**Nutrient uptake and Quality Parameters of cotton (*Gossypium hirsutum*) by using organic and inorganic nutrients with Phytohormone**

**Abstract**

In India, 6 million farmers directly depend on cotton for their income, while 40–50 million people are employed in the cotton trading and processing industry. In the twenty-first century, agriculture has faced several challenges in providing the food and fiber that the growing population need. A field experiment was conducted in Farmer’s Field at Jayapuram Village, Natrampalli Taluk in Thirupathur District during Aug-Jan (2021-22) to investigate the effect of soil application of NPK fertilizers, Zn-enriched compost and foliar spray of ZnO2 and NAA on enhancement of cotton nutrient uptake and quality in sandy loam soil.

Fertilizers (N: P2O5: K2O) were applied at the appropriate dose (60:30:30 kg ha-1) using Urea, SSP, and MOP. Zn-enriched compost (Zn-EC) was treated at 1.0 t ha-1 as a basal one week before sowing. As per treatment ZnO2 at 0.1% was applied twice during the vegetative and blooming periods of the crop. The treatment included spraying NAA at 40 ppm twice during flowering and boll formation. Cotton *cv*. Sabari was cultivated as a test crop using suggested cultural methods

The results of the field experiment clearly proved that soil application of 75% RDF + Zn – EC @ 1.0 t ha-1 and foliar spray of ZnO2 @ 0.1% + NAA @ 40 ppm (T9) will be an effective management practices for achieving better yield, quality in cotton with due care on soil fertility. The conclusion made from this study is the farmers might enhance cotton production as well as quality by applying 75% required NPK, zinc-enriched compost at 1.0 t ha-1, and foliar sprays of ZnO2 at 0.1% and NAA at 40 ppm in sandy loam soil. The treatment improved sandy loam soil health, including physical, chemical, biological, and nutrient availability.

In the world market demand for cotton is very high, and the present research adequately explained how the use of various organic and inorganic fertilizers not only enhances the quality but also the yield parameters.

**Keywords:** *Cotton, Zinc oxide, Enriched compost, NAA, Quality.*

**Introduction**

Cotton (*Gossypium hirsutum*) is an important commercial crop of India often referred as “white gold” or “queen of fibers”, the most versatile cash crop which plays a distinguishable role in Indian economy as the country's textile industry is predominantly cotton based. India is one of the largest producers as well as exporters of cotton yarn and Indian textile industry contributes about 11 percent to industrial production, 14 percent to the manufacturing sector, 4 percent to the GDP and 12 per cent to the country's total export earnings.

The productivity of cotton in India is significantly lower (568 kg ha-1) as compared to the four major cotton growing countries *viz*., China (1300 kg ha-1), USA (900 kg ha-1),   
Pakistan (700 kg ha-1) and Brazil (2047 kg ha-1) though India ranks first in area with   
11.88 m ha-1, accounting 30 per cent of world coverage and 22 per cent (351 lakh bales of lint) of the world cotton production (second rank) with a productivity of 568 kg ha-1.

The purpose of this experiment is to study how organic and inorganic nutrients mixed with phytohormones improve cotton quality indices and production. NPK fertilizer treatment has a significant impact on cotton growth, development, and maturity, increasing yield components, yield, and fibre quality. Incorrect fertilization results in economic costs owing to reduced output, as well as environmental hazards. Plant growth regulators (NAA) are tiny chemicals that stimulate or hinder natural plant growth regulation. Using chemical fertilizers, composts, and growth regulators together improves soil health and increases productivity.

The primary reasons for the low productivity of cotton are cultivation of crops predominantly under rain fed condition, use of less efficient cultivars, predominance of pests, excessive vegetative growth, boll shedding and inadequate supply of nutrients etc., (Patil *et al*. 2012 and   
Jayakumar *et al*. 2014).

In Cotton, Nitrogen (N), controls growth and prevents abscission of squares and bolls, essential for photosynthetic activity and stimulates the mobilization and accumulation of metabolites in newly develop bolls thus increasing their number and weight. Phosphorus deficiency reduces the rate of leaf expansion and photosynthetic rate per unit leaf area. The physiological role of potassium (K) during fruit formation and maturation periods is mainly expressed in carbohydrate metabolism and translocation of metabolites from leaves and other vegetative organs to developing bolls. Zinc **(**Zn) is required in the biosynthesis of tryptophan, a precursor of the auxin - indole-3-acetic acid (IAA), which is the major hormone inhibiting abscission of squares and bolls.

The application of organic sources like manure application improved the soil physical properties especially soil texture, availability of nutrients like N, P and S as well as the micro nutrients and also lower down the soil temperature and conserve the moisture (Jan *et al*. 2020, Neugschwandtner et al., 2014, Celik, 2005)

Many studies have reported that the improved results for soil health indicators (soil organic matter, N, P, and K) and crop parameters with the application of organic manures in combination with inorganic nutrients. Song et al., (2016), Liu wt al, (2020).

NAA positively affects the plant growth and improves the maturity of cotton. In comparison with other natural auxin, NAA enhanced the weight and fibre elongation by hindering the secondary cell wall cellulose synthesis (Singh, 2009).

**Materials and Methods**

The field experiment was conducted in Farmer’s Field at Jayapuram Village, Natrampalli Taluk in Thirupathur District during August, 2021-January, 2022 to investigate the effect of soil application of NPK fertilizers, Zn-Enriched compost and foliar spray of ZnO2 and NAA on enhancement of cotton yield and quality in sandy loam soil. A Randomized block design (RBD) with three replications was used in the experiment to ascertain how different sources of nutrients will affect how cotton (*Gossypium hirsutum*) reacts.

Table 1: **Treatment details**

|  |  |  |
| --- | --- | --- |
| **S. No.** | **Treatment No.** | **Details** |
| 1 | T1 | Control |
| 2 | T2 | 100% RDF (N: P2O5: K2O) (60:30:30 kg ha-1) |
| 3 | T3 | 75% RDF + Zn – EC @ 1.0 t ha-1 |
| 4 | T4 | 75% RDF + ZnO2 @ 0.1% |
| 5 | T5 | 75% RDF + NAA @ 40 ppm |
| 6 | T6 | 75% RDF + Zn – EC @ 1.0 t ha-1 + ZnO2 @ 0.1% |
| 7 | T7 | 75% RDF + FS – ZnO2 @ 0.1 % (F.S) + NAA @ 40 ppm |
| 8 | T8 | 75% RDF + Zn – EC @ 1.0 t ha-1 + NAA @ 40 ppm |
| 9 | T9 | 75% RDF + Zn – EC @ 1.0 t ha-1 + ZnO2 @ 0.1% (F.S) + NAA  @ 40 ppm |

##### Preparation of Zinc Enriched Compost (Zn- EC)

Zn-EC was prepared by taking quantities of well decomposed FYM along with recommended quantity of ZnSO4 @ 25 kg ha-1. This mixture kept under anaerobic condition for 4 weeks in a pit with a dimension of 90×90×90 cm. This mixture was sprinkled with water to maintain 65% moisture level. The top of the pit was sprinkled with mud and incubated for a period of 45 days. After 45 days, the enriched compost was used for the field experiment. To protect composting mass from rainwater, the surface of the pit was covered by suitable polyethylene. Zinc solubilizing bacteria is also added with compost for the enrichment.

##### Fertilizer application

The recommended dose of fertilizers (N: P2O5: K2O) (60:30:30 kg ha-1) were applied to the field through Urea, SSP and MOP, respectively. Nitrogen was applied in two splits at 20 and 40 DAS. The full dose of P2O5 and K2O were given as basal by band placement method. Based on the treatments, Zn-EC was applied @ 1.0 t ha-1 as basal one week before sowing. As per treatment schedule, ZnO2 @ 0.1% (Dissolve 0.1 g of Zinc oxide in 100 ml of water) was sprayed twice during vegetative and flowering stages of the crop. NAA @ 40 ppm was also sprayed as per the treatment twice during the flowering and boll formation stages of the cotton crop.

#### **QUALITY CHARACTERS OF THE FIBRE**

##### Ginning percentage

##### It denotes the ratio of the weight of lint to the weight of seed cotton. It is expressed in percentage. Ginning percentage is calculated by using the formula.

Weight of lint (g)

Ginning percentage = x 100

Weight of seed cotton (g)

##### Lint Index

##### The weight of lint obtained from 100 seed cotton was expressed as lint index. (Santhanam, 1976).

##### Seed index

##### Seed index is the weight of seeds obtained from 100 seed cotton (Santhanam, 1976).

##### Mean fibre length

##### The mean fibre length was determined by ‘Boll sorter’, where the weight ratio method was adopted and is expressed in mm.

##### Fibre fineness

##### The weight per unit length (cm) of the fibre is generally taken as a measure of fineness. This was determined by air flow method using the micronaire instrument (Santhanam, 1976).

##### Fibre bundle strength

##### It is the ratio of the breaking strength of a fibre to its weight. Duplicate tufts of fibre weighing one mg were fed into the ‘pressley strength tester’ which gave reading in lb mg -1. The value was expressed in g tex-1 by multiflying the pressley strength index with 5.36 (Sundaram, 1974).

#### **PLANT ANALYSIS**

#### **Plant sampling and analysis**

#### Plant sample from various treatments in each replication were collected on 30, 60, 90 days and at harvest. The plants were cut at 2.5cm above the ground level and washed thoroughly with water to remove the adhering soil particles. The washed samples were shade dried followed by oven – dried at 60 oC to a constant weight and then weighed to find out the dry matter production and expressed as kg ha-1.

#### After drying, the samples were cut into small pieces and ground in a Wiley mill and processed through one mm sieve and taken for analysis. Then powdered haulm plant sample was analysed for N, P, K, Zn and uptakes of respective nutrients were computed.

##### Uptake of nutrients

The nutrient uptake *viz.,* N, P, K and Zn by cotton were calculated by using the following formula and expressed in kg ha-1

Nutrient uptake by plant (kg ha-1) = Nutrient content (%) x 100

DMP (kg ha-1)

DMP- Dry matter Production

##### Nitrogen uptake (kg ha-1)

Nitrogen content in the plant samples was analysed by microkjeldhal method   
(Yoshida *et al*., 1976). The nitrogen uptake was calculated by multiplying the total biomass with the nitrogen content and recorded in kg ha-1.

##### Phosphorus uptake (kg ha-1)

The phosphorus content in the plant sample was determined by calorimetrically by using the triple-acid digestion method (Jackson, 1973). The phosphorus uptake was worked out by multiplying the total biomass with P content and recorded as kg ha-1.

**Zinc uptake (mg kg-1)**

Zinc content in plant samples was estimated by the DTPA extract method and the values were recorded by using Atomic Absorption Spectrophotometer (AAS) (Lindsay and Norvell, 1978). The zinc uptake was worked out by multiplying the total biomass with Zn content in plant and recorded as mg kg-1.

**Results and discussion**

#### **QUALITY CHARACTERISTICS OF COTTON**

##### Ginning percentage

##### The data pertaining to ginning percentage, Seed index and lint index with different treatments are given in table 2. Among the different treatments, application of 75% RDF + Zn – EC @ 1.0 t ha-1+ ZnO2 @ 0.1%+ NAA @ 40 ppm (T9) showed highest ginning percentage (34.05). Control treatment registered lowest ginning percentage of 32.60. The highest ginning percentage of 34.05% recorded with 75%RDF + Zn-EC @ 1.0 tha-1 + ZnO2 @ 0.1%+ NAA @ 40ppm (T9) while lowest ginning percentage (32.60) observed in control (T1). Nitrogen deficiency had more impact over seed than lint growth, thus low seed weight resulted in higher ginning percentage (Tewolde *et al*. 2007). Ginning percentage is not significantly influenced by spraying of NAA@ 40 ppm. Similar results were reported by Rajendran *et al*. (2011).

##### Seed index

##### The treatments T1, T2, T3 and T 4 recorded the seed index of 8.45, 8.99, 8.66 and 8.54 which were received control, 100% RDF, 75% RDF + Zn EC@ 1.0 t ha-1 and 75% RDF + ZnO2 @ 0.1%, respectively. Application of 75% RDF + Zn – EC @ 1.0 t ha-1 + ZnO2 @ 0.1%+ NAA @ 40 ppm (T9) registered highest seed index of 9.13 which was higher compared to other treatments. There is a non-significant difference were observed between the treatments. Application of 75% RDF + Zn EC @ 1.0 t ha-1 + ZnO2 @ 0.1%+ NAA @ 40 ppm (T9) recorded the highest seed index (9.13) and it was found to be on par with (T2) 100% RDF (N:P2O5:K2O) (60:30:30 kg ha-1).The highest seed index recorded in inorganic fertilizers with zinc enriched compost might be due to supply of judicious amount of nutrient at all growth stages as well as activation of various enzymes that regulate different biochemical reactions, assimilation of photosynthetic product in to reproductive parts which lead to increased flowering and seed index in cotton. Seed index is not significantly influenced by spraying of NAA @ 40 ppm alone. Similar finding was observed by Rajendran *et al*. (2011).

##### Lint index

##### A trend similar to seed index was also observed in lint index due to different treatments. Application of 75% RDF + Zn – EC @ 1.0 t ha-1+ ZnO2 @ 0.1%+ NAA @ 40 ppm (T9) registered highest lint index of 4.20. The treatment control (T1) registered the lowest lint index (3.96) compared to other treatments. The highest lint index of 4.20 was found to be with 75% RDF + Zn EC @ 1.0 t ha-1 + ZnO2 @ 0.1%+ NAA @ 40 ppm (T9). The improvement in lint index might be due to the combined application of inorganic fertilizer (macro and micro nutrients) and zinc-enriched compost.

**Table 2.** Effect of inorganic fertilizers, Zn-enriched compost and phyto-hormone on quality characteristics of cotton *cv*. Sabari

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatment No.** | **Treatment Details** | **Ginning (%)** | **Seed index** | **Lint index** |
| T1 | Control | 32.60 | 8.45 | 3.96 |
| T2 | 100% RDF(N:P2O5:K2O) (60:30:30 kg ha-1) | 34.00 | 8.99 | 4.16 |
| T3 | 75%RDF + Zn EC@ 1.0 t ha-1 | 33.09 | 8.66 | 4.02 |
| T4 | 75%RDF + ZnO2 @ 0.1% | 32.81 | 8.54 | 3.99 |
| T5 | 75%RDF + NAA @ 40 ppm | 33.38 | 8.76 | 4.05 |
| T6 | 75%RDF + Zn EC @ 1.0 t ha-1+ ZnO2 @0.1% | 33.40 | 8.81 | 4.07 |
| T7 | 75%RDF + ZnO2 @0.1% + NAA@40 ppm | 33.59 | 8.86 | 4.10 |
| T8 | 75%RDF + Zn EC@ 1.0 t ha-1+ NAA@40 ppm | 33.94 | 8.94 | 4.14 |
| T9 | 75%RDF + Zn EC@ 1.0 t ha-1 + ZnO2  @0.1%+ NAA@40ppm | 34.05 | 9.13 | 4.20 |
| **S. Ed** |  | **1.32** | **0.34** | **0.16** |
| **CD (P=0.05)** |  | **NS** | **NS** | **NS** |

**Fibre length (mm)**

The data pertaining to Fibre length, fibre fineness and fibre bundle length with different treatments are given in table 3. The fibre length varied from 29.29 to 30.44 mm due to different treatments. Among the treatments, application of 75% RDF + Zn – EC @ 1.0 t ha-1+ ZnO2 @ 0.1% + NAA @ 40 ppm (T9) recorded highest fibre length of 30.44 mm. Phosphorus had no consistent role over fibre properties (Malik and Iqbal Makhdum, 1992). However, lowest fibre length of 29.29 mm was observed in control (T1) which was received no inorganic fertilizers i.e., zinc enriched compost and phyto-hormone.

**Fibre fineness**

Micronaire values were recorded to study the fibre fineness of cotton due to different treatments. The fibre fineness ranged from 3.94 to 4.20 due to different treatments. However, lowest fibre fineness of 3.94 mm was found to be with control (T1). This was because fibre quality is more of a genetic character. Nitrogen sources had only minimal or no effect over fibre quality (Watts *et al.* 2017).

**Fibre bundle strength**

It was ranged from 24.25 to 26.61 g tex-1. Soil application of 75% RDF, zinc enriched compost @ 1.0 t ha-1and foliar spray of ZnO2 @ 0.1%+ NAA @ 40 ppm (T9) registered highest fibre bundle strength of 26.61 g tex-1. However lowest fibre bundle strength noticed in control (T1) (24.25). This was conformity with the present findings. This was conformity with the present findings. The quality characters were mostly governed by genetic makeup of cotton plant and they were not changed by spraying of chemicals   
(Rajendran *et al*.2011).

**Table 3.** Effect of inorganic fertilizers, Zn-enriched compost and phyto-hormone on quality characteristics of cotton cv. Sabari

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatment No.** | **Treatment Details** | **Fibre Length (mm)** | **Fibre fineness (µg/inch)** | **Fibre bundle strength (g tex-1)** |
| T1 | Control | 29.29 | 3.94 | 24.25 |
| T2 | 100% RDF(N:P2O5:K2O) (60:30:30 kg ha-1) | 30.16 | 4.13 | 26.03 |
| T3 | 75%RDF + Zn EC@ 1.0 t ha-1 | 29.05 | 3.99 | 24.90 |
| T4 | 75%RDF + ZnO2 @ 0.1% | 29.41 | 3.96 | 24.57 |
| T5 | 75%RDF + NAA @ 40 ppm | 29.69 | 4.04 | 25.21 |
| T6 | 75%RDF + Zn EC @ 1.0 t ha-1+ ZnO2 @0.1% | 29.50 | 4.05 | 25.44 |
| T7 | 75%RDF + ZnO2 @0.1% + NAA@40 ppm | 29.63 | 4.09 | 25.75 |
| T8 | 75%RDF + Zn EC@ 1.0 t ha-1+ NAA@40 ppm | 30.23 | 4.16 | 26.27 |
| T9 | 75%RDF + Zn EC@ 1.0 t ha-1 + ZnO2 @0.1%+  NAA@40ppm | 30.44 | 4.20 | 26.61 |
| **S. Ed** |  | **1.18** | **0.16** | **1.00** |
| **CD (P=0.05)** |  | **NS** | **NS** | **NS** |

**Nitrogen uptake (kg ha -1)**

Nutrient uptake is the product of dry matter production and nutrient content. The growth and yield attributes of cotton crop is directly related to uptake of NPK. Nutrient uptake primarily depends on dry matter production and nutrient concentration in plants. Increased photosynthesis has resulted in higher DMP and in turn higher nutrient uptake. Application of inorganic fertilizers, zinc-enriched compost and phyto-hormone significantly influenced the nitrogen uptake by cotton. Application of 75% RDF + Zn EC @ 1.0 t ha-1 + ZnO2 @ 0.1%+ NAA @ 40 ppm (T9) recorded the highest N uptake (70.15 kg ha-1 at harvest) by cotton. The increase in N uptake might be due to higher availability of nitrogen in soil and direct addition of nitrogen through compost and greater accumulation of soil microbes, which could convert organically bound nitrogen into inorganic form. Furthermore, added organics improved the organic carbon content in soil through decomposition, which helped in the release of organically bound macro nutrients in soil.

Application of zinc also been reported to increase concentration and uptake of nitrogen through synergetic interaction between these two nutrients. The increase in N uptake by crops due to application of compost might be due to the enzymatic effects in metabolic process (Singh *et al*.1978). Nutrient uptake especially N is mostly dependent on seed yield level, which is the major sink for these nutrients. .

These results are associated with the fact that decomposition of organic amendments slowly releases the nutrients, and the losses of nutrients are reduced under minimum tillage due to improved soil structure which might be a reason behind improved growth, yield and quality traits of cotton. (Khan et,al. 2021)

Additionally, higher growth, morphological, and yield attributes were associated with positive effect of reduced tillage practices and residue retention on soil properties such as organic matter, nutrients availability, especially total nitrogen (Somasundaram et al., 2020).

Zn enriched compost during decomposition release nutrients which became available to the plants and thus increased NPK content. Further, integrated application of plant nutrients resulted in more uptakes of them as compared to sole use of organic or inorganic or bio-fertilizer alone and control. This might be because of balanced and combined use of various plant nutrient sources results in proper absorption, translocation and assimilation of those nutrients, ultimately increasing the dry matter accumulation and nutrient contents of plant and thus showing more uptake of NPK nutrients. Similar findings were reported by Tyagi *et al*. (2014) and Kalaiyarasi *et al*. (2019).

**Table 4.** Effect of inorganic fertilizers, Zn-enriched compost and phyto-hormone on Nitrogen uptake (kg ha-1) by cotton *cv*. Sabari at different stages

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Treatment No.** | **Treatment Details** | **30**  **DAS** | **60**  **DAS** | **90**  **DAS** | **At Harvest** |
| T1 | Control | 4.73 | 16.64 | 25.84 | 40.60 |
| T2 | 100% RDF(N:P2O5:K2O) (60:30:30 kg ha-1) | 7.48 | 36.19 | 58.51 | 65.89 |
| T3 | 75%RDF + Zn EC@ 1.0 t ha-1 | 5.92 | 25.14 | 38.73 | 49.91 |
| T4 | 75%RDF + ZnO2 @ 0.1% | 5.46 | 21.25 | 33.12 | 45.67 |
| T5 | 75%RDF + NAA @ 40 ppm | 6.39 | 29.16 | 44.68 | 54.64 |
| T6 | 75%RDF + Zn EC @ 1.0 t ha-1+ ZnO2 @0.1% | 6.52 | 30.81 | 45.49 | 55.93 |
| T7 | 75%RDF + ZnO2 @0.1% + NAA@40 ppm | 6.97 | 31.57 | 51.55 | 61.26 |
| T8 | 75%RDF + Zn EC@ 1.0 t ha-1+ NAA@40 ppm | 7.62 | 35.21 | 57.24 | 66.09 |
| T9 | 75%RDF + Zn EC@ 1.0 t ha-1 + ZnO2  @0.1%+ NAA@40ppm | 8.11 | 39.70 | 64.19 | 70.15 |
| **S. Ed** |  | **0.23** | **1.62** | **2.45** | **1.12** |
| **CD (P=0.05)** |  | **0.45** | **3.18** | **4.86** | **2.25** |

**Phosphorus uptake (kg ha-1)**

In the present study, phosphorus uptake by cotton crop was significantly influenced with inorganic fertilizers, zinc enriched compost and phyto-hormone. Application of 75% RDF + Zn [EC@1.0](mailto:EC@1.0) tha-1 + ZnO2 @0.1%+ NAA@40ppm (T9) recorded the highest P uptake (29.86 kg ha-1 at harvest) by cotton. Phosphorous is the key element for cotton growth and yield. Cotton plants utilize about 7 to 10 kg of P2O5 per bale of lint. Cotton seed is the highest reservoir containing about half the total plant phosphorus. Phosphorus mobility is the prime limitation to its uptake by cotton plants. It does not move in soil water, so cotton roots, must reach phosphate ions for their utilization. Cotton roots are aided in intercepting soil phosphorus by mycorrhizal fungi, making cotton highly dependent on mycorrhizae for phosphorus uptake. Similar findings were observed by Malik, (1998). The higher phosphorus uptake was also due to adequate and steady availability of nutrients throughout the crop growth period due to mineralization and slow release of nutrients to cotton crop resulting in to higher uptake of nutrients with the increased dry matter production and seed cotton yield. Similar findings were observed by Vani *et al*. (2020).

Nutrient uptake especially phosphorus is mostly dependent on seed yield, which is the major sink for these nutrients. Therefore greater productivity of compost and balanced fertilizer plots contributed to greater nutrient removal than control plots. These results are in conformity with Blaise and prasad (2005). The higher phosphorus uptake by cotton might be also due to application of NPK, Zn enriched compost and foliar spray of NAA increased the absorption power of the soil for cations and anions, particularly nitrogen and phosphate. These ions are released gradually during entire growing period of the crop which might have increased concentration as well as improved plant growth and accumulation of greater biomass which helped to increase nutrients uptake. The present study is in line with Ghosh and Das (2011).

**Table 5.** Effect of inorganic fertilizers, Zn-enriched compost and phyto-hormone on phosphorus uptake (kg ha-1) by cotton *cv.* Sabari at different stages

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Treatment No.** | **Treatment Details** | **30**  **DAS** | **60**  **DAS** | **90**  **DAS** | **At Harvest** |
| T1 | Control | 1.24 | 5.24 | 10.51 | 12.71 |
| T2 | 100% RDF(N:P2O5:K2O) (60:30:30 kg ha-1) | 2.26 | 15.19 | 23.04 | 27.25 |
| T3 | 75%RDF + Zn EC@ 1.0 t ha-1 | 1.64 | 8.68 | 15.73 | 15.60 |
| T4 | 75%RDF + ZnO2 @ 0.1% | 1.36 | 6.95 | 13.89 | 18.47 |
| T5 | 75%RDF + NAA @ 40 ppm | 1.78 | 10.40 | 17.77 | 21.43 |
| T6 | 75%RDF + Zn EC @ 1.0 t ha-1+ ZnO2 @0.1% | 1.85 | 11.54 | 17.82 | 22.28 |
| T7 | 75%RDF + ZnO2 @0.1% + NAA@40 ppm | 2.04 | 13.33 | 20.48 | 24.64 |
| T8 | 75%RDF + Zn EC@ 1.0 t ha-1+ NAA@40 ppm | 2.34 | 15.31 | 23.15 | 27.31 |
| T9 | 75%RDF + Zn EC@ 1.0 t ha-1 + ZnO2 @0.1%+  NAA@40ppm | 2.62 | 18.17 | 24.67 | 29.86 |
| **S. Ed** |  | **0.09** | **0.66** | **0.46** | **0.72** |
| **CD (P=0.05)** |  | **0.18** | **1.32** | **0.93** | **1.45** |

##### Potassium uptake (kg ha-1)

##### Potassium uptake by cotton was significantly influenced by the application of inorganic fertilizers, zinc enriched compost and phyto-hormone. Application of 75% RDF + Zn EC @ 1.0 t ha-1 + ZnO2 @ 0.1%+ NAA @ 40 ppm (T9) recorded the highest K uptake by cotton (61.67 kg ha-1 at harvest). However lowest K uptake of 37.24 kg ha-1 was recorded in the treatment control (T1). Potassium supplied adequate quantity of nutrients to coincide with peak demand for nutrients to cotton. Besides, the external application of K might have increased the quantity of readily available K to cotton thus resulting in higher K uptake. These results are in conformity with the findings of Srinivasan, (2003). The higher nutrient uptake with organic manure might be attributed to solubilisation of native nutrients, chelation complex of intermediate organic molecules produced during decomposition of added manures with nutrients their mobilization and accumulation of nutrients in different plant parts (Chesti *et al*. 2015). This was also might be due to attributed to improved utilization of N in the presence of K and availability of nutrients at growth stage when cotton crop starts growing faster. These results are in line with the findings of Bhati and singh, 2015).

**Table 6.** Effect of inorganic fertilizers, Zn-enriched compost and phyto-hormone on potassium uptake (kg ha-1) by cotton *cv*. Sabari at different stages

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Treatment No.** | **Treatment Details** | **30**  **DAS** | **60**  **DAS** | **90**  **DAS** | **At Harvest** |
| T1 | Control | 4.15 | 12.19 | 22.46 | 37.24 |
| T2 | 100% RDF(N:P2O5:K2O) (60:30:30 kg ha-1) | 6.42 | 26.85 | 40.12 | 57.18 |
| T3 | 75%RDF + Zn EC@ 1.0 t ha-1 | 4.70 | 17.68 | 30.14 | 45.08 |
| T4 | 75%RDF + ZnO2 @ 0.1% | 5.11 | 14.43 | 25.89 | 40.97 |
| T5 | 75%RDF + NAA @ 40 ppm | 5.49 | 20.82 | 33.49 | 48.79 |
| T6 | 75%RDF + Zn EC @ 1.0 t ha-1+ ZnO2 @0.1% | 5.68 | 21.99 | 34.38 | 49.84 |
| T7 | 75%RDF + ZnO2 @0.1% + NAA@40 ppm | 6.06 | 24.44 | 37.17 | 53.61 |
| T8 | 75%RDF + Zn EC@ 1.0 t ha-1+ NAA@40 ppm | 6.53 | 27.16 | 40.26 | 58.09 |
| T9 | 75%RDF + Zn EC@ 1.0 t ha-1 + ZnO2 @0.1%  + NAA@40ppm | 6.92 | 29.74 | 43.50 | 61.67 |
| **S. Ed** |  | **0.10** | **1.00** | **0.70** | **0.99** |
| **CD (P=0.05)** |  | **0.21** | **1.86** | **1.36** | **1.98** |

##### Zinc uptake (g kg-1)

##### In the present study, zinc uptake by cotton was significantly influenced with the application of inorganic fertilizers, zinc-enriched compost and phyto-hormone. Application of 75% RDF + Zn EC @ 1.0 t ha-1 + ZnO2 @ 0.1%+ NAA @ 40 ppm (T9) recorded the highest Zn uptake by cotton (178.8 g ha-1). However lowest Zn uptake (122.4 g ha-1) was recorded in control (T1). The increased uptake of Zn by the application of ZnO2 and Zn-Enriched compost might be attributed to the increased root biomass and increased availability of Zn in soil. The application of compost with zinc resulted in higher Zn availability due to mineralization of organic manures. Thus, zinc enriched compost application could result in release of more nutrients in easily available form which would directly affect the uptake of zinc by cotton. Similar results were reported by Chitdeshwari and Poongothai, 2003. The increase in zinc uptake might be attributed to improved zinc availability in soil as organics that facilitates higher activity of zinc in soil solution and enhance the zinc uptake through mass flow and diffusion. Zinc enriched compost on decay produce a varieties of biochemical substances (organic manure, poly phenols, amino acids and polysaccharides ) which stimulate the solubility, transport and availability of Zn in soil (Prasad *et al*. 2010). Addition of zinc enriched compost resulted in higher micronutrient availability like Zn due to mineralization according to Mali *et al*. (2015). This was also might be due to the application of zinc enriched compost resulted in release of more micronutrients in easily available form which reflected in overall growth and uptake of nutrients. These results are in accordance with the earlier reports of Mohanty *et al*. (2015).

##### Addition of zinc enriched compost caused higher Zn uptake mainly due to beneficial effect in mobilizing the native nutrient to increase the availability besides addition of Zn-enriched organics to the soil by naturally chelated form. This might have caused better Zn nutrition over a longer

##### period to cause better growth (Gupta et al.2002).

**Table 7.** Effect of inorganic fertilizers, Zn-enriched compost and phyto-hormone on zinc uptake (g ha-1) by cotton *cv*. Sabari at different stages

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Treatment No.** | **Treatment Details** | **30**  **DAS** | **60**  **DAS** | **90**  **DAS** | **At Harvest** |
| T1 | Control | 12.4 | 38.4 | 72.3 | 122.4 |
| T2 | 100% RDF(N:P2O5:K2O) (60:30:30 kg ha-1) | 13.9 | 50.3 | 76.5 | 131.1 |
| T3 | 75%RDF + Zn EC@ 1.0 t ha-1 | 15.4 | 58.2 | 81.3 | 145.6 |
| T4 | 75%RDF + ZnO2 @ 0.1% | 15.8 | 59.0 | 83.9 | 144.0 |
| T5 | 75%RDF + NAA @ 40 ppm | 13.5 | 48.7 | 76.0 | 132.4 |
| T6 | 75%RDF + Zn EC @ 1.0 t ha-1+ ZnO2 @0.1% | 18.6 | 72.3 | 93.7 | 169.3 |
| T7 | 75%RDF + ZnO2 @0.1% + NAA@40 ppm | 17.8 | 66.1 | 89.6 | 158.9 |
| T8 | 75%RDF + Zn EC@ 1.0 t ha-1+ NAA@40  ppm | 17.1 | 65.6 | 88.2 | 156.1 |
| T9 | 75%RDF + Zn EC@ 1.0 t ha-1 + ZnO2  @0.1%+ NAA@40ppm | 19.8 | 79.2 | 98.4 | 178.8 |
| **S. Ed** |  | **0.33** | **1.25** | **1.70** | **3.03** |
| **CD (P=0.05)** |  | **0.65** | **2.48** | **3.41** | **6.04** |

#### **CONCLUSION**

#### Considering the salient findings in perspective, the present investigation clearly concluded that 75% RDF + Zn EC @ 1.0 t ha-1 + ZnO2 @ 0.1%+ NAA @ 40 ppm (T9) was the best treatment for enhancing quality and nutrient uptake by cotton cv. Sabari. This was followed by 75% RDF+ Zn EC @1.0 t ha-1 + NAA @ 40 ppm (T8) were was at par with 100% RDF (T2). It is also concluded that soil application of 75% recommended NPK, zinc enriched compost @ 1.0 t ha-1 and foliar spray of ZnO2 @ 0.1% and NAA @ 40 ppm is an economical and feasible practice for the farmers for improving the yield and quality of cotton grown in sandy loam soil. The same treatment also enhanced the soil health of sandy loam soil in terms of physical, chemical, biological properties and nutrients availability.

Disclaimer (Artificial intelligence)

I hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

**Reference**

1. Bhati, A. S and S. Manpreet. 2015. Effect of split application of nitrogen and potassium on yield, nutrient uptake and nutrient use efficiency in Bt cotton. **Ann. Plant Soil Res**., **17**(1):71-73.
2. Blaise, D and R. Prasad, 2005. Effect of split application of nitrogen and potassium on yield, nutrient uptake and nutrient use efficiency in Bt cotton. **Ann. plant soil Res**., **17**(1): 71-73.
3. Celik, I. Land-use effects on organic matter and physical properties of soil in a southern Mediterranean highland of Turkey. Soil Till. Res. 83, 270–277 (2005).
4. Chesti, M.H., K.M. Anshuman, J.A. Sofi, N.Q. Tabasum, Q.J.A. Peer, M.A. Dar and L.A. Bisati, 2015. Effect of integrated application of inorganic and organic sources on soil properties, yield and nutrient uptake by rice (oryza sativa l.) in intermediated zone of jammu and Kashmir**. J. indian Soc. Soil**., **1**: 88-92.
5. Chitdeshwari, T. and S. Poongothai. 2003. Integrated nutrient management using zinc enriched organic manures and fertilizers on yield and nutrient uptake by fodder maize. **Madras Agric. J***.,* **90(7-9):** 442-443.
6. Ghosh, M. and B. Das. 2011. Effect of integrated nutrient management on yield, uptake and economics of blackgram (*Vigna mungo*) under Terai Region of West Bengal**. J. Crop Weed***,* **7(2):** 120-123.
7. Gupta, P.K., N.L. Sharma, H.K. Acharya, S.K. Gupta and G.C. Mali, 2002. Response of mungbean to zinc and iron on vertisols in south-eastern plains of Rajasthan. **Adv. Arid Leg. Res.***,***13:** 259-262.
8. Jackson, M.L. 1973. Soil chemical analysis. Asia Publication house, Bombay.
9. Jan, M., Hussain, S., Haq, M. A., Iqbal, J., Ahmad, I., Aslam, M., & Faiz, A. (2020). Effect of farm yard manure and compost application on transgenic BT cotton varieties. **Pak. J. Agric. Sci**., **33**(2):371-380.
10. Jayakumar, M., U. Surendran and P. Manickasundaram. 2014. Drip fertigation effects on yield, nutrient uptake and soil fertility of Bt Cotton in semiarid tropics. **Int. J. Plant Prod**., **8**(3): 375-390.
11. Kalaiyarasi, S., S. Avudaithai, S. Somasundaram and M. Sundar. 2019. Effect of INM on chemical properties of soil, nutrient uptake and yield of greengram in sodic soil. **Int. J. Chem. Studies***,* **7(3):** 2053-2055.
12. Khan, N. U. et al. Effect of zero and minimum tillage on cotton productivity and soil characteristics under different nitrogen application rates. Sustain. 13, 13753 (2021).
13. Lindsay, W. L., and W.A. Norvell. 1978. Development of a DTPA soil test for Zinc, Iron, Manganese, and Copper. **Soil Sci. Soc. Am. J., 42**(3): 421-428.
14. Liu, D. et al. Biochar and compost enhance soil quality and growth of roselle (Hibiscus sabdarifa L.) under saline conditions. Sci. Rep. 11(1), 1–11 (2020).
15. Mali, M.K., R.H. Meena, S.K. Sharma, J. Gajanand and H.S. Purohit. 2015. Effect of phosphorus rich compost with and without PSB and vermiculture on growth, yield and economics of maize *Zea mays* L. **Ann. Agric. Res. New Series***,* **36(3):** 299-303.
16. Malik, M. N. A.; M. I. Makhdum (1992): Influence of phosphorus fertilization on crop growth, seed cotton yield and fibre quality. **Pak J. Sci. and Res**., 35: 288–290.
17. Malik, M., 1998. Fertilizer role in sustainable cotton production.   
    *Place Published*, .20-29.
18. Mohanty, S., A.K. Nayak, A. Kumar, Gayan, Y.B. Devi and B. Bhattacharyya. 2015. Effect of integrated nutrient management on soil enzymes, microbial biomass Carbon and soil chemical properties after eight years of rice (*Oryza sativa)* cultivation in an aeric endoaquept. **J. Indian Soc. Soil Sci.***,* **63**(4)**:** 406-413.P.498.
19. Neugschwandtner, R. W., Liebhard, P., Kaul, H. P. & Wagentristl, H. Soil chemical properties as affected by tillage and crop rotation in a long-term feld experiment. Plant Soil Environ. 60, 57–62 (2014).
20. Patil, A.S.P, Chittapur, B.M. and Reddy, Sharanbhoopal (2012), Yield and nutrient status of Bt cotton hybrids under site specific nutrient management (SSNM) approach, **Internat. J. Forestry & Crop Improv., 3** (2) : 119-123.
21. Prasad, R.K., V. Kumar, B. Prasad and A.P. Singh,2010. Long-term effect of crop residue and zinc fertilizer on crop yield, nutrient uptake and fertility build- up under rice-wheat cropping system in calciorthents. **J. Indian Soc. Soil Sci**., **58**(2):205-211.
22. Rajendran, K., A. Palchamy, K. Sankaranarayanan, K. Prabakaran and K. Bhararhi. 2011. Enhancing productivity of summer irrigated cotton through plant growth regulator and foliar nutrition. **Madras Agric. J**., **98**(7-9): 248-250.
23. Santhanam, V. 1976. Cotton, (Ed.). ICAR, New Delhi.
24. Singh, B., H. D. Cheek and C.H. Haigler. 2009. A synthetic auxin (NAA) suppresses secondary wall cellulose synthesis and enhances elongation in cultured cotton fiber. **Plant cell reports., 28**(7):1023-1032.
25. Singh, M., T. P. S. Srivastava and K. Kalyan Singh, 1978. Effect of micronutrinets and their methods of applications on yiled and nutrient uptake of drilled rice variety, IR 8. **Indian J. Agron**., 23:31.
26. Somasundaram, J. et al. No-till farming and conservation agriculture in South Asia–issues, challenges, prospects and benefts. Crit. Rev. Plant Sci. 39(3), 236–279 (2020).
27. Song, K. et al. Influence of tillage practices and straw incorporation on soil aggregates, organic carbon, and crop yields in a rice wheat rotation system. Sci. Rep. 6, 36602 (2016).
28. Srinivasan, G., 2003. Response of cotton (Gossypium hirsutum) to split application of major nutrients. **Indian J. Agron***.*, **48**(1).59-61.
29. Sundaram, V. 1974. Definitions of some technical terms used in cotton development, trade and technology. **Cotton Dev.**, **4**(1): 35-40.
30. Tewolde, H, K Sistani, D Rowe, A Adeli, and J Johnson. 2007. "Lint yield and fiber quality of cotton fertilized with broiler litter." **Agron. J., 99** (1): 184-194.
31. Tyagi, P.K., A.K. Upadhyay and R.S. Raikwar. 2014. Integrated approach in nutrient management of summer green gram. *The Bioscan An Int. Quarterly* **J. Life Sci***.,* **9(4):** 1529-1533.
32. Vani. K. P, K. Banu Rekha and N. Nalini. 2020. Yield and nutrient uptake of Bt cotton as influenced by composted waste, organic and inorganic fertilizers. **Chem Sci Rev Lett. 9**(34):432-441.
33. Watts, DB, GB Runion, and KS Balkcom. 2017. "Nitrogen fertilizer sources and tillage effects on cotton growth, yield, and fiber quality in a coastal plain soil." **Field Crops Research***,***201**:184-191.
34. Yoshida, S., D. A. Forno, J. H. Cook and K. A. Gomez. 1976. Labortatory manual for physiological studies of rice. Third ed**. IRRI**: 7-76.