2022) PiLSL: pairwise interaction learning-based graph neural network for synthetic lethality prediction in human cancers. Bioinformatics 38:ii106–ii112.

Maino A et al (2022) Airborne radiometric surveys and machine learning algorithms for revealing soil texture. Remote Sens. https://doi.org/10.3390/rs14153814.

Martinelli G, Gasser M-O (2022) Machine learning models for predicting soil particle size fractions from routine soil analyses in Quebec. Soil Sci Soc Am J 86(6):1509–1522. https://doi.org/10.1002/saj2.20469.

Mulla AR, Rodd SM, Sankpal SV, Yedave PM, Ghorpade YB, Nejkar MV (2023) Assessment of water logging and its remedial measures. Int J New Media Stud Int Peer Rev Sch Index J 10(1):143–151.

Naimi S, Ayoubi S, Demattê JAM, Zeraatpisheh M, Amorim MTA, Mello FA (2022) Spatial prediction of soil surface properties in an arid region using synthetic soil image and machine learning. Geocarto Int 37(25):8230–8253.

D. G. Panpatte, Artificial Intelligence in Agriculture: An Emerging Era of Research, Anand Agricultural University, 2018 .

Pernet CA, Ribi Forclaz A (2019) Revisiting the Food and Agriculture Organization (FAO): international histories of agriculture, nutrition, and development. Int Hist Rev 41(2):345–350.

Rayne N, Aula L (2020) Livestock manure and the impacts on soil health: a review. Soil Syst. https://doi.org/10.3390/soilsystems4040064.

Rooney EC et al (2022) Soil pore network response to freeze-thaw cycles in permafrost aggregates. Geoderma 411:115674.

Singh IR, Nair PN (2023) Evaluation of physicochemical properties with the availability of plant nutrients in forests and crop farms in different Fijian provinces. Plant Sci Today 10(3):211–219.

Vico G, Tang FHM, Brunsell NA, Crews TE, Katul GG (2023) Photosynthetic capacity, canopy size and rooting depth mediate response to heat and water stress of annual and perennial grain crops. Agric for Meteorol 341:109666.

Wang Q et al (2021a) Coastal soil texture controls soil organic carbon distribution and storage of mangroves in China. CATENA 207:105709.

Wang S et al (2021b) Advances in data preprocessing for biomedical data fusion: an overview of the methods, challenges, and prospects. Inform Fus 76:376–421.

Xu Y, Gao Y, Li W, Chen S, Li Y, Shi Y (2023) Effects of compound water retention agent on soil nutrients and soil microbial diversity of winter wheat in saline-alkali land. Chem Biol Technol Agric 10(1):2.

Zhai Y, Thomasson JA, Boggess JE, Sui R (2006) Soil texture classification with artificial neural networks operating on remote sensing data. Comput Electron Agric 54(2):53–68.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

TRENDS IN AGRICULTURE SCIENCE

Vol.3 Special Issue 01 January 2024, Page: 155-157

# Smart Coconut Farming with Artificial Intelligence (AI)

**Dr.P.Vasuki**
Department of CSE, Bharath Institute of Higher Education Research,
Selaiyur, Tambaram

Coconut farming is widespread in India, particularly in states like Kerala, Karnataka, Tamil Nadu, Andhra Pradesh, and Maharashtra. The country is one of the world's largest producers of coconuts. Farmers cultivate coconuts for various purposes, including oil extraction, copra production, and consumption of tender coconuts. The diverse uses of coconut contribute significantly to India's agricultural and economic landscape. There are several types of coconut trees, each with its unique characteristics and uses. The two main types are:

Tall Coconut Trees (Cocos nucifera): These are the most common and traditional type of coconut trees. They grow tall, reaching up to 30 meters in height, and have a straight trunk. Tall coconut trees are primarily cultivated for copra (dried coconut kernel) and coconut oil production.

Dwarf Coconut Trees: These coconut trees are shorter in stature, typically reaching a height of 6 to 12 meters. Dwarf varieties are known for their shorter, more compact form, making them easier to manage and harvest.

They are often preferred for home gardens and commercial plantations where space is limited. Within these broad categories, there are numerous cultivars and varieties adapted to different climates and regions. Some coconut varieties are selected for their resistance to diseases, adaptability to specific soil conditions, or superior yield characteristics. It's important for coconut farmers to choose the appropriate variety based on factors such as climate, soil type, and intended use of the coconuts. Additionally, there are various coconut palm hybrids developed through breeding programs aimed at improving traits like disease resistance, productivity, and quality of coconut products.

**Water Sustainability**: Implementing smart watering techniques in coconut farms involves utilizing technology to optimize irrigation practices. Here are some strategies for smart watering in coconut farming:


**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

**Soil Moisture Sensors**: Install soil moisture sensors in different parts of the coconut plantation to measure soil moisture levels. This data helps in determining when and how much water is needed, preventing overwatering or under-irrigation.

**Weather-based Irrigation:** Integrate weather forecasting data with irrigation systems to adjust watering schedules based on upcoming weather conditions. This ensures that irrigation is aligned with the specific needs of the coconut palms. Drip Irrigation Systems: Implement drip irrigation, a precise and efficient method that delivers water directly to the base of each coconut palm.

This minimizes water wastage and promotes deep root penetration. Smart Irrigation Controllers: Use smart controllers that can be programmed or controlled remotely. These controllers can adjust irrigation schedules based on real-time data, optimizing water usage and responding to changing environmental conditions. Mobile Apps for Monitoring: Develop or use existing mobile applications that provide real-time monitoring of soil moisture and irrigation activities. Farmers can receive alerts and insights, allowing them to make informed decisions about watering.

**Rainwater Harvesting:** Integrate rainwater harvesting systems to collect and store rainwater during the monsoon season. This stored water can supplement irrigation needs during drier periods, contributing to sustainable water management.

**IoT-enabled Water Management:** Utilize Internet of Things (IoT) devices to create a networked water management system. These devices can communicate with each other, optimizing water distribution based on the specific requirements of different areas within the coconut farm. Implementing smart watering practices not only conserves water but also enhances the overall health and productivity of coconut palms by providing them with the right amount of water at the right time.

**Smart coconut farming**:

Smart coconut farming involves incorporating modern technologies and practices to enhance productivity, efficiency, and sustainability. Some aspects include: Precision **Agriculture:** Utilizing sensors and IoT devices to monitor soil moisture, temperature, and nutrient levels, allowing farmers to optimize irrigation and fertilization.

**Data Analytics:** Analysing data collected from sensors and other sources to make informed decisions about crop management, pest control, and resource allocation. Drones and **Satellite Imaging:** Employing drones or satellite imagery for aerial surveys to assess crop health, identify diseases, and plan plantation layouts effectively.

**Mobile Apps:** Providing farmers with mobile applications that offer real-time information, weather forecasts, and expert advice for better decision-making. Automation: Integrating


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

automated systems for tasks such as irrigation, harvesting, and pest control to streamline processes and reduce manual labor.

**Climate-Smart Agriculture:** Adapting farming practices to changing climate conditions by implementing strategies that enhance resilience, water conservation, and resource efficiency.

**ICT Solutions:** Using Information and Communication Technology solutions to connect farmers, facilitate knowledge exchange, and improve market access.

By adopting these smart farming practices, coconut farmers in India can enhance their yields, reduce resource inputs, and contribute to the sustainability of coconut cultivation.

**AI to smart coconut farming:**

Incorporating artificial intelligence (AI) can revolutionize the industry by providing advanced analytics, decision support, and automation. Here are some ways AI can be applied to smart coconut farming:

**Predictive Analytics:** AI algorithms can analyse historical data, weather patterns, and soil conditions to predict optimal planting times, disease outbreaks, and yield expectations, assisting farmers in making proactive decisions.

**Image Recognition:** AI-powered image recognition can identify crop diseases, pests, and nutrient deficiencies early on, enabling prompt intervention and minimizing crop losses. Precision Farming: AI-based precision agriculture uses sensors and data analytics to precisely manage irrigation, fertilization, and pesticide application, optimizing resource usage and improving overall efficiency.

**Crop Monitoring with Drones:** Drones equipped with AI-powered cameras can monitor coconut plantations, providing high-resolution images for detailed crop health analysis and identifying areas that need attention. Smart Irrigation Systems: AI algorithms can analyse real-time weather data, soil moisture levels, and crop requirements to autonomously control irrigation systems, ensuring water is used efficiently.

**Harvesting Automation:** AI-driven robotic systems can be employed for automated coconut harvesting, reducing labour costs and improving overall efficiency. Chatbot Assistance: AI-powered chatbots can assist farmers by providing instant information on best practices, troubleshooting, and general guidance, contributing to continuous learning and improvement. Integrating

AI into coconut farming not only enhances productivity but also helps in sustainable and resource-efficient practices, making the farming process more adaptive to dynamic conditions.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

TRENDS IN AGRICULTURE SCIENCE
Vol.3 Special Issue 01 January 2024, Page: 158-160

# Artificial Intelligence Applications in Soil and Water Management: A Comprehensive Review

**Dr. Sangeetha**
HOD, Department of Tourism and Hospitality Management,
Bharath University, Chennai - 600073.
https://doi.org/10.5281/zenodo.10605404

***Abstract***

Agriculture, a cornerstone of human civilization, faces unprecedented challenges in the 21st century. Population growth, climate change, and resource limitations compel the industry to seek innovative solutions. Artificial Intelligence (AI) has emerged as a transformative force, offering unprecedented opportunities to enhance efficiency, sustainability, and productivity in agriculture.
**Key Words**: sustainability, innovative, transformative

**Introduction:**

In recent years, the application of artificial intelligence (AI) in agriculture has gained significant attention, particularly in the realms of soil and water management. Traditional agricultural practices face increasing challenges due to climate change, population growth, and resource scarcity. AI technologies offer innovative solutions to optimize resource usage, enhance productivity, and promote sustainable agriculture.

1. **Precision Agriculture:**

AI enables precision agriculture, a paradigm shift from traditional blanket approaches to targeted, data-driven strategies. By leveraging sensors, drones, and satellite imagery, AI assists farmers in optimizing resource usage. This results in improved crop yields, reduced environmental impact, and enhanced overall efficiency.

2. **Crop Monitoring and Management:**

AI plays a pivotal role in monitoring crop health, predicting diseases, and optimizing management practices. Machine learning algorithms analyse vast datasets, including climate patterns and soil conditions, to provide real-time insights. This empowers farmers to make informed decisions, mitigating risks and maximizing crop output.


**Published**: 23 Jan. 2024
**ISSN**: 2583-7850

3. **Autonomous Machinery:**

Advancements in AI have led to the development of autonomous farming machinery. Smart tractors and harvesters equipped with AI-driven systems can perform tasks with unparalleled precision. This not only reduces the need for manual labour but also enhances the efficiency of farm operations.

4. **Challenges in Traditional Soil and Water Management:**

Traditional soil and water management practices are often constrained by their reliance on historical data and manual intervention. Climate variability, soil degradation, and inefficient water usage pose substantial challenges to the agricultural sector. These challenges necessitate a paradigm shift, and AI emerges as a promising tool to address these issues.

5. **AI Technologies in Soil Quality Assessment:**

AI models, particularly machine learning algorithms, play a pivotal role in assessing soil quality. These models leverage vast datasets to predict soil properties, nutrient levels, and potential crop yields. By analysing historical and real-time data, AI contributes to precision agriculture, allowing farmers to make informed decisions regarding soil amendments, fertilization, and crop selection.

6. **Precision Irrigation Management:**

AI-driven systems are transforming irrigation practices by optimizing water usage. Smart irrigation systems utilize sensor data, weather forecasts, and soil moisture levels to tailor irrigation schedules. This not only conserves water resources but also ensures that crops receive the precise amount of water required for optimal growth.

7. **Remote Sensing and AI for Environmental Monitoring:**

The integration of remote sensing technologies with AI enhances environmental monitoring. Satellite imagery, coupled with machine learning algorithms, allows for the detection of soil erosion, water stress, and crop health. Real-time monitoring facilitates timely interventions, enabling farmers to address issues before they escalate.

8. **Case Studies:**

Numerous case studies demonstrate the successful implementation of AI in soil and water management. For instance, a project in California utilized AI algorithms to analyze soil moisture data and optimize irrigation across vineyards, resulting in a 20% reduction in water usage while maintaining crop yield.

9. **Challenges and Future Directions:**

Despite the advancements, challenges such as data privacy, algorithm robustness, and the digital divide need addressing. On-going research aims to refine AI models, enhance


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

interpretability, and make these technologies accessible to a broader range of farmers, ensuring equitable benefits across diverse agricultural landscapes.

**Conclusion:**

Artificial intelligence stands as a transformative force in soil and water management, offering sustainable solutions to age-old challenges. As technology continues to evolve, the agricultural sector has the opportunity to embrace AI, foster innovation, and build a resilient foundation for future food security.

**Reference:**

Smith, A., et al. (2022). "Machine Learning Approaches for Soil Quality Assessment in Agriculture." Journal of Agricultural Science, 45(3), 267-285.

Chen, B., et al. (2021). "Application of Artificial Intelligence in Precision Irrigation: A Review." Agricultural Water Management, 198, 106981.

Wang, Y., et al. (2023). "Remote Sensing and Machine Learning for Agricultural Environmental Monitoring: A Comprehensive Review." Remote Sensing of Environment, 215, 112176.

Johnson, C., et al. (2020). "AI-Enabled Precision Agriculture: A Case Study in Sustainable Water Management." Agricultural and Forest Meteorology, 281, 107855.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

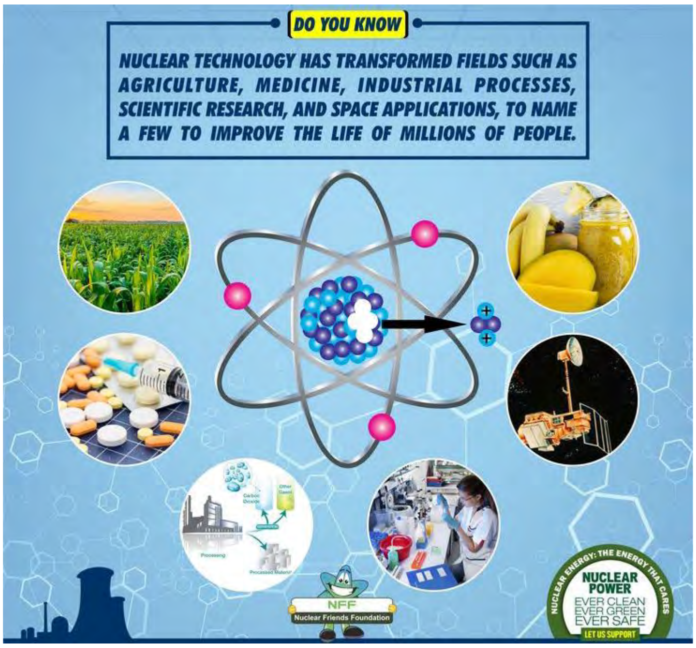
TRENDS IN AGRICULTURE SCIENCE
Vol.3 Special Issue 01 January 2024, Page: 161-163

# Nuclear Techniques in Agriculture Biotechnology

**C. Gurumoorthy**

Dean, School of Civil
Director, Centre of Excellence in Applied Nuclear Research
Bharath Institute of Higher Education and Research
Selaiyur, Chennai-600073
https://doi.org/10.5281/zenodo.10605417

Centre of Excellence in application of nuclear techniques was commissioned in this university to spearhead Nuclear Research Interdisciplinary research programs in Environmental Sciences, Industrial Biotechnology, Medical, Agriculture, Material Science, Nanotechnology. As such, this centre envisages an insight in generating professionals with specialization in Applied Nuclear techniques to achieve their prospective goals. Academic and Research activities are interdisciplinary in nature and this is to ensure that the related field would be an added advantage to those who are motivated to develop their career with specialization in Applied Nuclear Techniques in National /International arena. Joint project programs with National and International Academic, R&D Institutions and Industries are in progress.





Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

- Nuclear techniques in Agriculture are associated with application of radiation to increase the genetic variation of cereals, oilseeds, and industrial crops as well as fruit trees
- Also, usage of radioisotopes helps to assess the mechanism of soil nutrition uptake by plants as well as fertilizer/pesticide contamination levels in Agriculture products
- Irradiation is as an effective and widely accepted method that has been endorsed by international bodies such as the World Health Organization, the Food and Agricultural Organization who judged the process to be safe without detriment to health and with minimal effect on nutritional or sensory quality.
- Evaluation of soil erosion rates by tracing cosmic $Be^7$ isotope

With an objective to understand the importance of nuclear techniques applications in the field of Agricultural Science, especially in the field of biotechnology, this article summarizes various aspects of agriculture biotechnology incorporating applications of nuclear techniques:

**Gamma radiation induced mutation in plant breeding**

In plant breeding programs, one of the oldest methods is mutation breeding. Currently, in plant biotechnology, mutation breeding has become popular among the breeders. Scientists use physical mutagens techniques (X-rays, UV light, neutrons-alpha-beta particles, fast and thermal neutrons, especially gamma rays) to artificially induce mutations (mutagenesis). However, gamma-rays are widely used. During the irradiation of the seeds with ionizing radiation to generate mutants with desirable traits, reactive oxygen species (ROS) or free radicals can be generated in cells. Usability of gamma-irradiation is to provide the permanent gene expression of antioxidant enzymes and proline through the production of ROS.

Effective method that can cause DNA changes via direct and indirect actions. Many crop varieties have been created using gamma irradiation mutagenesis technology for trait improvement that enhance the characteristic or increase the abiotic and biotic stress tolerance. Interestingly, up to 97% of the gamma irradiation mutations were concentrated in certain regions in chromosome 5H and chromosome 7H. Of the 26,745 expressed genes, 140 were affected by gamma-ray radiation; their biological functions included cellular and metabolic processes.

In recent decades, many mutation genes have been identified which are responsible for phenotype changes in mutants in various species including *Arabidopsis* and rice. Mutation feature in induced mutants and the underlying mechanisms of various types of artificial

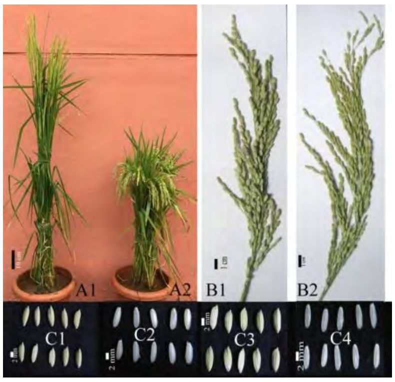

Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

mutagenesis remain unclear.Of the 26,745 expressed genes, 140 were affected by gamma-ray radiation; their biological functions included cellular and metabolic processes.

Due to the loss of arable lands and changing climatic patterns there is a need to develop cultivars with improved plant architecture, high yield and superior grain quality. Improved White Ponni (IWP) is one such rice variety with fine-slender grain, high yield potential, moderate resistance to tungro, rice blast, bacterial blight, mite and green leafhopper. Semi-dwarfism in rice, conferred by the *sd-1* gene, improves lodging resistance and yield. After the release of IR8 –the miracle rice by IRRI, most of the modern rice varieties were developed with the semi-dwarf gene, *sd1*.

**Mechanisms of Radiation induced mutation**

- ✓ Seeds of Improved White Ponni were treated with different doses of gamma irradiation (100, 200, 300, 400 and 500 Gy) in the Gamma Chamber facility (Model GC1200, Tamil Nadu Agricultural University, Coimbatore, India).
- ✓ The overall agronomic performances of the IWP mutants were better than the IWP-control as studied in the $M_6$ generation.
- ✓ The mean performance of IWP mutants indicates a significant reduction in plant height and days to flowering.
- ✓ IWP mutants showed increased yield than IWP-control.
- ✓ A yield increase of up to 18.65 g (45.73%) in mutant WP-15-5.
- ✓ WP-15-1, WP-15-5, WP-16-1, WP-16-2, WP-16-4, WP-22-2 and WP-22-3 have recorded yield increase above 20% than IWP-control.




A1) The parent variety IWP;
A2) a semi-dwarf, early maturing and high-yielding mutant, WP-22-2 (note: the IWP is still in the flowering stage while in the WP-22-2, the panicles are already maturing); scale bar– 10 cm;
B1) Panicle of the IWP and B2) WP-22-2; scale bars– 1 cm; C1 & C3) Rice kernels of IWP and WP-22-2; 2&C4) dehusked kernels of IWP and WP-22-2; scale bars– 2mm.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

TRENDS IN AGRICULTURE SCIENCE

Vol.3 Special Issue 01 January 2024, Page: 164-168

# IoT in Agriculture: Applications and Advantages

**Dr.S.Neduncheliyan**
Dean & Professor
School of Computing
Bharath Institute of Higher Education Research,
Selaiyur, Tambaram
https://doi.org/10.5281/zenodo.10605431

The rapid advancement of technology across various sectors has revolutionized how we live and work. For agriculture with the Internet of Things (IoT), a new wave of innovation has emerged that promises increased productivity, sustainability, and efficiency. With a network of interconnected devices and sensors that collect and exchange data, IoT in Agriculture will enhance the management of livestock rearing and crop cultivation, fostering predictability and optimizing efficiency. By harnessing IoT in the agriculture industry, farmers & agribusinesses can make data-driven decisions, maximize resource utilization, monitor crop health, and automate various processes. In this article, just explore some of the applications of the Internet of Things in agriculture with their benefits

## I. What is Smart Agriculture, and Why Do We Need IoT in Agriculture Industry?

Smart Agriculture, also called precision agriculture or agrotechnology, is all about using advanced technologies & data-driven approaches for optimizing agricultural practices and improving overall efficiency. Smart farming leverages the power of automation, connectivity, and real-time monitoring to enhance decision-making processes & maximizing agricultural output.

IoT provides a network of interconnected devices and sensors for the industry that collects and share data. They can be embedded in soil, crops, machinery, and livestock to monitor temperature, humidity, soil moisture, nutrient levels, and animal behavior. Further, this gathered data is then analysed & utilized for making informed decisions about irrigation, fertilization, disease prevention, and overall farm management. For instance, farmers can now access real-time data from their smartphones or tablet and monitor soil conditions and crop


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

health. Precise insights enable efficient decision-making to maximize fertilizer usage and optimize farm vehicle routes.

## II. Market Size of IoT in Agriculture

The Global IoT and Agriculture Market is rapidly growing, with a project valuation of USD 26.93 Billion by 2027. The increasing demand for agricultural produce fuels this market, IoT and AI technology adoption, and a focus on livestock monitoring and disease detection to enhance farming efficiency.

Food companies worldwide are embracing modern devices and technologies for systematic storage to meet the rising demands for quality food commodities. Meanwhile, governments actively promote smart farming through awareness programs, policy transformations, and collaborations with the private sector.

## III. Impact of the Industrial Internet of Things on Agriculture

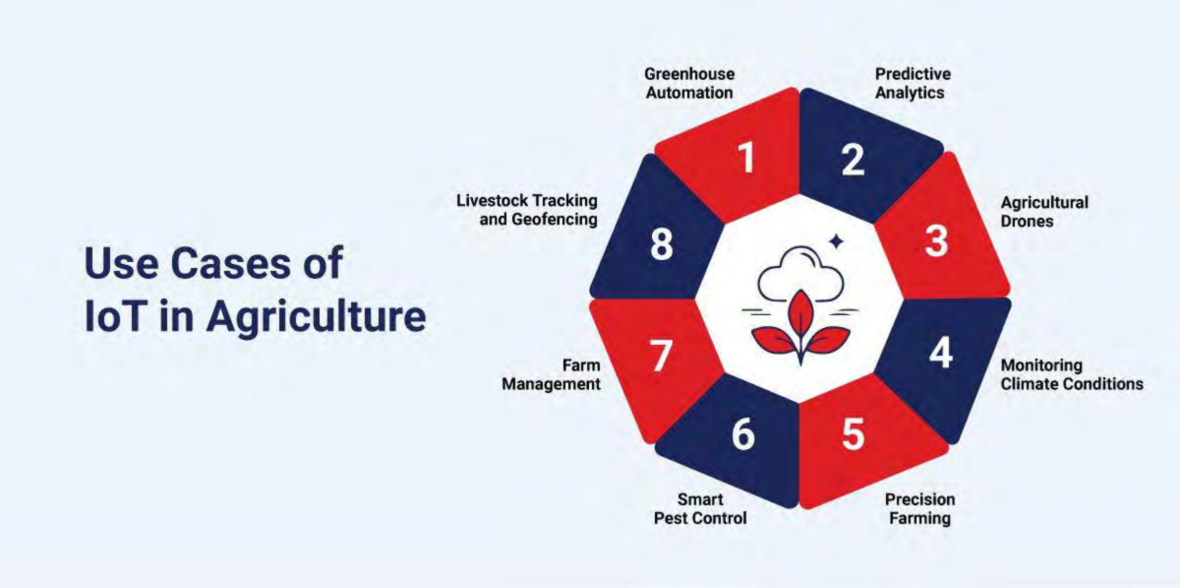
Industrial IoT (IIoT) has significantly impacted the agriculture industry. Today, it is revolutionizing traditional farming practices and enabling a new era of smart agriculture.

Listed below are some of the critical impacts of IIoT in agriculture:

- **Enhanced efficiency and productivity** with remote monitoring of soil conditions, weather patterns, crop health, and equipment performance.
- **Improved resource management** with intelligent irrigation systems to adjust watering schedules based on real-time data, ensuring that crops receive the right amount of water at the right time.
- **Enhanced crop monitoring and disease detection** enable continuous monitoring of crops, allowing farmers to detect early signs of illness, nutrient deficiencies, or pest infestations.
- **Livestock monitoring and management** for livestock health, behavior, and environmental conditions to track parameters like body temperature, heart rate, feeding patterns, and location in real time.
- **Data-driven decision-making** helps farmers to leverage insights to optimize production processes, fine-tune resource allocation, and mitigate risks.
- **Supply chain optimization** with end-to-end visibility and traceability throughout the agricultural supply chain – from field to fork, data collected along the value chain can be tracked and analyzed, ensuring transparency, quality control, and food safety.

IV. **IoT Applications in Agriculture:** Here are some real-world applications of IoT in smart farming that are revolutionizing the way farms operate by enabling farmers to optimize resource use, automate processes, and make data-driven decisions.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

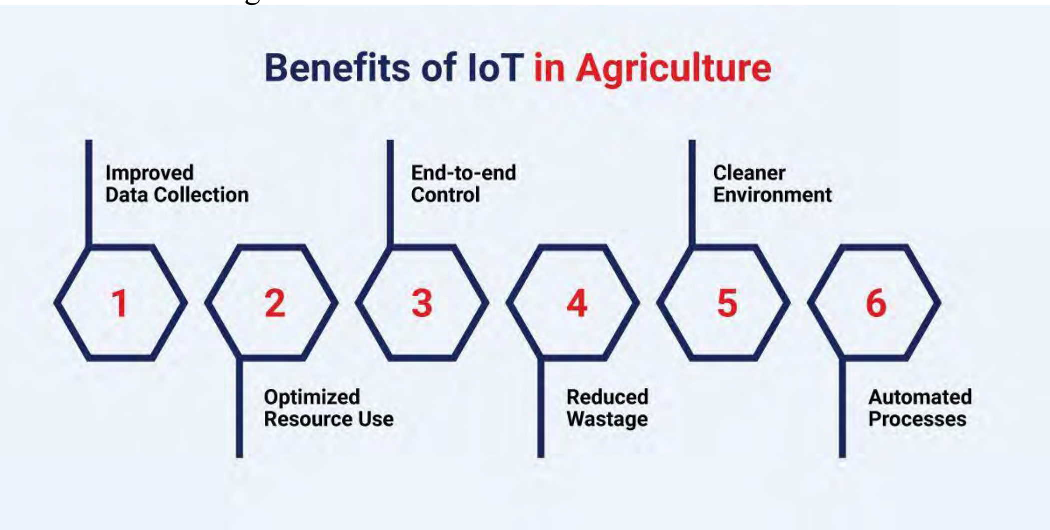



- **Greenhouse Automation:** IoT sensors and actuators are vital in greenhouse automation. They monitor and control crucial environmental factors such as temperature, humidity, and lighting. By maintaining optimal conditions, IoT enables careful cultivation, accelerates plant growth, and boosts overall greenhouse productivity.
- **Predictive Analytics for Smart Farming:** By collecting and analyzing data from various sources, including weather patterns, soil moisture levels, and crop health sensors, IoT empowers farmers with predictive analytics. This input enables making informed decisions regarding irrigation, crop rotation, disease prevention, and resource allocation.
- **Agricultural Drones:** IoT sensors and cameras support gathering data on crop health, plant density, and irrigation needs. It enables the farmers to analyze & identify problem areas, take proactive measures, and optimize their farming practices. It leads to increased yield and a reduction in resource wastage.
- **Monitoring Climate Conditions:** The installation of IoT weather stations across farms helps collect accurate data on temperature, humidity, wind speed, and rainfall. This input can be used in real-time to make precise irrigation schedules, pest control, and crop management decisions.
- **Precision Farming:** It is made possible by combining data from different sources, such as soil sensors, satellite imagery, and machine vision. And this data-driven approach enables farmers to optimize pesticide & water usage for higher crop yields.
- **Smart Pest Control:** IoT devices can precisely detect pests using sensors and image recognition technology. Early detection enables farmers to implement targeted pest control measures, thereby minimizing crop damage and reducing the need for excessive pesticide usage.

- **Farm Management:** These systems enable farmers to consolidate and manage all their data in a suitable location. From crop yields and livestock records to financial information and inventory levels, the system is a centralized hub for planning schedules and optimizing resource use.
- **Livestock Tracking and Geofencing:** With IoT-enabled tracking devices, farmers can monitor the location and behavior of their livestock in real time. Geofencing allows them to set virtual boundaries and receive alerts if animals stray beyond designated areas. This technology ensures better management of grazing patterns and enhances animal welfare.

## V. Advantages of IoT in Agriculture

From improving efficiency and reducing wastage to enabling precision farming and enhancing product quality, IoT empowers farmers to meet the challenges of feeding a growing population while ensuring a more sustainable future for agriculture. Let's look at the key benefits of IoT in agriculture:




- **Improved Data Collection for Enhanced Farming Efficiency:** Farmers strive to produce more on shrinking land amidst fluctuating weather patterns and degrading soil conditions. Fortunately, IoT-enabled agricultural solutions have come to their rescue, empowering them to monitor their crops and environmental conditions in real time. Farmers gain valuable insights and can predict potential issues by swiftly collecting crucial data on weather, land conditions, livestock, and crop health. This information enables them to make informed decisions & proactively address challenges, increasing their farming efficiency.
- **Optimized Resource Use for Sustainable Agriculture:** IoT precision farming allows farmers to gather real-time data from sensors deployed across farms. With this input at their fingertips, farmers can make accurate decisions regarding resource allocation,


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

ensuring that their crops receive the right amount of water, fertilizers, and other essential inputs.

- **End-to-end Control of the Production Process:** Farmers can respond swiftly to weather conditions, air quality, and humidity changes using prediction and real-time monitoring systems. This level of control helps them prevent potential damages while ensuring a more successful crop production cycle.
- **Reduced Wastage and Efficient Cost Management:** IoT solutions in farming play a crucial role in mitigating risks and reducing wastage by detecting anomalies and inconsistencies in crop production. Farmers can take immediate action to minimize waste and manage costs effectively.
- **A Cleaner Environment with a Greener Approach:** Farmers can minimize fertilizers & pesticides through precision farming techniques. It would lead to more organic crop production. And, this eco-friendly approach enables reducing the overall carbon footprint for agriculture initiatives while ensuring high-quality yields.
- **Enhanced Efficiency with Process Automation:** The introduction of IoT solutions has also automated various farming processes, such as demand-based fertilizing, irrigation, and robot harvesting. Farmers can optimize their operations, save time, and improve overall productivity by streamlining these tasks.

## VI. The Future of IoT in Agriculture

The integration of IoT in agriculture holds immense potential. It revolutionizes cultivating crops, raising livestock, and managing our farms. And modern-day farmers are struggling to strike a balance between shrinking agricultural lands & depleting finite natural resources. Farmers can optimize resource utilization, enhance productivity, and make data-driven decisions to ensure sustainable and efficient farming practices by leveraging the power of connected devices, sensors, and data analytics.

With the world population increasing exponentially, the goal is to bridge the supply-demand gap. And here’s where precision farming steps in as the ultimate problem solver. Smart farming goes way beyond the conventional approach, driving remarkable results.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

TRENDS IN AGRICULTURE SCIENCE
Vol.3 Special Issue 01 January 2024, Page: 169-176

# Functional Genomics for Plant Breeding

L. Jeyanthi Rebecca
https://doi.org/10.5281/zenodo.10605441

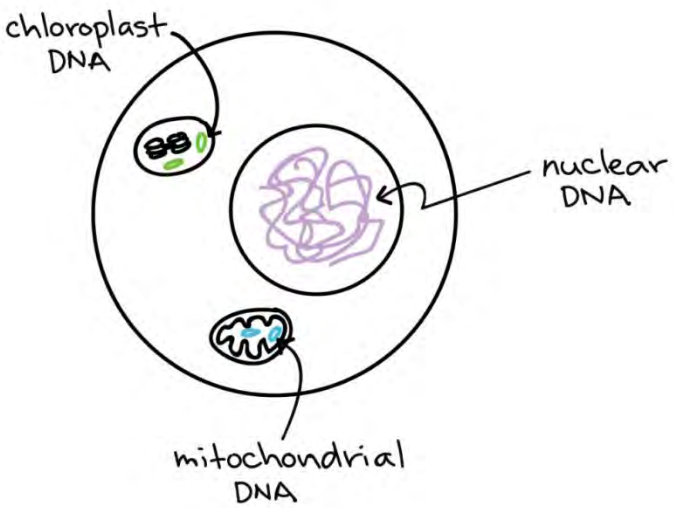
Genomics is the study of an organism's genome, its genetic material, and how that information is applied. All living things, from single-celled bacteria, to multi-cellular plants, animals and humans, have a genome, and is made up of DNA.

**The Plant Genome**

The genome of plant cells comprises three parts

- Nuclear genome
- Chloroplasts genome and
- Mitochondrial genome

It is formed during evolution via the capture of proteobacteria and cyanobacteria by ancestors of eukaryotes and their subsequent adaptation as endosymbionts.




***Plant Nuclear Genome***

- It is organized into chromosomes that provide the structure for the genetic linkage groups and allow replication, transcription and transmission of the hereditary information.
- Genome sizes in plants are diverse, from 63 to 1,49,000Mb


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

- The smallest genomes consist of mostly coding and regulatory DNA sequences present in low copy along with highly repeated rRNA genes and intergenic spacers, centromeric and telomeric repetitive DNA and some transposable elements.
- The larger genomes have similar numbers of genes, with abundant tandemly repeated sequence motifs, and transposable elements

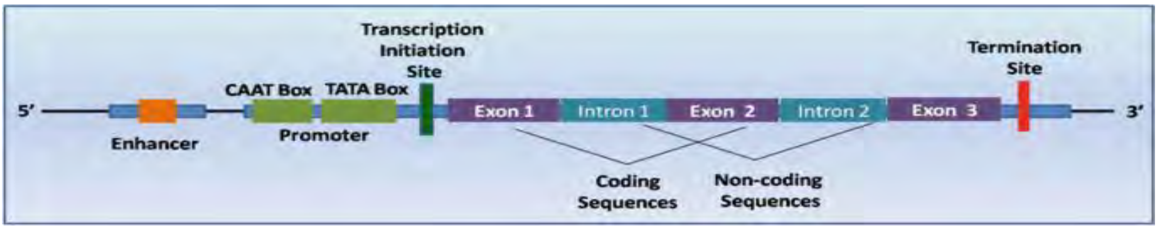
***Plant Mitochondrial Genome***

- Plants possess mitochondrial genomes that are large and complex compared to animals.
- Animal mitochondrial genomes are about 16.5 kbp in length, whereas plant mitochondrial genomes range between 200-2,000 kb
- the additional DNA found in plant mitochondrial genomes consists of large introns, repeats and non-coding regions.
- It does not exist as large circular DNA molecules but mostly as a collection of linear DNA with combinations of smaller circular and branched molecules.

***Plant Chloroplast Genome***

- It comprises of a single circular molecule with a quadripartite structure that includes two copies of an IR region that separate large and small single-copy regions
- The chloroplast genome includes 120–130 genes, participating in photosynthesis, transcription, and translation
- chloroplast genome size varies between species, ranging from 107 kb (*Cathaya argyrophylla*) to 218 kb (*Pelargonium*), and is independent of nuclear genome size

***The Plant gene***




***Evolution of Genomics***

The following major milestones that have influenced the history of genomics

1953: James Watson and Francis Crick discover the double helix structure of DNA

1977: Frederick Sanger introduces a technique in DNA sequencing

1995: The first genome sequence of bacteria (Haemophilus influenza) has been completed.

2000: Full genome sequence of the Drosophila melanogaster model organism (fruit fly).

2003: The Human Genome Project has been completed and confirms that some 20,000–25,000 genes are available to humans.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

2018: On 17 August 2018, the IWGSC published a detailed description and review of the bread wheat genome reference sequence in the international journal Science, the world's most widely cultivated crop.

***Genomics in Crop Plants***

- Plant genomics work began in December 2000 with the publication of the entire genome sequence of the Arabidopsis thaliana model plant species.
- It resulted in a significant improvement in our understanding of the molecular basis of both plant growth and environmental stimulus response.
- Having the genome sequence enabled genomic approaches aimed at assigning a function to each of the 26,000 genes that were predicted.
- Knockout mutation generated by RNAi technique insertion mutagenesis or gene silencing indicates a role for a gene if it is possible to link the mutants to phenotype.

Further significant developments include

- the August 2005 release of a high-quality rice genome sequence
- September 2006 draft poplar genome
- 2007 full genome sequence of two grapevine genotypes
- 2008 transgenic papaya and
- 2018 full wheat genome.

***Classification of Genomics***

The genomics discipline consists of three sections

- Structural Genomics
- Comparative Genomics
- Functional Genomics

***Structural Genomics***

- It deals with the study of the structure of entire genome of a living organism.
- It deals with the study of the genetic structure of each chromosome of the genome.
- It specifies the size of a species genome in [Mb] mega-bases as well as the genes found in a species entire genome.
- It focuses on building genomic sequence data, finding and locating gene and building gene maps.
- It uses DNA Sequencing technology and program software to produce, store and analyze information about the genomic sequence.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

***Comparative Genomics***

- It is a biological research field in which the genome sequences of different organisms are compared
- By comparing the genomic sequences of different organisms, researchers can explain what distinguishes different forms of life from each other at the molecular level.
- Comparative genomics also provides a powerful tool for researching evolutionary changes among organisms, helping to recognize retained or common genes among species, as well as genes that give unique characteristics to each organism.
- This compares the sequences of genes to explain the relationship is functional or evolutionary.
- It is a promising method for species with largely unexplored genomes to gain information by using conservation among closely related plant species

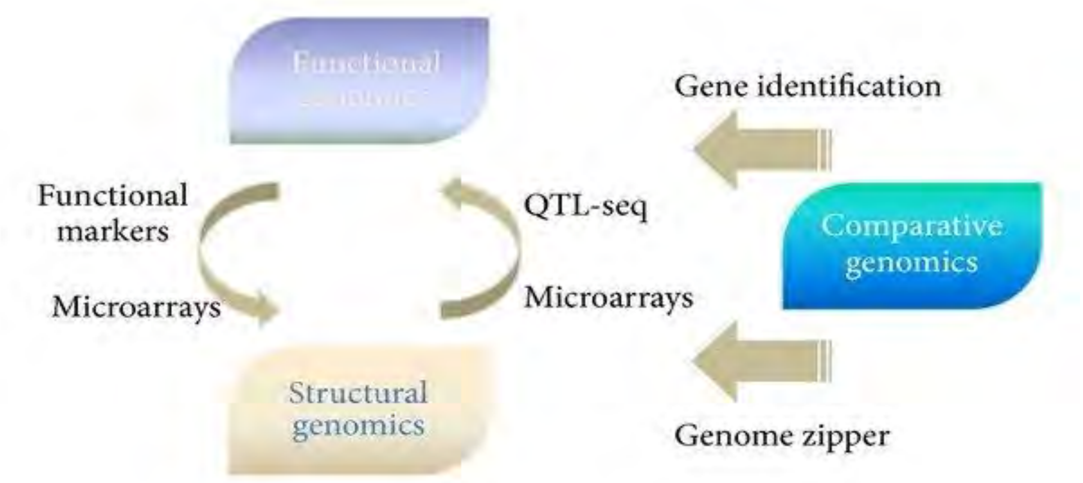
***Functional Genomics***

- It is involved in the research of the function of all genes found in the entire genome.
- This deals with the proteome and transcriptome.
- The transcriptome refers to a complete set of genome-transcribed RNAs and refers to a complete set of genome-encoded proteins.
- Functions must be allocated to all genes in the series after genome sequencing is annotated.
- Some of the genes may already allocate functions using a conventional method Mutagenesis and linkage mapping.
- Functional approaches to genomics use methodologies based on sequence or hybridization.
- Expressed Sequence Tags (ESTs), Serial Analysis of Gene Expression (SAGE) and Massively Parallel Signature Sequencing (MPSS) are analyzed sequence-based approaches.
- Hybridization-based approaches are array-based techniques that use target DNA hybridization with cDNA or oligonucleotide samples attached to a surface for expression assessment.
- The array-based approaches are targeted; that is prior transcript information to be studied, either sequence or clones, is a prerequisite for designing samples.
- Targeting Induced Local Lesions In Genomes (TILLING) primarily allows high-throughput analysis of large numbers of mutants, a modified technique, called Eco


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

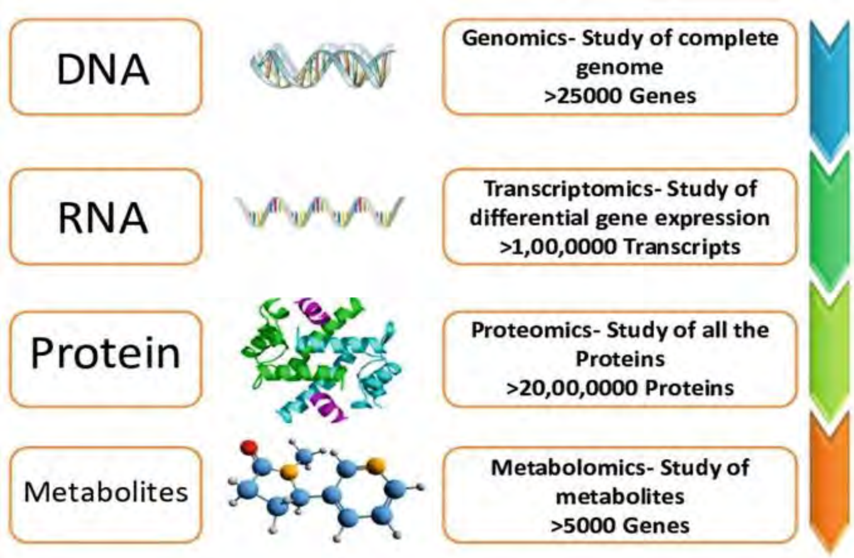
TILLING, has been developed to detect natural polymorphisms, similar to TILLING-assisted induced mutation detection.

- Editing of TDNA, RNAi and Genome editing also used to assign Gene function.




There are several specific functional genomics approaches

- DNA level (genomics and epigenomics)
- RNA level (transcriptomics)
- Protein level (proteomics)
- Metabolite level (metabolomics)




***Why functional genomics?***

- Global climate changes and rapidly increasing population have been making sustainable supplies of food and energy unprecedented challenging.


Published: 23 Jan. 2024
ISSN: 2583-7850

- Superior traits such as better yield, abiotic and biotic stress tolerance, better water and nitrogen use efficiency and better food processing and nutritional qualities are of greater need.
- Cereal crops have been domesticated and bred as the staple food for global population for hundreds to thousands of years.
- Omics technologies (including genomics, transcriptomics, proteomics, metabolomics and epigenomics), their increasing accessibility and decreasing costs enable the applications of omics technologies in plant sciences, and hence expand our knowledge in both model and non-model plant species
- Combination of molecular genetics approaches and omics technologies lead to rapid development in the fields of functional genomics, which have helped to unveil the functions of different types genetic components (such as genes, regulatory elements and non-coding RNAs), and laid solid foundations for crop genetic improvement.

***Role of Genomics in Crop Improvement***

Genomics has a range of practical uses to boost crops. In a number of ways, genome mapping is useful. It is useful or provides information on genome size, gene number, gene mapping, gene sequencing, crop plant evolution, gene cloning, DNA marker recognition, marker assisted selection, transgenic breeding, linkage map creation and QTL mapping.

i. Genome size: Genome mapping is a very useful technique for assessing the size of the genome in different species of plants. The largest genome size was recorded in Wheat (14.5 Gb) and the smallest in Arabidopsis thaliana (120 Mb) in the plant species studied so far.

ii. Gene Number: Genome mapping provides information on a species ' gene number. The maximum number of genes reported in Wheat that is 107,891 was reported in crop plants studied so far.

iii. Gene mapping: Genome research is very useful in mapping / tagging genes on a genome's different chromosomes. In other words, it helps to discover new genes in a genome on a large scale.

iv. Gene Sequencing: Genome mapping helps to establish the chromosome gene order. The gene order is determined on each genome chromosome.

v. Evolution: Genome mapping provides information on various organisms ' evolution. This tests the interaction between different genomes and thus provides information on crop plants ' association or evolutionary biology.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
**Published**: 23 Jan. 2024
**ISSN**: 2583-7850

vi. Gene Cloning: Genome research is very useful in making multiple gene copies and moving the same from genotype to genotype. It therefore assists in the precise transfer of genes.

vii. DNA marker identification: genome mapping techniques are useful to classify DNA markers that can be used in molecular breeding, i.e. marker assisted selection. From the mapping groups, For DNA markers, inter-specific crosses are extremely polymorphic than those representing populations resulting from intra-specific crosses.

viii. Marker Assisted Selection: Marker Assisted Selection refers to indirect selection based on the band pattern of related DNA markers for a specific phenotype. Using such selection, crop improvement is called molecular breeding. Similar DNA markers used for this purpose are RFLP, AFLP, SSR, etc. DNA marker results are associated with morphological markers and then it's picked for a particular characteristic. Selection based on DNA markers is more effective because environmental factors do not affect DNA markers.

ix. Transgenic breeding: In gene cloning, genome mapping is important. The gene of interest can be cloned and used in the development of transgenic plants. Transgenic breeding enables the direct transfer of genes bypassing the sexual cycle.

x. Linkage maps construction: Genome mapping helps to create linkage classes. Based on gene mapping and gene sequencing details, the linkage groups can be constructed.

xi. QTL Mapping: The techniques of genome mapping are commonly used for quantitative trait loci (QTL) mapping. Through conventional methods, i.e. recombination mapping and deletion mapping techniques, mapping of QTL or polygenic traits is not feasible.

The availability of a crop's entire genome sequence is very useful for plant breeding, given the high cost of sequencing the entire genome; transcriptome sequencing was a cheaper alternative. The cDNA sequences (expressed sequence tags, ESTs) provide relevant information on the genes expressed in a particular tissue or organ, at a particular stage of development and under specific environmental conditions. With the advent of NGS technologies, the genomics landscape has shifted. Such new technologies have lowered sequencing costs by more than 1,000 times compared to Sanger technology, reducing time consuming and repetitive Modern steps in cloning and allowing millions of simultaneous sequencing reactions.

***Marker Assisted Selection***

Marker assisted selection (MAS) is an indirect process where selection is carried out on the basis of a marker instead of the trait itself. The probability of recombination, given the close relation between the marker and the gene, restricts the use of MAS. Using intragenic markers can help to overcome this limitation, also called functional markers. Projects for NGS sequencing produce large sets of usable markers. Such markers boost the actual gene supported reproduction, thus reducing the risk of loss of desirable feature of recombination.

**Conclusions**

Genomic methods and strategies will help conventional breeding make significant progress in crop breeding that has either remained orphaned or ignored from the point of view of genetic improvement. Thus, though traditional plant breeding pre-genomics has been, is and will be effective in improving our crops, the application of genomic tools and resources to realistic plant breeding will drive forward the genetic gains obtained through breeding programs.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

TRENDS IN AGRICULTURE SCIENCE
Vol.3 Special Issue 01 January 2024, Page: 173-176

# The Vital Role of Insects in Soil Health: Guardians of Earth's Living Cradle

*** Abarna.V [1] and Abhinav Kumar [2]**

[1]School of Agriculture, Bharath Institute of Higher Education and Research, Selaiyur, Chennai 600 073.

[2]Department of Entomology, Bihar Agriculture University, Sabour, Bhagalpur 813210.

https://doi.org/10.5281/zenodo.10605451

**Introduction:**

Soil, often referred to as the "skin of the Earth," is a complex and dynamic ecosystem that sustains life in myriad ways. Beneath its surface lies a bustling world of microorganisms, plant roots, and, crucially, insects. This article delves into the indispensable role of insects in maintaining soil health, exploring their diverse functions and the symbiotic relationships that make them the unsung heroes of our terrestrial environments. Soil residing insect diversity, distribution and richness are determined by several factors such which includes organic matter content, soil features, cover vegetation, soil disturbance (mechanical soil tillage), fire, and pollution. Moreover, the diverse taxa respond in a different way to a variety of prevailing environmental factors. Some groups are more sensitive and their population fluctuates with slight changes in degree of features available to their surroundings, while others are profuse and more able to react to soil degradation. In addition, different species belonging to the same taxonomic group can respond differently. As it is known, the Acari and Collembola are the two major groups which are generally considered in soil quality evaluation approach. Some other groups, such as Coleoptera, Diptera and Araneae, are often elaborate in studies aimed to estimate soil health/quality/degradation/pollution, while other groups, usually Symphyla, Pauropoda, Pseudoscorpionida and others, are normally little discussed in soil quality monitoring or conferred together with other soil arthropods taxa.

**1. Decomposition and Nutrient Cycling:**

One of the primary contributions of insects to soil health lies in their ability to decompose organic matter. Insects such as beetles, ants, and larvae play a pivotal role in breaking down dead plant material, releasing essential nutrients back into the soil. This process,


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

known as nutrient cycling, is vital for sustaining plant growth and overall ecosystem health. Insects, with their amazing diversity and adaptableness, are significant players in this crucial process. In the woods when the plants shed their leaves, animals die, or other organic material decays, scavenger insects dive in to feast on these fragments. They breakdown the complex organic molecules into simpler forms, liberating nutrients like nitrogen and phosphorus back into the soil. Termites contribute actively to soil turnover, and the contribution of termite and mounds of several species of ant to soil turnover is a regular and never ending process which adds several factors to soil. Termite mounds can persevere in the landscape for more than two decades, while ant mound durability varies from weeks to even decades. Ants and termites directly involved two different services they either increase infiltration by improving soil structure and porosity, or to decrease infiltration by producing compact surfaces which assist runoff and erosion. Additional effects include the chemical adjustment of the soil profile by ants and termites gathering and moving live and dead animal and plant materials to their nest structures, and by the additions of excretions and excreta in nest construction. The majority of ants and termites known to increase C and other nutrient levels, especially N, P and K, as well as exchangeable Mg and Ca.

**2. Soil Aeration and Structure:**

Burrowing insects and earthworms are good architects of soil structure. Their habit of constant tunnelling improves soil aeration, allowing oxygen to reach plant roots and promoting the movement of water and nutrients. The intricate network of tunnels created by these soil engineers improves soil structure, preventing compaction and facilitating the absorption of water. Insects known to improve soil porosity thus provide adequate aeration and improve the water-holding capacity of soil, also facilitate root penetration, and prevent surface crusting and erosion of topsoil.

**3. Pest Control and Soil Protection:**

Certain insects act as natural predators, keeping pest populations in check and contributing to the overall balance of the soil ecosystem. Various species of rove beetles, predatory ground beetles, soil nesting hymenopterans, orbatids, ants and plentiful spiders help control the populations of harmful insects, protecting both plants and the soil from potential threats.

**4. Pollination and Plant Interaction:**

While the role of insects in pollination is often associated with flowers, some insects play a crucial role in soil-based pollination. Beetles, for instance, pollinate plants that lack showy flowers, contributing to the reproduction of a variety of plant species. Various soil


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

dwelling insects and spiders are known to contribute in pollination, various soil nest builder hymenopteran are actively involved in pollination to the vegetation nearby as well as the role of rove beetles and ground beetles cannot be ignored in pollination. This interaction is essential for maintaining biodiversity and ensuring the health of both soil and vegetation.

**5. Soil Biodiversity:**

Insects are key players in the intricate web of soil biodiversity. The insects are the crucial members in soil food web insects alone comprises a significant portion of diverse fauna in soil biodiversity, the ability to thrive in various degraded soil as well as eroded land make insects a good candidate as bio indicator since their presence and quantities are extensively used to uncover various soil physical property. Their presence influences the diversity and abundance of other soil organisms, creating a dynamic ecosystem where each component plays a unique role. A rich insect community reflects a healthy and balanced soil environment.

**6. Adaptation to Urban Environments:**

As urbanization continues to reshape landscapes, certain insects adapt and thrive in urban soil environments. Studying these adaptable species can provide insights into sustainable practices that balance the needs of human development with the preservation of soil health and biodiversity.

**Conclusion:**

Insects are the unsung guardians of soil health, orchestrating a symphony of interactions that sustain life beneath our feet. Recognizing their multifaceted roles in decomposition, nutrient cycling, pest control, pollination, and soil structure is crucial for fostering sustainable agricultural practices and preserving the delicate balance of our planet's living cradle. As we delve deeper into the intricacies of soil- insect relationships, we unveil the remarkable tapestry of life that flourishes in the hidden realm beneath our feet, reminding us that the health of our soil is intrinsically linked to the well-being of the entire ecosystem.

**REFERENCE**

Fox, C. J. S. (1957). Remarks on influence of insects on the floristic composition of grassland. Rep. Queb. Soc. Prot. Pl., 39, 49-51.

Losey, J. E., & Vaughan, M. (2006). The economic value of ecological services provided by insects. Bioscience, 56(4), 311-323.

Macfadyen, S., Kramer, E. A., Parry, H. R., & Schellhorn, N. A. (2015). Temporal change in vegetation productivity in grain production landscapes: linking landscape complexity with pest and natural enemy communities. Ecological Entomology, 40, 56-69.

Makkar, H. P., Tran, G., Heuzé, V., & Ankers, P. (2014). State-of-the-art on use of insects as animal feed. Animal Feed Science and Technology, 197, 1-33.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

Shepherd, V. E., & Chapman, C. A. (1998). Dung beetles as secondary seed dispersers: impact on seed predation and germination. Journal of Tropical Ecology, 14(2), 199-215.

Wardle, D. A. (2002). Communities and ecosystems: Linking the aboveground and belowground components. Princeton Univ. Press, Princeton, NJ. Communities and ecosystems: Linking the aboveground and belowground components. Princeton Univ. Press, Princeton, NJ.

Weisser, W. W., & Siemann, E. (2008). The various effects of insects on ecosystem functioning. In Insects and ecosystem function (pp. 3-24). Springer, Berlin, Heidelberg.

Farwig, N., Brandl, R., Siemann, S., Wiener, F. and Muller, J. (2014). Decomposition rate of carrion is dependent on composition not abundance of the assemblages of insect scavengers. Oecologia, 175 : 1291–1300.

Muneer Ahmad and Nadeem Dar(2020). Insects : Their importance and role in ecosystem.Advance research journal of crop improvement,15(1),15-16.

https://www.ctpublic.org/environment/2021-03-05/insects-aroundthe- world-are-disappearing-what-can-we-do-about-it.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

TRENDS IN AGRICULTURE SCIENCE
Vol.3 Special Issue 01 January 2024, Page: 177-179

# Insect Indicators of Soil Quality: Unveiling the Underground Tapestry

*Abhinav Kumar[1] and Abarna.V[2]

[1]Department of Entomology, Bihar Agriculture University, Sabour, Bhagalpur 813210

[2]School of Agriculture, Bharath Institute of Higher Education and Research, Selaiyur, Chennai 600 073

https://doi.org/10.5281/zenodo.10605462

## Introduction

Living things alone have "health" so before discussing about "soil health", we need to acknowledge that the soil is alive! As per the USDA-NRCS definition, "Soil health is the continued capacity of a soil to function as a vital living ecosystem that sustains plants, animals, and humans." The precise biological life in the Soil is the key indicator of good soil health. A healthy soil should be full of earthworms, varied soil arthropods include beetles, spiders, ants, and other soil life confining to the top six inches. Healthy soils largely have live plants thriving continuous to feed soil microbes and other soil as well as terrestrial arthropods. Soil arthropods constitute a varied and rich community in the soil, playing their significant key roles in various ecological processes. Their response to fluctuations in the varied soil conditions makes them valued bio-indicators, reflecting alterations in the environment that may not be immediately apparent through conventional assessments. This article combines current research on soil-dwelling insects, emphasizing their potential as sensitive indicators of soil quality.

Various insect taxa, such as ground beetles, ants, termites, and springtails, exhibit distinct responses to shifts in soil properties, including organic matter content, moisture levels, and nutrient availability. By monitoring changes in insect community composition and behavior, researchers gain insights into the intricate relationships between soil health and biodiversity.

Practical applications of insect indicators in soil quality assessments are discussed, highlighting their relevance in agriculture, ecosystem restoration, and urban planning. Leveraging the ecological services provided by these insects can enhance our ability to evaluate soil health and implement targeted interventions. For instance, certain beetle species may indicate soil compaction, while ant diversity could signal changes in soil moisture levels.

Despite their potential, challenges in utilizing insect indicators are acknowledged. Mobility, species-specific responses, and potential confounding factors are considered, emphasizing the need for standardized protocols. The article also explores emerging technologies, such as DNA metabarcoding, to refine and streamline insect-based soil assessments.

**Types of measures of soil and litter arthropods indicating soil quality and health with their challenges**

Several soil and litter arthropods counting collembolan, Oribatida, Isopoda and Diplopoda living a rather sedentary life and hence reflect local conditions of a habitat (Van Straalen, 1998). These facts have been documented since long time, and associations between soil types and soil with litter arthropods have been established in various studies (Rusek, 1989). Usage of soil and litter arthropods as indicators of soil quality and health has commonly been done by gaging different properties and state in soil like litter arthropod biomass, density, abundance, species richness, and biological indices (Yeates & Bongers, 1997; Foissner, 1994) of either single taxon groups or of the total community (Aspetti et al., 2010).

In recent time, a simplified ecomorphological index (EMI) built on the morphology of micro-arthropods has been introduced (Parisi & Menta, 2008). Which can be used to assess soil quality and health based on the groups that are residing in the very soil samples, each taxonomic groups receive an EMI score from 1 to 20 (Table 1), conferring to its adaptability to the soil environment. Soil living forms residing deep are given an EMI score of 20 and intermediate forms are provided with a score proportional to their degree of concentration, whereas surface-roving forms are counted with an EMI equal to 1 (Parisi et al., 2005). The Biological Quality of Soil Index (BQS) is considered as the sum of EMI scores and soil quality correlates with the number of sets of arthropods having high EMI scores.

**Table 1:** Ecomorphological indices (EMIs) of the edaphic micro-arthropod groups (Parisi *et al.*, 2005).

| Group | EMI Score | Group | EMI Score |
|---|---|---|---|
| Blattaria | 5 | Acari | 20 |
| Coleoptera | 1-20 | Araneae | 1-5 |
| Collembola | 1-20 | Opiliones | 10 |
| Diplura | 20 | Isopoda | 10 |
| Diptera (larvae) | 10 | Chilopoda | 10-20 |
| Embioptera | 10 | Palpigradi | 20 |


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

| | | | |
|---|---|---|---|
| Hemiptera | 1-10 | Diplopoda | 10-20 |
| Hymenoptera | 1-5 | Pauropoda | 20 |
| Orthoptera | 1-20 | Symphyla | 20 |
| Other holometabolous insects (adults) | 1 | Dermaptera | 1 |
| Other holometabolous insects (larvae) | 10 | Psocoptera | 1 |
| Protura | 20 | Microcoryphia | 10 |
| Thysanoptera | 1 | Zygentomata | 10 |

## Conclusion

Recognizing insects as indicators of soil quality adds a nuanced dimension to our understanding of ecosystem dynamics. Their role in reflecting the health of soils, often referred to as the 'underground tapestry,' underscores the importance of holistic approaches to soil management. Incorporating insect indicators into soil quality assessments not only enriches our comprehension of soil health but also offers sustainable solutions for preserving this vital resource for future generations.

The diversity of Soil arthropod, distribution and their abundance are determined by several factors that includes organic matter content, soil features, cover vegetation, soil disturbance (mechanical soil tillage), fire, and the pollution. Additionally, the diverse taxa respond differently to a variety of environmental factors. Some groups are more delicate, whereas others are abundant and more able to react to soil degradation. In addition, different species belonging to the same taxonomic group can respond differently.

## References

Aspetti G. P., Boccelli R. D., Ampollini A., Del Re A.M. & Capri E., 2010. Assessment of soil-quality index based on microarthropods in corn cultivation in Northern Italy. Ecological Indicators, 10, 129-135.

Foissner W., 1994. Soil Protozoa as bioindicators in ecosystems under human influence. In: Darbyshire J.F. (Ed.). “Soil Protozoa”. CAB International, Wallingford, UK, 147-194.

Parisi V. & Menta C., 2008. Microarthropods of the soil: convergence phenomena and evaluation of soil quality using QBS-ar and QBS-C. Fresenius Environmental Bulletin, 17, 1170 -1174.

Parisi, V., Menta C., Gardi C., Jacomini C. & Mozzanica, E., 2005. Microarthropod communities as a tool to assess soil quality and biodiversity: a new approach in Italy. Agriculture, Ecosystems and Environment, 105, 323-333.

Rusek J., 1989. Ecology of Collembola. In: Dallai, R. (Ed.) Proceedings of the 3rd International Seminar on Apterygota. University of Siena. 271-281.

Van Straalen N.M., 1998. Community Structure of Soil and litter as bioindicators of soil health. In: Pankhurst C.E., Doube B.M., and Gupta V.V.R. (Ed.). “Biological Indicators of Soil Health”. CAB International, Wallingford, UK, 235-264.

Yeates G.W. & Bongers T., 1997. Nematode diversity in agro-ecosystems. In: Paoletti M.G. (Ed.). “Biodiversity in Agro-ecosystem: role of sustainability and bioindication”. Lewis Publishing, Boca Raton, USA, 113-135.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

TRENDS IN AGRICULTURE SCIENCE
Vol.3 Special Issue 01 January 2024, Page: 180-190

# Validation of Aquacrop Model for various deficit irrigation schedules in Maize hybrid

**A Bharathi*, T. Ragavan[1] and V. Geethalakshmi[1]**

*Assistant Professor, Kalasalingam Academy of Research and Education, Virudhunagar
[1]Professor, Tamil Nadu Agricultural University, Coimbatore
https://doi.org/10.5281/zenodo.10605468

*Abstract*

Field experiments were conducted at Agricultural College and Research Institute, TNAU, Madurai during summer 2017 and 2018 with different deficit irrigation treatments. The experiment was laid out in randomized block design, and replicated thrice under sandy clay loam soil. Experiments consisted of eleven treatments through drip system based on PE and $ET_c$ approach *viz.*, regulated deficit irrigation (RDI) at 80 and 60 percent ($T_2$ to $T_5$), alternate deficit irrigations (ADI) at 80 and 60 per cent ($T_6$ and $T_7$), critical stage-based deficits ($T_8$ to $T_{11}$) and conventional drip irrigation (CDI) at IW/CPE of 0.75 ($T_1$) for comparison. The test crop of CO(M)H-6, maize hybrid was used. Aquacrop model simulated and observed grain and biomass yield with water use efficiency (WUE). The validation efficiency of Aquacrop was tested by the statistical measures such as root mean square error (RMSE), normalised mean square error (NRMSE), Bias (BIAS), coefficient of determination ($R^2$) and index of agreement (D).

**Keywords:** Deficit irrigation, Aquacrop model, validation, statistical measures

## INTRODUCTION

Irrigated agriculture is continuously being the major fresh water exploiting sector at global level. Water being a critical input, has received the attention of researchers and policy makers all over the world leading to development of different approaches to use the scarce water very judiciously. Of the approaches, the most recent advanced irrigation technology is deficit irrigation  It means irrigation scheduling in terms of changing quantities of irrigation water to be applied as well as changing frequency of intervals along with other agronomic management practices (Bharathi, 2020).

The crop simulation models are very powerful tools to understand the behavior of crop with response to water applied under different climatic conditions (Farahani *et al.,* 2009, Bharathi *et al.*, 2018). AquaCrop is the water driven model developed by Land


**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

and Water Division of FAO to simulate yield response of several herbaceous crops to water. It is designed to balance simplicity, accuracy and robustness, and is particularly suited to address conditions where water is a key limiting factor in crop production. AquaCrop is a companion tool for a wide range of users and applications including yield prediction under climate change scenarios (Steduto *et al.,* 2009).

Yawson *et al.* (2010) simulated AquaCrop model for maize water productivity under rainfed condition and results showed that a coefficient of determination (R = 0.81) between farmers' yield and AquaCrop simulated yield. He concluded that AquaCrop has the ability to simulate the water productivity of crops with considerable accuracy under rainfed conditions in a tropical humid climate. Kipkorir *et al.* (2010) studied the application of AquaCrop model for prediction of maize yields in western Kenya. AquaCrop model was used to simulate yield with observed daily weather inputs and in response to selected historic rainfall data. Results indicated that yield predictions issued later in the growing season were more accurate than predictions issued earlier because they incorporated more close-to-actual weather conditions. They concluded that application of AquaCrop model would be useful for accurate yield estimates several months before harvest for strategic planning. Hsiao *et al.* (2009) investigated the AquaCrop model to simulate yield response to water for Maize. AquaCrop simulated the final above ground biomass within 10 per cent of the measured value and also the grain yield. The simulated results were within 5 per cent of the measured value for biomass as well as for grain yield. With this background the current research was done with various deficit irrigation schedules for Maize hybrid. Aquacrop model simulated and observed grain and biomass yield with water use efficiency (WUE) are furnished under.

## MATERIALS AND METHODS

### Field Experiment

Field experiment was conducted at Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai, to study the effect of varying deficit irrigation regimes in maize under drip irrigation system during summer, 2017. The experimental soil was texturally classified as sandy clay having 25.2 per cent field capacity, 12.5 per cent permanent wilting point and has 1.36 (g $cc^{-1}$) bulk density. Soil has pH value of 7.95, organic carbon content of 0.36 per cent and EC of 1.55 $dsm^{-1}$. The available status of nitrogen in the soil was low (264 kg $ha^{-1}$), with medium phosphorus (18.5 kg $ha^{-1}$) and high in potassium (378 kg $ha^{-1}$). The experiment was laid out in a randomized block design and the treatments were replicated thrice. Treatments comprised of seven irrigation levels through drip (Table 1). Drip irrigation


Published: 23 Jan. 2024
ISSN: 2583-7850

system was operated once in three days and irrigation was applied as per the treatments based on PE and $ET_c$ levels.

**Table 1. Treatment details**

| |
|---|
| $T_1$ – Conventional Irrigation at IW/CPE of 0.75 |
| $T_2$ – Irrigation at 80 % PE |
| $T_3$ – Irrigation at 80 % ETc |
| $T_4$ – Irrigation at 60 % PE |
| $T_5$ – Irrigation at 60 % ETc |
| $T_6$ – 80 and 60% PE as ADI [ADI – Alternate Deficit Irrigation] |
| $T_7$ – 80 and 60% ETc as ADI |

The experimental field was thoroughly ploughed. Beds were formed in the dimensions of 120 cm width, 30 cm furrow and 15 cm height. Buffer channels were formed to control the lateral seepage of water from one plot to another. The plot size was 7.2 × 4.5 m, accommodating six rows of crop. Maize hybrid COHM-6, was used for the experimental study. Seeds were hand-dibbled at the rate of one per hole. Paired row spacing of 120 + 30 × 60 cm was followed. Sowing irrigation was uniformly given to all treatments.

Water requirement (litres per day or Lpd) or ETc= CPE × Kp× Kc× Wp× S,

$$PE = CPE \times K_p$$

Where, ETc= crop evapotranspiration,

CPE = cumulative pan evaporation (mm),

Kp= pan factor (0.8)

Kc= crop coefficient,

Wp= wetting area percentage (80%) (Veeraputhiran, 2000),

S = Crop spacing (0.60 × 0.25 m for maize).

Irrigation water was pumped from the water source and conveyed to the main line of 63-mm outer diameter (OD) polyvinyl chloride (PVC) pipes after filtering through sand filter. In the main line, venturi was installed for fertigation. From the main, sub-mains of 40 mm OD PVC pipes were drawn, and from the sub-main, laterals of 12-mm low linear density polyethylene (LLDPE) pipes were installed at an interval of 1.2 m. Each lateral was provided with individual tap control for imposing respective irrigation schedules. Along the laterals, inline drippers with a discharge capacity of 4 L $hr^{-1}$ were spaced at 0.4 m. Single lateral was used for a paired row of maize. Sub-mains and laterals were closed at the end with end cap. After installation, trial run was conducted to assess mean dripper discharge and uniformity coefficient. This was taken into account while fixing the irrigation water application time.

During the irrigation period an average of 90–95% uniformity was observed. The recommended dose of fertilizer was applied as N: $P_2O_5$:$K_2O$ @ 250:75:75 kg $ha^{-1}$. All the package of practices was carried out as per recommendation of CPG (2012).

All the relevant biometric observations on growth parameters were recorded at periodic interval of the crop growth stages *viz.,* 30, 60 DAS and at harvest stage. The yield and yield attributes of maize were recorded as per the procedure. Data of each character collected were statistically analyzed using standard procedure of variance analysis.

**Aquacrop model simulation**

Elaborating irrigation schedules and optimizing the water use merely on the basis of field research is expensive and time consuming. To optimize the irrigation schedule, it is advised to use simulation models as it the decision can be made in short time. Several models are available to simulate yield response to water and Aquacrop is one of the important models developed by Food and Agriculture Organization (FAO).

**Input requirement for setting up Aquacrop**

Aquacrop model uses a relatively small number of explicit parameters and largely intuitive input variables, either widely used or requiring simple methods for their determination. Input consists of weather data, crop and soil characteristics, and management practices that define the environment in which the crop is grown.

**1. Climate data**

Aquacrop model requires minimum (Ta) and maximum (Tx) air temperature, reference evapotranspiration ($ET_0$) as a measure of the evaporative demand of the atmosphere, and rainfall on daily basis. Additionally, the mean annual $CO_2$ concentration has to be known. Historical line series of mean annual atmospheric $CO_2$ concentrations measured at Mauna Loa Observatory in Hawaii, as well as the expected concentrations for the near future are provided in Aquacrop model.

**2. Crop characteristics**

Aquacrop uses minimum number of crop parameters that describe the plant physiological and growth characteristics. It had been calibrated with crop parameters for major agriculture crops, and generic values are available in the model. However, distinction is made between conservative, cultivar-specific and less conservative parameters in Aquacrop. The conservative crop parameters do not change with time, management practices, or geographical locations. They were calibrated with data of crop grown under non-limiting fertilizer and water supply situations and remain applicable for stress conditions using stress response functions. Conservative parameters require no adjustment to the local conditions and can be used as such


Published: 23 Jan. 2024
ISSN: 2583-7850

in the Aquacrop simulation process. Cultivar specific or less- conservative crop parameters are affected by field management, conditions of the soil profile or the weather parameters. These parameters might require an adjustment during model calibration process to account for local varieties and local environmental conditions.

**3. Soil characteristics**

In Aquacrop model, the soil profile was partitioned to five different layers of variable depths to account for the altering physical characteristics, *viz*., soil texture, hydraulic conductivity at saturation (Ksat), drainage coefficient, soil water content at saturation (SAT), field capacity (FC) and at permanent wilting point (PWP). The user can import the soil texture data of the experimental site with the help of pedo-transfer functions. Moreover, the existence of any impervious layer within or below the root zone needs to be specified during the model calibration process. This information will be used by the water budgeting module of Aquacrop to estimate the soil water content in the crop root zone leading lo estimation of crop growth and yield.

**4. Management practices**

The options for management practices to stimulate the Aquacrop model are divided into two categories *viz*. field and irrigation management practices. Under field management practices, the choice of soil fertility levels, and practices that affect the soil water balance such as mulching to reduce soil evaporation, soil bunds to store water on the field, and tillage practices such as ridges or contours that reduce surface runoff were considered. Further, the four fertility levels such as non-limiting, near optimal, moderate and poor were considered in Aquacrop which affects the WP, rate of canopy growth, maximum canopy cover and the crop senescence Whereas, under irrigation management practices the Aquacrop model has the options for the rainfed and irrigated conditions. Further, under irrigated condition, user can select the application methods (*i.e* sprinkler, drip or surface methods), the fraction of wetted surface and specify the irrigation quantity and the timing for each irrigation event. There are also options to assess the net irrigation requirement and to generate irrigation schedules based on specified time and depth criteria. Since the criteria might change during the growing season, the model provides the means to test deficit irrigation strategies by applying chosen amounts of water at various stages of crop development.

**Validation of Aquacrop model for Maize**

Aquacrop model was validated using the field data from the experiments carried out at Agricultural College and Research Institute (AC & RI), Madurai.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

**1. Climate data**

The daily weather data on sunshine hours (hrs), maximum and minimum air temperatures (˚C), rainfall (mm), windspeed (m/s) and relative humidity (%) were collected from the meteorological observatory at AC&RI, Madurai.

**2. Crop data**

The crop components including initial canopy, canopy development, rooting depth, flowering and yield formation were recorded and used in Aquacrop model.

**3. Soil data**

The model required full dataset of a given soil texture *viz*., wilting point, field capacity, bulk density, hydraulic conductivity, saturation, total available water (TAW), fertility status and initial soil water content. These required soil parameters were estimated by analysing the soil of the experimental field.

**4. Irrigation application**

Experimental plots were prepared according to various deficit irrigation schedules. Irrigation was given in drip system once in 3 days.

**Statistical indexes used for model validation**

**1. Root Mean Square Error (RMSE)**

$$\text{RMSE (Root Mean Square Error)} = \left[\sqrt{\frac{\sum_{t=1}^{n}(\text{Si} - \text{Oi})^2}{n}}\right]$$

Where $S_i$ and $O_i$ refer to the simulated and observed values for the studied variables, respectively. E.g. grain yield and total biomass and n is the mean of the observed variables. Normalized RMSE ($RMSE_n$) gives a measure (%) of relative difference of simulated verses observed data. The simulation is considered excellent with a normalized RMSE less than 10 per cent, good if the normalized RMSE is greater than 10 and less than 20 per cent, fair if the normalized RMSE is greater than 20 per cent and less than 30 per cent and poor, if the normalized RMSE is greater than 30 per cent (Loague and Green 1991). The $RMSE_n$ was calculated following Equation.

$$\text{NRMSE (Normalized Root Mean Square Error)} = \left[\frac{RMSE \text{ x } 100}{\bar{O}}\right]$$

**2. BIAS**

BIAS was calculated as

$$\text{Bias} = n^{-1}\sum_{i=1}^{n}(\text{Si} - \text{Oi})$$


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

Where Si: Simulated yield, Oi: Observed yield, n: Number of observations. BIAS measures the average tendency of simulated data to be larger or smaller than the observed counterparts. BIAS values with small magnitude are preferred. Positive values indicate model overestimation bias and negative values indicate underestimation model bias (Gupta and Nagar, 1999).

**3. Coefficient of determination ($R^2$)**

Coefficient of determination was calculated as follow, the coefficient of determination $r^2$ is defined as the squared value of the coefficient of correlation according to Bravais-Pearson. It is calculated as:

$$\left| r^2 = \left( \frac{\sum_{i=1}^{n}(O_i - \overline{O})(P_i - \overline{P})}{\sqrt{\sum_{i=1}^{n}(O_i - \overline{O})^2}\sqrt{\sum_{i=1}^{n}(P_i - \overline{P})^2}} \right)^2 \right|$$

Where, O observed and S simulated values. $R^2$ can also be expressed as the squared ratio between the covariance and the multiplied standard deviations of the observed and simulated values. Therefore it estimates the combined dispersion against the single dispersion of the observed and simulated series. The range of $r^2$ lies between 0 and 1 which describes how much of the observed dispersion is explained by the simulated.

**4. Index of agreement (d)**

The index of agreement d was proposed by Willmot (1981) to overcome the insensitivity of E and $r^2$ to differences in the observed and simulated means and variances (Legates and McCabe, 1999). The index of agreement represents the ratio of the mean square error and the potential error (Willmot, 1984) and is defined as

$$d = 1 - \frac{\sum_{i=1}^{n}(O_i - P_i)^2}{\sum_{i=1}^{n}\left(|P_i - \overline{O}| + |O_i - \overline{O}|\right)^2}$$

Where, n is the number of observations, Si is simulated and Oi is observed values.

According to the D-statistic, the closer the index value is to one, the better the agreement between the two variables that are being compared and vice versa.

**RESULT AND DISCUSSION**

Aquacrop model simulated and observed grain and biomass yield with water use efficiency (WUE) are furnished in Table 2. The results revealed that model simulated grain and biomass yield closely matched with the observed grain and biomass yield under all the irrigation treatments. Similarly model simulated WUE had good match with observed WUE. Aquacrop simulation revealed that maize productivity was found higher in IW/CPE based irrigation treatment compared to the various deficit irrigation schedules.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

**Table 2. Simulated and observed grain and biomass yield with water use efficiency (Summer, 2017)**

| Treatments | Grain yield (kg ha$^{-1}$) | | Biomass yield ( kg ha$^{-1}$) | | WUE (kg ha mm$^{-1}$) | |
|---|---|---|---|---|---|---|
| | Observed | Simulated | Observed | Simulated | Observed | Simulated |
| $T_1$ | 7571 | 7336 | 14283 | 13840 | 16.72 | 14.50 |
| $T_2$ | 7093 | 6922 | 13505 | 13179 | 15.67 | 14.36 |
| $T_3$ | 6755 | 6559 | 13034 | 12657 | 14.92 | 14.07 |
| $T_4$ | 6107 | 6033 | 12002 | 11857 | 13.49 | 13.91 |
| $T_5$ | 4290 | 4276 | 8618 | 8389 | 9.48 | 9.70 |
| $T_6$ | 6860 | 6527 | 13261 | 12617 | 15.15 | 14.14 |
| $T_7$ | 7233 | 7169 | 13672 | 13551 | 15.98 | 14.39 |
| $T_8$ | 5413 | 5642 | 10229 | 10661 | 11.96 | 13.01 |
| $T_9$ | 6166 | 5709 | 11638 | 10776 | 13.62 | 13.04 |
| $T_{10}$ | 5573 | 5318 | 10615 | 10129 | 12.31 | 12.91 |
| $T_{11}$ | 5952 | 5552 | 11266 | 10509 | 13.15 | 12.97 |

In order to employ the Aquacrop model for optimizing the irrigation in maize, the model parameters were adjusted based on the field experiment data and validated by comparing selected model outputs with the available observed data (Fig 1 -3). In the current study the Aquacrop model output on maize yield, biomass and water use efficiency (WUE) were validated by comparing with observed data.

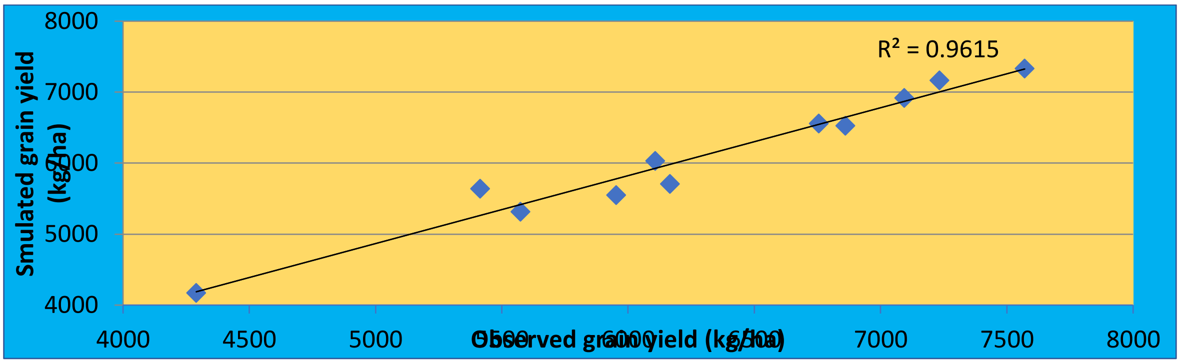



**Fig 1.** Comparison between the simulated and observed grain yield (kg ha$^{-1}$) of Summer, 2017

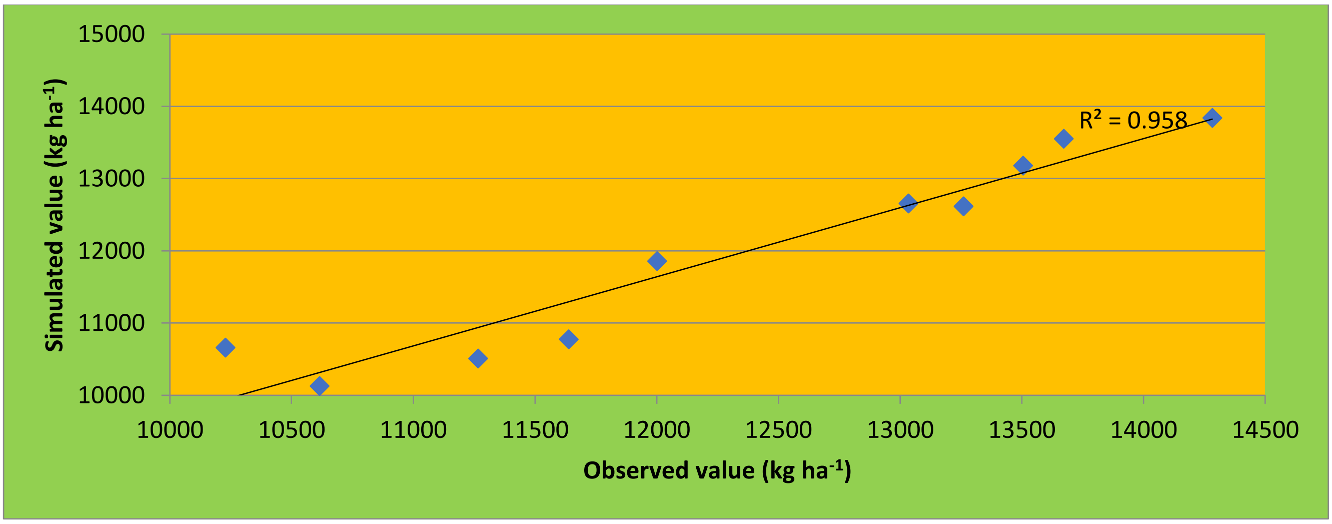



**Fig 2.** Comparison between the simulated and observed biomass yield (kg ha$^{-1}$) of Summer, 2017


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

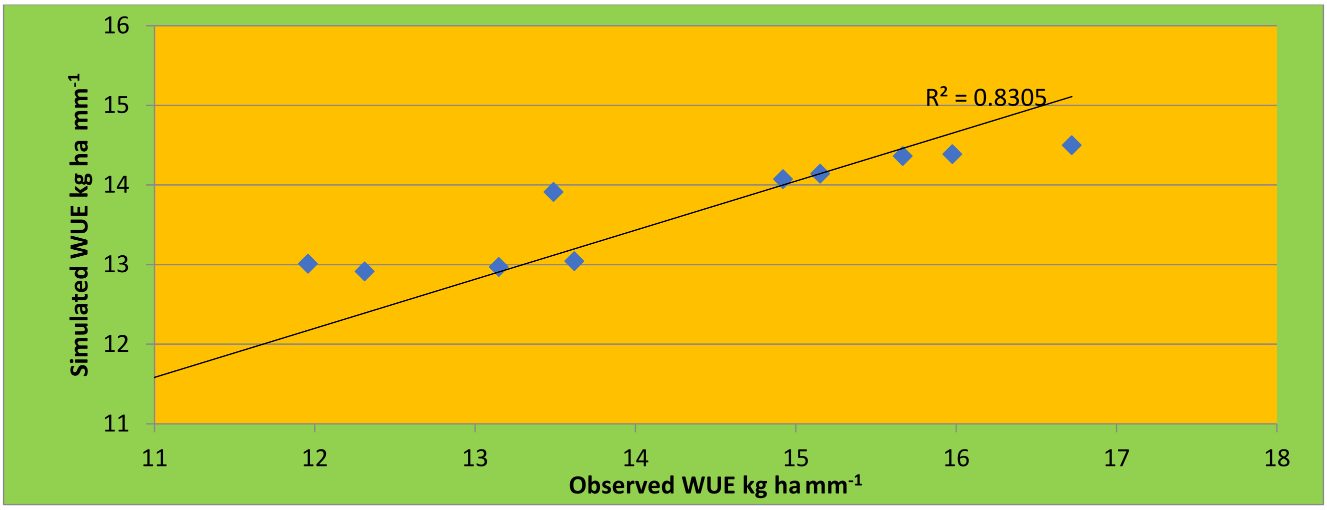



**Fig 3.** Comparison between the simulated and observed WUE (kg ha mm$^{-1}$) of Summer, 2017

The validation efficiency has been tested by the statistical measures such as BIAS Root Mean Square Error (RMSE), Normalized RMSE (NRMSE), coefficient of determination ($R^2$) and Index of agreement (d) and the results are presented in Table 3.

**Table 3. Comparison between observed and simulated values of grain yield, biomass and WUE (Summer, 2017)**

| Statistical Index | Grain Yield | Biomass | WUE |
|---|---|---|---|
| **RMSE** | 260 kg ha$^{-1}$ | 494 kg ha$^{-1}$ | 1.08 kg ha mm$^{-1}$ |
| **NRMSE** | 4.14% | 4.12 % | 7.82% |
| **BIAS** | -128 kg ha$^{-1}$ | -340 kg ha$^{-1}$ | -0.55 kg ha mm$^{-1}$ |
| **$R^2$** | 0.93 | 0.91 | 0.83 |
| **D** | 0.9 | 0.9 | 0.8 |

Less BIAS values of -128, -340 kg ha$^{-1}$ and -0.55 kg ha$^{-1}$ mm$^{-1}$ and RMSE of 260, 494 kg ha$^{-1}$ and 1.08 kg ha$^{-1}$ mm$^{-1}$ for grain, biomass yield and WUE indicated that the Aquacrop model performance was acceptable in simulating grain, biomass yield and WUE. NRMSE values for grain, biomass yield and WUE were 4.14, 4.12 and 7.82 per cent which indicates model simulation is excellent as the NRMSE is < ±10 per cent and NRMSE was 7.82 per cent for WUE which indicates model is good (Loague and Green 1991). The $R^2$ value for grain yield, biomass and WUE was more than 0.9 to 0.8 indicating high degree of co linearity between simulated and measured data as opined by Bitri *et al*. (2014) and Sema Kale (2016). High D value (0.9 and 0.8) for grain yield, biomass and WUE indicating very high predictability of the model (Bitri *et al*., 2014).

The $R^2$ values of 0.93, 0.91 and 0.83 respectively of grain yield, biomass and WUE through model statistics indicated that there was good agreement between observed and model simulated data. RMSE values for grain yield and biomass were found to be 260 and 494 kg ha$^{-1}$


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

indicating good match between simulated and observed values. WUE was also found to have lower RMSE of 1.08 kg ha $mm^{-1}$.

From the model simulation, based on NRMSE, it was found that the performance of model was categorised as excellent (<10 %) in predicting the maize grain yield (with a deviation of 4.14 %) and biomass (with a deviation of 4.12 %) and WUE (with a deviation of 7.82 %). The amount of deviation from the observed quantities was 128, 340 kg $ha^{-1}$ and 0.55 kg ha $mm^{-1}$ respectively of grain yield, biomass yield and WUE. Higher D value (0.8 to 0.9) showed good agreement between the simulated and observed values of all the three components

## CONCLUSION

Good predictability of Aquacrop indicates its sufficient degree of simulation accuracy make it a valuable tool for estimating crop productivity under deficit irrigation as an on-farm water management strategies for improving the efficiency of water use in agriculture. So it is concluded that Aquacrop model can be used with a high degree of reliability in practical management, strategic planning of the use of water resources for irrigation.

## REFERENCE

Bharathi,A., T Ragavan, V Geethalakshmi, A Rathinasamy and R. Amutha. 2018. Influence of deficit irrigation schedules on nutrient uptake of maize hybrid under drip system. Journal of Pharmacognosy and Phytochemistry. 7(4):272-275

Bharathi, A. 2020. Deficit Irrigation Strategy as an Adaptation Tool to Climate Change. In Book: Climate Change and Agriculture – Volume 2, AkiNik Publications, Delhi. Pp 1-26

Bitri, M., Grazhdani, S., and Ahmeti, A. 2014. Validation of the AquaCrop model for full and deficit irrigated potato production in environmental condition of Korea Zone, South-eastern Albania.

Crop production guide (CPG).2012.Published by DEE.TNAU offset press. Coimbatore.

Farahani, H. J., Izzi, G., & Oweis, T. Y. (2009). Parameterization and Evaluation of the AquaCrop Model for Full and Deficit Irrigated Cotton All rights reserved. No part of this periodical may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or any information storage and retrieval system, without permission in writing from the publisher. *Agronomy Journal*, *101*, 469–476.

Gupta, A. K., & Nagar, D. K. (2018). *Matrix variate distributions*. Chapman and Hall/CRC.

Hsaio, T.C., Heng. L., Steduto, P., Rojas-Lara, B., Raes. D and Fereres, E. 2009. AquaCrop - The FAO crop model to simulate yield response to water:III. Parameterization and testing for maize. ***Agron.J.,*** 101:448-459.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

Kipkorir, E.C., Mugalavai, E.M., and Bargerei, R.J. 2010. Application of AquaCrop model for within-season prediction maize yield. IN: Workshop of Capacity Development for Farm Management Strategies to Improve Crop-Water Productivity using AquaCrop.2010, Yogyakarta, Indonesi.,8-10:Dec.57-64.

Loague, K., and Green, R. E. 1991. Statistical and graphical methods for evaluating solute transport models: overview and application. Journal of contaminant hydrology.,7(1-2): 51-73.

Sema Kale, S. 2016. Assessment of AQUACROP model in the simulation of wheat growth under different water regimes. Scientific Papers-Series A, Agronomy., 59: 308-314.

Steduto, P., Hsiao, T. C., Raes, D., & Fereres, E. (2009). AquaCrop—The FAO crop model to simulate yield response to water: I. Concepts and underlying principles. *Agronomy Journal*, *101*, 426–437.

Veeraputhiran, R., & Chinnusamy, C. (2009). Soil moisture and water use studies under drip and furrow irrigation methods in hybrid cotton. *Journal of Cotton Research and Development*, *23*, 74–79.

Willmott, C. J. 1981. On the validation of models, Physical Geography. Spatial statistic and models., 18.

Willmott, C. J. 1984. On the evaluation of model performance in physical geography. In Spatial statistics and models (pp. 443-460). Springer Netherlands.

Yawson, D.O., Sam-Amoah, L.K., Armah, F.A. 2010. AquaCrop simulation of rainfed maize water productivity in south-central Ghana. IN: Workshop of Capacity Development for Farm Management Strategies to Improve Crop-Water Productivity using AquaCrop.2010, Y Yogyakarta, Indonesi.,8-10:Dec.26-31.


Published: 23 Jan. 2024
ISSN: 2583-7850

TRENDS IN AGRICULTURE SCIENCE

Vol.3 Special Issue 01 January 2024, Page: 191-196

# Demonstration of of Zinc solubilising bacteria in Paddy in selected zinc deficient soils of Dharmapuri district

**K. Sivakumar[1], M.A.Vennila[1], S.Sivagnanam[2],C.Sivakumar[1], D.Rajbaskar[1], R.Thangadurai[1], K.Indhumathi[1] and M.Deivamani[1]**

[1]ICAR-Krishi Vigyan Kendra, Dharmapuri,

Tamil Nadu Agricultural University

[2]School of Agriculture, Bharath Institute of Higher Education and Research, Selaiyur,

Tambaram - 600 073.

https://doi.org/10.5281/zenodo.10605483

***Abstract***

Among the micronutrients iron, manganese, zinc, copper and molybdenum zinc is found to be predominantly deficient throughout the country. Zinc is an imperative micronutrient required for optimum plant growth as it is the precursor for many of the growth hormone production. Zinc solubilizing bacteria (ZSB) are potential alternatives for zinc supplementation and convert applied inorganic zinc to available forms ($Zn^{2+}$). In addition, the application of zinc-solubilizing bacteria as a potential biosource represents a cost-effective and alternate biofortification strategy. Zinc-solubilizing bacteria act as natural bio-fortifiers that can solubilize the unavailable form of zinc by secreting organic acids, siderophores, and other chelating compounds.It has been found from the analytical reports of soil and plants that 48.5% of the soils and 44% of the plant samples were potentially zinc-deficient. In India, zinc (Zn) is now considered as fourth most important yield limiting nutrient in agricultural crops. Zn deficiency in Indian soils is likely to increase from 49 to 63% by 2025.The deficiency of zinc was found in more than fifty per cent of Tamil Nadu soil. In Paddy, Zn deficiency causes multiple symptoms that usually appear 2 to 3 weeks after transplanting (WAT) rice seedlings; leaves develop brown blotches and streaks that may fuse to cover older leaves entirely, plants remain stunted and in severe cases may die, while those that recover will show substantial delay in maturity and reduction in yield. Zn deficiency has been associated with a wide range of soil conditions: high pH (>7.0), low available Zn content, prolonged submergence and low redox potential and high available P. Availability of both soil and applied zinc is higher in upland soil than in submerged soil. Soil submergence causes decrease in zinc concentration in the soil solution.Rice crop removes 30-40 g Zn per tonne of grain. Zinc deficiency in Paddy can also be overcome by 0.5 per cent of foliar application of Zn (or) as soil application of $ZnSO_4$ @ 25 kg/ha.

**Key words :** Zinc Solubilising Bacteria (ZSB), Paddy, Zinc deficiency



**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

## Introduction

Micronutrients play an important role in plants. Iron, Manganese, Zinc, Copper and Molybdenum are the commonly identified micronutrients. Among these Zinc (Zn) is required for the metabolism of plants, enzyme function, and ion transport. The physicochemical involvement of Zn in soil-plant systems. Consequently, inadequate Zn availability in soil is a main consideration for plant nutrition, resulting in a significant loss in production and grain nutrient content. Zinc is distributed biogeochemically in various basins. Overall, there are five distinct forms of Zn in soil: adsorbed, interchangeable, water-soluble, complex, and chelated **Figure** 1. The phyto-availability, leachability, and extractability of these Zn pools vary substantially (Alloway, 2008). The Zn levels in the soil, pH, soil texture, and the occurrence of competing cations all affect the presence of Zn in the abovementioned basins. However, the minerals, chemical structure, amount of organic matter, and pH of the soil all affect the availability of Zn (Wang *et al.*, 2014). Zn availability is influenced by soil structure; sandy loam and organic soils are more prone to Zn deficiency than clayey or silty soils . Considering all aspects, soil pH has the greatest impact on the availability of Zn in soil. A higher pH soil has less availability of Zn than a lower pH soil ). Various soil characteristics, including cation exchange ability, moisture content, and electrical conductivity, can influence the Zn availability in soil (Moreno-Lora and Delgado, 2020).

## Role of Zinc in Paddy:

Micronutrients are important in order to help rice reach its full potential and zinc (Zn) is the most commonly deficient micronutrient both in rice and in soils. From an agronomic perspective, zinc is important to rice for a number or reasons:

Nitrogen assimilation and protein metabolism – Approximately 10% of proteins in plants require Zn for structural function and integrity. Low Zn supply limits the rice plant's ability to convert amino acids to proteins. Additionally, the rate of protein synthesis is drastically reduced in Zn-deficient plants.

**Auxin metabolism** – Zn deficiency causes reduced auxin levels, leading to little leaf syndrome, stunted growth and reduced shoot elongation. An example is indole acetic acid (IAA). Indole requires Zn to produce tryptophan which leads to IAA. Reduced Zn leads to higher stress responses, causing production of more free radicals, leading to the degradation of IAA.

Membrane structure, function and maintenance – Zinc deficiency can cause chlorosis by allowing the breaking down of chlorophyll.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

**Carbohydrate metabolism**

Zinc also helps in carbohydrate metabolism

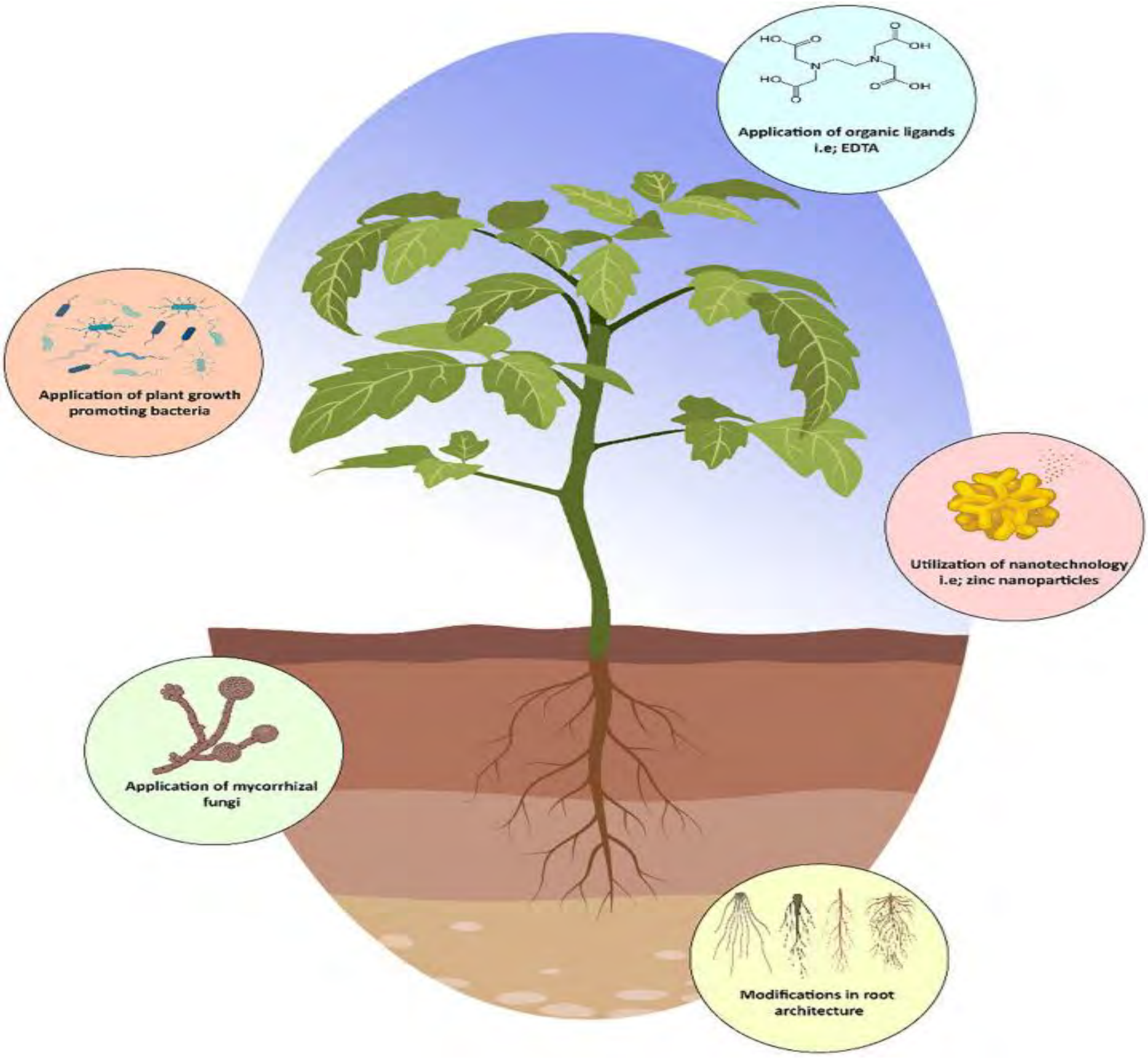



Figure 1. Strategies to enhance Zn uptake in plants.

**Materials and Methods:**

Field trials were conducted in the district of Dharmapuri. The trials were conducted in five different villages viz,, Bairnaickenpatty, Ganapatty, Papparapatty, Gettur, Seriyampatty . The rice variety chosen was ADT 39. The field was applied with recommended dose of fertilizer. The soils were found to be deficient in zinc.The treatments were $T_1$ - Control (Without applying any of the biofertilizer), $T_2$- RDF + With Azospirillum alone and $T_3$ - RDF + Azospirillum + ZSB. The FLD trials were replicated thrice in each village.

**Application of Zinc to Paddy crop:**

**Seed treatment:**

**Zinc Deficient Soils:** Along with existing recommended biofertilizers, seed treatment is required for one hectare with 1 kg of zinc solubilizing bacterium using rice gruel, shade dry for 30 minutes before sowing.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

**Main field application**

**Zinc Deficient Soils:** Along with existing recommended biofertilizers (Azospirillum), 2 kg each zinc solubilizing bacterium with 25 kg of FYM and 25 kg of sand and broadcast uniformly before transplanting.

**Application of Liquid formulation of Zinc solubilizing bacteria :**

**Zinc Deficient Soils:** Along with existing recommended biofertilizers (Azospirillum), seeds should be treated with liquid formulation of ZSB which is required for one hectare with 125 ml of zinc solubilizing bacterium shade dry for 30 minutes before sowing

**Parameters recorded**

The grain yield and straw yield were recorded in the front-line demonstration trials conducted at five different villages of the Dharmapuri district.

**Results and Discussion**

The Zinc Solubilising Bacteria (ZSB) was applied to the paddy crop along with other recommended dose of biofertilizer (i.e) Azospirillum. The yield was recorded as grain yield and straw yield. The grain yield and straw yield obtained in different villages were recorded as in table.1.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

**Table 1. Effect of Zinc Solubilizing Bacteria on Grain and straw yield of ADT 39 Paddy variety in Dharmapuri district (Mean values)**

| Villages | Grain yield (kg/ha) | | | Straw yield (kg/ha) | | |
|---|---|---|---|---|---|---|
| | $T_1$ | $T_2$ | $T_3$ | $T_1$ | $T_2$ | $T_3$ |
| **Bairnaickenpatty** | 4450 | 4625 | 4800 | 8050 | 8100 | 8200 |
| **Ganapatty** | 4525 | 4700 | 4900 | 8100 | 8150 | 8250 |
| **Papparapatty** | 4650 | 4800 | 5025 | 8150 | 8200 | 8300 |
| **Gettur** | 4600 | 4750 | 5000 | 8075 | 8125 | 8250 |
| **Seriyampatty** | 4750 | 4900 | 5150 | 8125 | 8225 | 8300 |
| **Mean** | **4595** | **4755** | **4975** | **8100** | **8160** | **8260** |

**$T_1$- Control (Farmers practice - without applying any biofertilizer)**

**$T_2$ - RDF +Azospirillum alone $T_3$ - RDF + Azospirillum + ZSB**

The results of the experiment showed that the highest grain yield (4975 kg/ha) was obtained in the treatment $T_3$ which received RDF + Azospirillum + ZSB followed by $T_2$ (4755 kg/ha) which received RDF + Azospirillum alone. The straw yield was also recorded to be higher in $T_3$. But there was no significant difference.The increase recorded in yield could be attributed to higher mobilization of Zn by Zn solubilizing bacteria . Mader *et al*. (2011) also stated an increase of 23% in rice yield obtained due to the application of ZSB. The bacterial isolates would have induced IAA production, a phytohormone responsible for increasing the length of the root hairs which could promote better absorption of nutrients from the soil. According to Volkmar and Bremer (1998) rapid establishment of roots including elongation of primary roots or proliferation of lateral/adventitious roots is advantageous for young seedlings as it increases their ability to explore the soil to easily obtain water and nutrients.

Thus, in the present study the ZSB has an effective role in increasing the grain and straw yield of the paddy crop in the five villages of Dharmapuri district.

**References:**

Alloway BJ (2008). Zinc in soils and crop nutrition, Second edition, published by IZA and IFA Brussels, Belgium and Paris, France

Mäder, P., Kaiser, F., Adholeya, A., Singh, R.,Uppal, H.S., Sharma, A.K., Srivastava, R.,Sahai, V., Aragno, M., Wiemken, A., Johri,B.N., Fried, P.M. 2011. Inoculation of root microorganisms for sustainable wheat rice and wheat black gram rotations in India.Soil. Biol. Biochem. 43, 609-619.

Moreno-Lora A., Recena R., Delgado A. (2019). Bacillus subtilis QST713 and cellulose amendment enhance phosphorus uptake while improving zinc biofortification in wheat. *Appl. Soil Ecol.* 142, 81–89. doi: 10.1016/j.apsoil.2019.04.013


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

Volkmar, K.M., Bremer, E. 1998. Effect of seed inoculation with a strain of *Pseudomonas fluorescens* on root growth and activity of wheat in well-watered and drought-stressed glass-fronted rhizotrons. *Can. J. Plant Sci.*78, 545-551.

Wang, Y., Yang, X., Zhang, X., Dong, L., Zhang, J., Wei, Y., et al. (2014). Improved plant growth and Zn accumulation in grains of rice *(Oryza sativa* L.) by inoculation of endophytic microbes isolated from a Zn hyperaccumulator, *Sedum alfredii* H. *J. Agric. Food Chem*. 62, 1783–1791. doi: 10.1021/jf404152u


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com

**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

TRENDS IN AGRICULTURE SCIENCE
Vol.3 Special Issue 01 January 2024, Page: 197-202

# Phytoremediation Technology in Agriculture – A Review

**Anjali Deshmukh[1*], Dr C Anbalagan[2]**
[1*] Ph.D. Scholar (Environmental Engineering), Department of Civil Engineering, Bharat Institute of Higher Education and Research, Chennai.
[2] Professor, Department of Civil Engineering, Bharat Institute of Higher Education and Research, Chennai.
https://doi.org/10.5281/zenodo.10805899

***Abstract***

With the advent of industrialization, urbanization, and population explosion, the productivity of agricultural land has taken a drastic toll. Heavy metal pollution and over-fertilization are some of the causes of the present condition of agricultural lands. The conventional methods to improve soil fertility are expensive and not eco-friendly. Hence, it is important that we lay more emphasis on greener and less expensive technologies such as phytoremediation. It is a process of utilizing a variety of plants to remediate contaminated water, soil, and air. Phytoremediation is an eco-friendly, economical, and effective method to reduce, and in some cases eradicate the harmful effects of heavy metal pollution in the environment. The objective of this review paper is to understand the concept of phytoremediation, its types, the plants used, and its significance in the field of agriculture.

**Keywords:** Phytoremediation, Heavy metals, Eco-friendly, Economical, Agriculture.

## Introduction

Soil has been described as the basis of our agricultural resources. It also promotes food security, the global economy, and environmental quality. Soil has been progressively contaminated with various environmental pollutants because of increasing industrialization. This has posed serious threats to the ecosystem and human health (G.F Akomolafe *et al.*, 2018).

Industrial pursuits such as mining and manufacturing produce large amounts of heavy metal pollution worldwide. Heavy metals such as cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), nickel (Ni), and zinc (Zn) and metalloids such as arsenic (As) and selenium (Se) not only pollute soils in the immediate vicinity within which they are produced but can be easily dispersed via air and water, leading to contamination of soils far from the source of the pollutants. Unsound agricultural practices that intensify contamination of soils by heavy metals further exacerbate this problem, making it challenging to produce food safe for human or animal consumption. As the amount of land available for agriculture decreases the


**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

need for more land, or at least better use of currently available arable land, increases (S. Nielson *et al*., 2015).

The conventional methods used to improve the productivity of agricultural lands are quite expensive and not eco-friendly. Hence, we require a greener solution to tackle this issue. One of the methods that can help in the effective removal of pollutants is the phytoremediation technique. Phytoremediation is a word formed from the Greek prefix "phyto" meaning plant, and the Latin suffix "remedium" meaning restoring balance (Cunningham *et al*., 1997). In simple words, phytoremediation is an emerging technology that uses various plants to degrade, extract, contain, or immobilize contaminants including metals, pesticides, hydrocarbons, and chlorinated solvents from soil and water (Seyyed Gholamreza Moosavi *et al*., 2013). The plants used in phytoremediation break down the harmful contaminants in soil with the help of their roots. They can clean up the contamination in the following ways - store the pollutants in their roots, convert them into less harmful contaminants, or turn them into gaseous vapors. The level of tolerance of heavy metals varies from plant to plant. Some plants can tolerate the concentration of heavy metals better than others.

Phytoremediation is a relatively new technology and hence it requires exhaustive research so that it can be applied in various areas including agriculture. This review aims at understanding the various aspects of phytoremediation and its application in the field of agriculture.

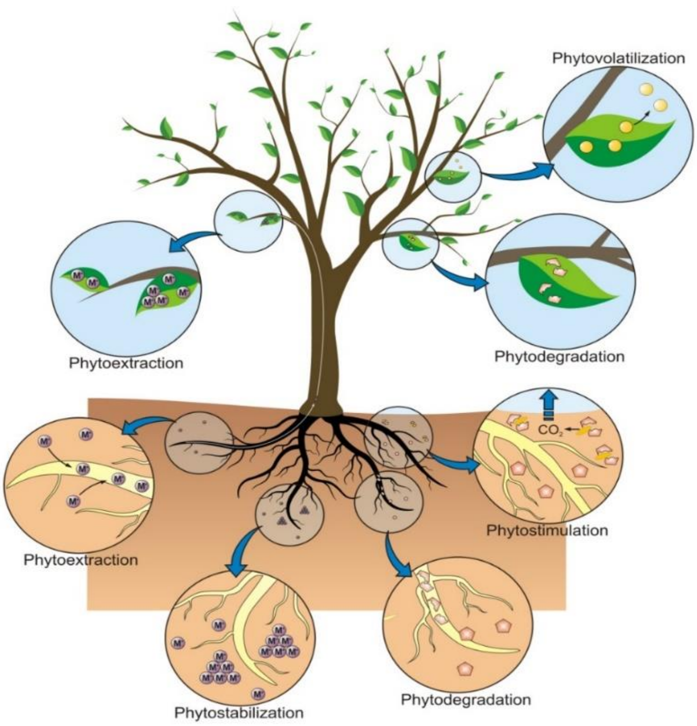



**Fig 1:** Schematic representation of phytoremediation techniques

**Phytoremediation Techniques**

Phytoremediation can be classified into different applications, such as phytofiltration or rhizofiltration, phytostabilization, phytovolatilization, phytodegradation (Long *et al*., 2002), and phytoextraction (Jadia and Fulekar, 2009).

**Phytoextraction** – This is also called phytoaccumulation. It refers to the uptake and translocation of metal contaminants in the soil by plant roots into the above-ground portions of the plants. Phytoextraction is primarily used for the treatment of contaminated soils (USEPA, 2000). To remove contamination from the soil, this approach uses plants to absorb, concentrate,


Published: 23 Jan. 2024
ISSN: 2583-7850

and precipitate toxic metals from contaminated soils into the above-ground biomass like shoots, leaves, etc. (E.E Etim, 2012). Eg - Elsholtzia splendens, Alyssum bertolonii, Thlaspi caerulescens , and Pteris vittata are known examples of hyperaccumulator plants for Copper, Nickel, Zinc/Cadmium, and Arsenic, respectively. (Paulo JC Favas et al., 2014)

**Phyto or Rhizofiltration** – In this method, the plants are kept in a hydroponic system. The effluent is passed through the system, where the roots absorb the contaminants. Plants with high root biomass are most suitable for this process. Eg – Helianthus annus, various species of Salix, Populus lemna, and Brassica juncea. (Paulo JC Favas *et al*., 2014)

**Phytovolatilization** - This involves the use of plants to take up contaminants from the soil, transforming them into volatile forms and transpiring them into the atmosphere. Phytovolatilization also involves contaminants being taken up into the body of the plant, but then the contaminant, a volatile form thereof, or a volatile degradation product is transpired with water vapor from leaves (USEPA, 2000). E.g. – Astragalus bisulcatus and Stanleya pinnata for Selenium, Liriodendron tulipifera, or Brassica napus for mercury. *(*Paulo JC Favas *et al*., 2014)

**Phytostabilization**- This is also referred to as in-place inactivation. It is primarily used for the remediation of soil, sediment, and sludge (USEPA, 2000). It is the use of certain plant species to immobilize contaminants in the soil and groundwater through absorption and accumulation by roots, adsorption onto roots, or precipitation within the root zone of plants (rhizosphere). This process reduces the mobility of the contaminant and prevents migration to the groundwater and it reduces bio-availability of metal into the food chain. This technique can also be used to re-establish vegetation cover at sites where natural vegetation fails to survive due to high metal concentrations in surface soils or physical disturbances to surface materials. (E.E Etim, 2012). Eg – Species of Humaiastrum, Gladiolus,Ascolepis. . (Paulo JC Favas *et al*., 2014)

**Phytodegradation** - It involves the degradation of complex organic molecules to simple molecules or the incorporation of these molecules into plant tissues. When the phytodegradation mechanism is at work, contaminants are broken down after they have been taken up by the plant. Phytodegradation has been observed to remediate some organic contaminants, such as chlorinated solvents, herbicides, and munitions, and it can address contaminants in soil, sediment, or groundwater. (E.E Etim, 2012). Eg – Populus species, Myrophyllium spicatum (Paulo JC Favas *et al*., 2014).

**Applications Of Phytoremediation**


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
**Published**: 23 Jan. 2024
**ISSN: 2583-7850**

Phytoremediation has a vast application in various fields. Due to its cost-effective and eco-friendly nature, this technology is gaining more popularity over conventional methods. Some of its major applications are listed below.

- Heavy metal is one of the most harmful pollutants in the environment, and its safe disposal is a major issue. It can have adverse effects on soil and water quality, as well as on the growth of plants and animals. Traditional disposal methods can be very expensive and difficult to implement. Therefore, phytoremediation is a better alternative in this scenario.
- Fly ash is a significant air pollutant, and it is hazardous to both the environment and the health of living organisms. Phytoremediation is a cheap and effective way to reclaim fly ash dump sites.
- Phytoremediation can be used in landfill sites by planting trees to prevent the leaching of contaminants into the soil.
- This method can also be utilized to reclaim soil near mining areas, helping to increase the amount of arable land.
- This technique is also useful in the rehabilitation of Ni-Cd-affected lands, bringing them back to a productive state.
- Additionally, it can be applied in constructed wetlands. However, for it to work in wetlands, the toxicity level must be low as high concentrations can limit plant growth.

**Significance of Phytoremediation in Agriculture**

Healthy soil is a major requirement for agricultural production, food production, and boosting of country's economy. Parts of the requirements needed by plants for survival are air, sun, water, and soil. The presence of essential elements along with water, air, and soil microorganisms that break down organic matter in the soil makes the soil healthy, rich, and fertile (G.F Akomolafe *et al*., 2018).

Polluted soil will yield crops that contain contaminants which will start a biomagnification chain. Hence, phytoremediation techniques act as an intervention to convert polluted soil into healthy soil. Phytoremediation techniques along with compost have to be employed to fix nitrogen, phosphorus, potassium, and other nutrients. Phytoremediation helps in maintaining and improving soil fertility by providing the basic nutrient requirements of the crop and by providing an enabling environment for the absorption of water and nutrients by plant roots. It also enhances the activities of soil organisms such as the decomposition of organic matter which in turn releases nutrients to plants (G.F Akomolafe *et al*., 2018).


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
Published: 23 Jan. 2024
ISSN: 2583-7850

Agriculture and phytoremediation go hand in hand. This technique along with sustainable agricultural practices such as crop rotation, integrating livestock and crops, incorporating perennial crops, reducing tillage, and adopting agroforestry can help in achieving a healthy agricultural land.

**Conclusion**

A healthy soil is crucial for maintaining the ecosystem's functionality. Phytoremediation techniques can be combined with sustainable agriculture to achieve better results on agricultural lands. To gain a better understanding of this method, people from different fields such as plant breeders, biologists, environmentalists, scientists, and agronomists can work together. Pilot studies as well as field studies are required in this direction. Phytoremediation has immense potential that needs to be explored and put into practice.

**References**

Blaylock M (2008), "Phytoremediation of contaminated soil and water: field demonstration of phytoremediation of lead-contaminated soils". *Lewis Publishers*, Boca Raton, Fl.

Seyyed Gholamreza Moosavi and Mohammad Javad Seghatoleslami (2013), "Phytoremediation: A review", *Advance in Agriculture and Biology*, 1 (1), 2013:

Cunningham SD, Shann JR, Crowley DE, Anderson TA, (1997), "Phytoremediation of contaminated water and soil.", *ACS symposium series* 664. American Chemical Society, Washington, DC.

Long X, Yang X, Ni W. (2002), "Current situation and prospect on the remediation of soils contaminated by heavy metals", *The Journal of Applied Ecology*. 13(6): 757-762.

Jadia CD, Fulekar MH (2009), "Phytoremediation of heavy metals: Recent techniques" *Afr. J. Biotechno*l. 8(6): 921-928.

United States Environmental Protection Agency (USEPA). (2000). "Introduction to Phytoremediation". EPA 600/R-99/107, U.S. Environmental Protection Agency, Office of Research and Development, Cincinnati, OH.

E. E. Etim, (2012), "Phytoremediation and Its Mechanisms: A Review", *International Journal of Environment and Bioenergy,* 2(3): 120-136.

Raskin, I., and Ensley, B. D. (2000). Recent developments for in situ treatment of metal contaminated soils. In: Phytoremediation of Toxic Metals: Using Plants to Clean Up the Environment. John Wiley & Sons Inc., New York. Available at: http//clu-n.org/techfocus Tanee,

Trap, S., Kohler, A., Larsen, L. C., Zambrano, K. C., and Karlson, U. (2005), "Phytotoxicity of fresh and weathered diesel and gasoline to willow and poplar trees", *Journal of Soil Sediments*, 1: 71-76.

Zhang BY, Zheng JS, Sharp RG, (2010), "Phytoremediation in engineered wetlands: Mechanisms and applications", *Procedia Environ. Sci.* 2: 1315-1325.

Paulo J.C. Favas, João Pratas, Mayank Varun, D'Souza R and Paul M.S, (2014), "Phytoremediation of Soils Contaminated with Metals and Metalloids at Mining Areas: Potential of Native Flora", *Environment Risk Assessment of Soil Contamination* (book).


**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

Akomolafe. G. F, Onwusiri K. C, Adokpa F. A, (2018), "Phytoremediation and Agricultural Productivity – A Mini review", *Journal of Floriculture and Landscaping, 4: 15-19.*

Nielson.S, Rajakaruna N, Ansari A.A. (2015), "Phytoremediation of Agricultural Soils: Using Plants to Clean Metal- Contaminated Arable Land", *Phytoremediation: Management of Environmental Contaminant, Springer International Publishing Switzerland*, Volume 1, 159 DOI 10.1007/978-3-319-10395-2_11.

Udawat P, Singh J (2020), "Phytoremediation: A way towards sustainable Agriculture", *International Journal of Environment, Agriculture and Biotechnology,* 5(4).

Sutrisno Sa'ad N, Artanti. R, and Dewi.T (2011), "Phyto-Remediation for Rehabilitation of Agricultural Land Contaminated by Cadmium and Copper", *Indonesian Journal of Agriculture* 4 (1), 17-21.


Official Website: trendsinagriculturescience.com
e-mail Address: trendsinagriculturescience@gmail.com
**Published**: 23 Jan. 2024
**ISSN:** 2583-7850

# SPONSORSHIP