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# Enhancement of Growth and Yield of Cotton by Organic and Inorganic Nutrients with Phytohormone

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

Cotton is an important fibre and cash crop in India, contributing significantly to the country's industrial and agricultural economies. It provides the textile industry with its main raw material (cotton fibre). Cotton in India is a direct source of income for 6 million farmers, while the cotton trade and processing employs approximately 40-50 million people. Agriculture in the twenty-first century

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has encountered numerous hurdles in meeting the expanding population's food and fibre needs. Humans will confront greater challenges in meeting their requirements as the population grows to reach nine billion by 2050.
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 $ZnO_2$ and NAA on enhancement of cotton yield and quality in sandy loam soil.
Fertilizers (N: $P_2O_5$: $K_2O$) were sprayed 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. $ZnO_2$ 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 highest seed cotton yield of 1813.73 kg $ha^{-1}$ was observed with application of 75% RDF + Zn EC @ 1.0 t $ha^{-1}$ + $ZnO_2$ @ 0.1%+ NAA @ 40 ppm ($T_9$). the present investigation clearly concluded that 75% RDF + Zn EC @ 1.0 t $ha^{-1}$ + $ZnO_2$ @ 0.1%+ NAA @ 40 ppm ($T_9$) was the best treatment for enhancing growth, yield, quality and nutrient uptake by cotton *cv*. Sabari. The study examined how different treatments affected growth, yield characteristics, quality, and soil health.

*Keywords: Cotton; zinc oxide; compost; NAA; foliar spray; blooming periods; flowering; soil health; commercial crop.*

## 1. INTRODUCTION

Cotton (*Gossypium hirsutum*) is a crucial commercial crop in India, known as "white gold" or "queen of fibres". It is a versatile cash crop that plays a significant role in the Indian economy, particularly in the textile industry is cotton based. India is a major producer and exporter of cotton yarn. The textile sector in India accounts for 11% of industrial production, 14% of manufacturing, 4% of GDP, and 12% of total exports.

Cotton is one of the important industrial crops playing a vital role in the history of mankind and civilization by providing the basic fibres of typical nature for clothing cellulose from its lint and oil [1].

Cotton plays a considerable role in the economic development worldwide and important source of fibre, oil, and animal feed. In the twenty-first century, agriculture has faced many challenges to produce food and fibre needs of the growing population. Since the population will be increased over nine billion by 2050, human beings may face more problems in satisfying their needs [2].

Cotton productivity is quite low in India, with a production contribution of only 9% compared to 22% in China and 19.4% in the United States [3].

Cotton yield is low due to factors such as Rainfed cultivation, inefficient cultivars, pests, excessive vegetative growth, boll shedding, and insufficient nitrogen delivery [4,5].

Nitrogen (N) in cotton regulates growth, prevents abscission of squares and bolls, promotes photosynthetic activity, and increases the amount of freshly formed bolls and weight.

Cotton growth is limited by phosphorus shortage, particularly during the early phases of growth. In addition, P is a necessary nutrient and a vital component of numerous key plant cells include several substances, such as sugar-phosphates for respiration, photosynthesis, membrane phospholipids, nucleotides for energy metabolism, and DNA/RNA molecules. Phosphorus deficit leads to slower leaf growth and lower photosynthetic rates per unit area.

Potassium (K) plays a crucial function in carbohydrate metabolism and metabolite transfer from leaves to developing bolls during fruit production and maturity. Potassium Enhances crop leaf photosynthetic rates, assimilates $CO^2$, and promotes carbon transport. Zinc (Zn) is necessary for the manufacture of tryptophan, which is a precursor to the hormone IAA, which inhibits square and boll abscission. Zinc deficiency symptoms include tiny leaves, shortened internodes, stunted growth, diminished boll set, and smaller boll size.

## 2. 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 $ZnO_2$ and NAA on enhancement of cotton yield and quality in sandy loam soil. A Randomised 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. The treatment details are shown in Table 1.

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

Zn-enriched compost (Zn-EC) was prepared by taking quantities of well decomposed FYM along with recommended quantity of $ZnSO_4$ @ 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.

## 2.2 Fertilizer Application

The recommended dose of fertilizers (N: $P_2O_5$: $K_2O$) (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 $P_2O_5$ and $K_2O$ were given as basal by band placement method. Based on the treatments, Zn-enriched compost (Zn-EC) was applied @ 1.0 t $ha^{-1}$ as basal one week before sowing. As per treatment schedule, $ZnO_2$ @ 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.

## 2.3 Growth Attributes

### 2.3.1 Plant height

The Plant height was recorded at 30, 60, 90 DAS and at harvest and their mean was calculated. The height was measured from the basal point of a plant to the cotyledonary node to the opened leaf of the main stem which was expressed in cm.

**Table 1. Treatment details**

| S. No. | Treatment No. | Details |
|---|---|---|
| 1 | $T_1$ | Control |
| 2 | $T_2$ | 100% RDF (N: $P_2O_5$: $K_2O$) (60:30:30 kg $ha^{-1}$) |
| 3 | $T_3$ | 75% RDF + Zn – EC @ 1.0 t $ha^{-1}$ |
| 4 | $T_4$ | 75% RDF + $ZnO_2$ @ 0.1% |
| 5 | $T_5$ | 75% RDF + NAA @ 40 ppm |
| 6 | $T_6$ | 75% RDF + Zn – EC @ 1.0 t $ha^{-1}$ + $ZnO_2$ @ 0.1% |
| 7 | $T_7$ | 75% RDF + FS – $ZnO_2$ @ 0.1 % (F.S) + NAA @ 40 ppm |
| 8 | $T_8$ | 75% RDF + Zn – EC @ 1.0 t $ha^{-1}$ + NAA @ 40 ppm |
| 9 | $T_9$ | 75% RDF + Zn – EC @ 1.0 t $ha^{-1}$ + $ZnO_2$ @ 0.1% (F.S) + NAA @ 40 ppm |

**Table 2. Crop details**

| S. No | Particulars | Details |
|---|---|---|
| 1 | Species | *Gossypium hirsutum* |
| 2 | Plant height | 100 – 120 cm |
| 3 | Leaves | Dark green and light hairy |
| 4 | Plant type | Tall, open and pyramidal shape |
| 5 | Flower | Cream, petal spot absent |
| 6 | Pollen colour | Cream |
| 7 | Duration | 150 days |
| 8 | Weight of bolls (g) | 4.55 |
| 9 | Yield (q $ha^{-1}$) | 13.20 |
| 10 | Ginning percentage | 33.2 |

#### 2.3.2 Leaf Area Index (LAI)

LAI was calculated using the formula suggested by Iruthayaraj and Sivaraj (1979). The leaf area was measured in tagged cotton plants at the flowering stage and at harvest was calculated.

LA = L x W x CF x NL x NP

Where,

LA = Leaf area ($cm^2$)
L = Length of the leaf (cm)
W = Width of the leaf (cm)
CF = Correction Factor (0.7)
NL = Number of leaves $plant^{-1}$
NP = Number of plants unit area $^{-1}$

LAI =K L x W x Number of leaves per hill **/**Area occupied by plant

#### 2.3.3 Dry Matter Production (DMP)

The plants for estimating dry matter production were cut close to the ground at 30, 60, and 90 and at harvest to estimate DMP. The collected samples were chopped, air dried and then oven-dried at $120^0C$ till concordant values were obtained. The dry weight of the samples were recorded and expressed in kg $ha^{-1}$.

### 2.4 Yield Characters

#### 2.4.1 Number of monopodial branches plant $^{-1}$

The number of Monopodial branches arising from auxiliary buds was counted and recorded $plant^{-1}$ at maturity.

#### 2.4.2 Number of sympodial branches plant $^{-1}$

Sympodial branches develop from the extra-auxiliary or accessory buds. The sympodial branches develop at the upper nodes of the main axis. The number of sympodial branches was counted and recorded plant $^{-1}$ at maturity.

#### 2.4.3 Number of squares plant $^{-1}$

The buds of flowers appearing first as small pyramidal shaped green structures are called squares. The total number of squares $plant^{-1}$ was recorded cumulatively up to 65 DAS.

#### 2.4.4 Number of bolls $plant^{-1}$

The total number of bolls picked at each picking plant $^{-1}$ till the harvest was summed up and recorded.

#### 2.4.5 Boll weight (g)

Five matured bolls were picked randomly from the five tagged plants in each plot were weighed and the mean boll weight was recorded and expressed in gram (g).

#### 2.4.6 Yield of seed cotton (kg $ha^{-1}$)

Seed cotton yield was recorded net plot wise for every picking. The picked seed cotton was dried in shade and then weighed. The total seed cotton yield was computed and recorded as kg $ha^{-1}$.

## 3. RESULTS AND DISCUSSION

### 3.1 Growth Parameters

#### 3.1.1 Plant height

Plant height is a direct index to measure the growth and vigour of plants. Plants supplied with 75%RDF + Zn EC @ 1.0 t $ha^{-1}$ + $ZnO_2$ @ 0.1% + NAA @ 40 ppm ($T_9$) recorded maximum values for plant height at all growth stages.(15.2, 48.3, 69.6 and 143.2 cm). Table 3 presents the data regarding plant height.

Nitrogen is the most important nutrient in increasing the growth of crop [6]. Application of RDF along with zinc sulphate resulted in increased plant height might be due to better uptake and translocation of plant to growing plants and more photosynthesis which in turn promoted plant height. Similar results were observed by Abdallah and Mohamed [7]. This was also might be due to application of Zn through $ZnSO_4$ or enriched Zn organics along with bio fertilizer, which enhanced plant growth, increased plant metabolites and encouraged the growth of microorganisms as well as organic matter. These results are in conformity with Veeranagappa et al. [8].

#### 3.1.2 Number of leaves $plant^{-1}$

The highest number of leaves $plant^{-1}$ at 30 DAS, 60 DAS, 90 DAS and at harvest stage were 9.6, 48.6, 62.5 and 56.7 were recorded with 75% RDF + Zn EC @ 1.0 t $ha^{-1}$ + NAA @ 40 ppm ($T_9$) resulted in increased nitrogen accumulation and thereby improved vegetative growth and number of leaves. Zinc enriched organics also played a role as a co- factor in the enzymatic reaction of the anabolic pathway in plant growth, number of leaves $plant^{-1}$ [9]. This was also due to the activities of various types of enzymes such as those required for $CO_2$ pathway and chlorophyll biosynthesis might have increased the vegetative growth of cotton [10]. Table 4 presents the data regarding number of leaves $^{-1}$.

#### 3.1.3 Leaf area index

Number of leaves has a direct influence over leaf area index. The increases in leaf area index in cotton due to that the leaf elongation due to application of NAA@40ppm. Similar findings were observed by Rajendran et al. [11]. Table 5 presents the data regarding leaf area index of cotton.

Leaf area index of cotton increased from 3.29 to 3.98 at harvest stage might be due to supply of inorganic fertilizers along with zinc sulphate, which increased the availability of nutrients and enhanced various growth hormones considerably resulting in a positive effect on leaf area index of cotton. Similar results are supported by the findings of More et al. [12]. Similar findings were also observed by Mir et al. [13] with foliar applications of growth regulators like NAA significantly increased leaf area index of cotton.

### 3.2 Number of Branches Plant $^{-1}$

#### 3.2.1 Monopodial branches plant$^{-1}$

The plot supplied with 75% RDF + Zn EC @ 1.0 tha$^{-1}$ + $ZnO_2$ @ 0.1% + NAA @ 40 ppm ($T_9$) has recorded maximum value of 2.25 for monopodial branches plant $^{-1}$. The results are in agreement with the findings of Kaleri et al. [14]. The higher number of monopodial branches plant$^{-1}$ due to the reason that organic sources of nutrients

**Table 3. Effect of inorganic fertilizers, Zn-enriched compost and phyto-hormone on Plant height (cm) at different growth stages of cotton *cv*. Sabari**

| Treatment No. | Treatment Details | 30 DAS | 60 DAS | 90 DAS | At Harvest |
|---|---|---|---|---|---|
| $T_1$ | Control | 11.5 | 37.7 | 58.8 | 111.8 |
| $T_2$ | 100% RDF($N:P_2O_5:K_2O$) (60:30:30 kg ha$^{-1}$) | 14.2 | 46.1 | 67.2 | 136.4 |
| $T_3$ | 75%RDF + Zn EC@ 1.0 t ha$^{-1}$ | 12.3 | 40.7 | 62.0 | 121.7 |
| $T_4$ | 75%RDF + $ZnO_2$ @ 0.1% | 12.0 | 39.3 | 60.4 | 118.9 |
| $T_5$ | 75%RDF + NAA @ 40 ppm | 12.9 | 42.6 | 63.6 | 126.3 |
| $T_6$ | 75%RDF + Zn EC @ 1.0 t ha$^{-1}$+ $ZnO_2$ @0.1% | 13.0 | 42.7 | 64.0 | 127.7 |
| $T_7$ | 75%RDF + $ZnO_2$ @0.1% + NAA@40 ppm | 13.6 | 44.4 | 65.7 | 132.1 |
| $T_8$ | 75%RDF + Zn EC@ 1.0 t ha$^{-1}$+ NAA@40 ppm | 14.6 | 46.5 | 67.8 | 138.6 |
| $T_9$ | 75%RDF + Zn EC@ 1.0 t ha$^{-1}$ + $ZnO_2$ @0.1%+ NAA@40ppm | 15.2 | 48.3 | 69.6 | 143.2 |
| S. Ed | | 0.26 | 0.69 | 0.78 | 2.07 |
| CD(P=0.05) | | 0.52 | 1.29 | 1.55 | 4.08 |

**Table 4. Effect of inorganic fertilizers, Zn-enriched compost and Phyto-hormone on number of leaves plant $^{-1}$ at different growth stages of cotton *cv*. Sabari**

| Treatment No. | Treatment Details | 30 DAS | 60 DAS | 90 DAS | At Harvest |
|---|---|---|---|---|---|
| $T_1$ | Control | 7.1 | 25.8 | 33.6 | 29.1 |
| $T_2$ | 100% RDF($N:P_2O_5:K_2O$) (60:30:30 kg ha$^{-1}$) | 9.0 | 44.2 | 56.7 | 51.2 |
| $T_3$ | 75%RDF + Zn EC@ 1.0 t ha$^{-1}$ | 7.6 | 31.9 | 45.9 | 36.9 |
| $T_4$ | 75%RDF + $ZnO_2$ @ 0.1% | 7.5 | 29.1 | 40.2 | 33.0 |
| $T_5$ | 75%RDF + NAA @ 40 ppm | 7.9 | 35.8 | 50.7 | 40.8 |
| $T_6$ | 75%RDF + Zn EC @ 1.0 t ha$^{-1}$+ $ZnO_2$ @0.1% | 8.1 | 36.7 | 51.6 | 41.8 |
| $T_7$ | 75%RDF + $ZnO_2$ @0.1% + NAA@40 ppm | 8.6 | 40.4 | 52.1 | 46.7 |
| $T_8$ | 75%RDF + Zn EC@ 1.0 t ha$^{-1}$+ NAA@40 ppm | 9.1 | 45.1 | 58.1 | 52.7 |
| $T_9$ | 75%RDF + Zn EC@ 1.0 t ha$^{-1}$ + $ZnO_2$ @0.1%+ NAA@40ppm | 9.6 | 48.6 | 62.5 | 56.7 |
| S. Ed | | 0.16 | 0.75 | 1.00 | 0.87 |
| CD (P=0.05) | | 0.33 | 1.48 | 1.99 | 1.70 |

**Table 5. Effect of inorganic fertilizers, Zn-enriched compost and Phyto-hormone on leaf area index at different growth stages of cotton *cv*. Sabari**

| Treatment No. | Treatment Details | At Flowering | At Harvest |
|---|---|---|---|
| $T_1$ | Control | 1.88 | 3.29 |
| $T_2$ | 100% RDF($N:P_2O_5:K_2O$) (60:30:30 kg $ha^{-1}$) | 2.25 | 3.82 |
| $T_3$ | 75%RDF + Zn EC@ 1.0 t $ha^{-1}$ | 2.00 | 3.49 |
| $T_4$ | 75%RDF + $ZnO_2$ @ 0.1% | 2.01 | 3.41 |
| $T_5$ | 75%RDF + NAA @ 40 ppm | 2.09 | 3.58 |
| $T_6$ | 75%RDF + Zn EC @ 1.0 t $ha^{-1}$+ $ZnO_2$ @0.1% | 2.10 | 3.67 |
| $T_7$ | 75%RDF + $ZnO_2$ @0.1% + NAA@40 ppm | 2.18 | 3.71 |
| $T_8$ | 75%RDF + Zn EC@ 1.0 t $ha^{-1}$+ NAA@40 ppm | 2.29 | 3.85 |
| $T_9$ | 75%RDF + Zn EC@ 1.0 t $ha^{-1}$ + $ZnO_2$ @0.1%+ NAA@40ppm | 2.38 | 3.98 |
| S. Ed | | 0.03 | 0.05 |
| CD(P=0.05) | | 0.07 | 0.09 |

play important role in sustaining the productivity by not only acting as source of nutrients but also by modifying soil physical behavior as well as increased efficiency of applied nutrients. Similar findings were observed by Vani et al. [15].

### 3.2.3 Sympodial branches plant $^{-1}$

Plants supplied with 75% RDF + Zn EC @ 1.0 t $ha^{-1}$ + $ZnO_2$ @ 0.1%+ NAA @ 40 ppm ($T_9$) recorded the highest number of sympodial branches plant $^{-1}$ (13.19). The number of sympodial branches increased with NPK fertilizers. Similar results were observed by Baraich et al. [16]. Plant height has a positive correlation with the number of sympodial branches [17]. Table 6 presents the data regarding monopodial branches plant $^{-1}$, sympodial branches plant $^{-1}$.

Application of recommended NPK along with zinc sulphate resulted increase in sympodial branches plant$^{-1}$ of cotton might be due to better uptake and translocation of plant to growing plants and more photosynthesis which in turn promoted sympodial branches per plant of cotton. The results are in agreement with the findings of Eleyan et al. [18] and Singh et al. [19].

**Table 6. Effect of inorganic fertilizers, Zn-enriched compost and phyto-hormone on monopodial and sympodial branches plant $^{-1}$ of cotton cv. Sabari**

| Treatment No. | Treatment Details | Monopodial branches plant$^{-1}$ (Before Flowering) | Sympodial branches plant$^{-1}$ (After Flowering) |
|---|---|---|---|
| $T_1$ | Control | 1.62 | 8.07 |
| $T_2$ | 100% RDF($N:P_2O_5:K_2O$) (60:30:30 kg $ha^{-1}$) | 2.08 | 12.35 |
| $T_3$ | 75%RDF + Zn EC@ 1.0 t $ha^{-1}$ | 1.80 | 9.67 |
| $T_4$ | 75%RDF + $ZnO_2$ @ 0.1% | 1.71 | 8.88 |
| $T_5$ | 75%RDF + NAA @ 40 ppm | 1.87 | 10.58 |
| $T_6$ | 75%RDF + Zn EC @ 1.0 t $ha^{-1}$+ $ZnO_2$ @0.1% | 1.92 | 10.64 |
| $T_7$ | 75%RDF + $ZnO_2$ @0.1% + NAA@40 ppm | 1.98 | 11.51 |
| $T_8$ | 75%RDF + Zn EC@ 1.0 t $ha^{-1}$+ NAA@40 ppm | 2.14 | 12.39 |
| $T_9$ | 75%RDF + Zn EC@ 1.0 t $ha^{-1}$ + $ZnO_2$ @0.1%+ NAA@40ppm | 2.25 | 13.19 |
| S. Ed | | 0.04 | 0.36 |
| CD (P=0.05) | | 0.08 | 0.73 |

### 3.2.4 Dry matter production (kg $ha^{-1}$)

Application of 75% RDF + Zn EC @ 1.0 t $ha^{-1}$ + $ZnO_2$ @ 0.1%+ NAA @ 40 ppm ($T_9$) has recorded the maximum values for dry matter production at 30 DAS, 60 DAS, 90 DAS and at harvest stage were 208.36, 1094.85, 2761.30 and 5260.45 kg $ha^{-1}$. Table 7 presents the data regarding Dry matter production.

These growth parameters enable the plant to ensure higher quantity of radiant energy with higher leaf surface area to convert it into chemical energy. This helps in accumulation of higher dry matter in cotton [20].

The higher dry matter production coupled with maximum translocation of dry matter into sink decides the yield of any crop. Similar findings were observed by Tayade and Dhoble [21].

### 3.2.5 Number of squares $plant^{-1}$

Among the different treatments tried, application of 75% RDF + Zn EC @ 1.0 t $ha^{-1}$ + $ZnO_2$ @ 0.1%+ NAA @ 40 ppm ($T_9$) has recorded the maximum number of squares $plant^{-1}$ (34.19). This might be due to foliar application of NAA increased retention of squares plant $^{-1}$.

Similar findings were observed by Jadhav et al. [22] and Sabale et al. [23]. Zinc is required in the synthesis of tryptophan, which is a precursor of IAA (Iodole acetic acid) synthesis, which is the hormone that inhibits abscission of squares and bolls.

The higher number of squares at flowering due to the enhanced supply of readily available macro and micronutrients apart from availability of native soil nutrients coupled with the improved efficiency of the applied inorganic fertilizers Table 8 presents the data regarding number of squares plant $^{-1}$, number of bolls plant $^{-1}$ and individual boll weight.

### 3.2.6 Number of bolls $plant^{-1}$

Nitrogen accumulation improves the number of bolls in cotton. Similar results were observed by Zhang et al. [24]. The highest numbers of bolls plant $^{-1}$ (20.81) was observed with 75% RDF + Zn EC @ 1.0 t $ha^{-1}$ + $ZnO_2$ @ 0.1%+ NAA @ 40 ppm ($T_9$). The total number of bolls increased due to the combined application of N and K rates compared with the sole application of N. Similar finding was reported by Akhtar et al. [25].

Foliar application of NAA resulted in high vegetative growth and by a series of reproductive parameter like higher number of bolls $plant^{-1}$ which in turns reflected in higher seed cotton yield. These results were confirmed by Jadhav et al. [22] and Sabale et al. [23].

Application of 100% NPK + FYM @ 10 t $ha^{-1}$ resulted in efficient translocation of photosynthates due to adequate amount of available nutrients that favored higher number of bolls $plant^{-1}$. These findings are in line with those reported by Vani et al. [15].

**Table 7. Effect of inorganic fertilizers, Zn-enriched compost and phyto-hormone on dry matter production (kg $ha^{-1}$) at different stages of cotton *cv*. Sabari**

| Treatment No. | Treatment Details | 30 DAS | 60 DAS | 90 DAS | At Harvest |
|---|---|---|---|---|---|
| $T_1$ | Control | 135 | 937 | 1894 | 3985 |
| $T_2$ | 100% RDF($N:P_2O_5:K_2O$) (60:30:30 kg $ha^{-1}$) | 194 | 1067 | 2565 | 4984 |
| $T_3$ | 75%RDF + Zn EC@ 1.0 t $ha^{-1}$ | 159 | 972 | 2052 | 4320 |
| $T_4$ | 75%RDF + $ZnO_2$ @ 0.1% | 148 | 998 | 2114 | 4144 |
| $T_5$ | 75%RDF + NAA @ 40 ppm | 170 | 1020 | 2182 | 4505 |
| $T_6$ | 75%RDF + Zn EC @ 1.0 t $ha^{-1}$+ $ZnO_2$ @0.1% | 173 | 1023 | 2304 | 4598 |
| $T_7$ | 75%RDF + $ZnO_2$ @0.1% + NAA@40 ppm | 183 | 1046 | 2438 | 4790 |
| $T_8$ | 75%RDF + Zn EC@ 1.0 t $ha^{-1}$+ NAA@40 ppm | 197 | 1073 | 2633 | 5065 |
| $T_9$ | 75%RDF + Zn EC@ 1.0 t $ha^{-1}$ + $ZnO_2$ @0.1%+ NAA@40ppm | 208 | 1095 | 2761 | 5260 |
| S. Ed | | 3.46 | 10.38 | 46.23 | 90.80 |
| CD (P=0.05) | | 6.89 | 20.60 | 91.63 | 182.80 |

**Table 8. Effect of inorganic fertilizers, Zn-enriched compost and phyto-hormone on number of squares plant$^{-1}$, number of bolls plant$^{-1}$ and boll weight (g) of cotton *cv*. Sabari**

| Treatment No. | Treatment Details | No. of squares plant$^{-1}$ | No. of bolls plant$^{-1}$ | Boll weight (g) |
|---|---|---|---|---|
| $T_1$ | Control | 23.87 | 14.23 | 2.53 |
| $T_2$ | 100% RDF($N:P_2O_5:K_2O$) (60:30:30 kg ha$^{-1}$) | 31.82 | 19.34 | 3.31 |
| $T_3$ | 75%RDF + Zn EC@ 1.0 t ha$^{-1}$ | 26.81 | 16.12 | 2.87 |
| $T_4$ | 75%RDF + $ZnO_2$ @ 0.1% | 25.26 | 15.25 | 2.78 |
| $T_5$ | 75%RDF + NAA @ 40 ppm | 28.19 | 17.06 | 3.02 |
| $T_6$ | 75%RDF + Zn EC @ 1.0 t ha$^{-1}$+ $ZnO_2$ @0.1% | 28.67 | 17.49 | 3.06 |
| $T_7$ | 75%RDF + $ZnO_2$ @0.1% + NAA@40 ppm | 30.28 | 18.46 | 3.18 |
| $T_8$ | 75%RDF + Zn EC@ 1.0 t ha$^{-1}$+ NAA@40 ppm | 32.60 | 19.92 | 3.37 |
| $T_9$ | 75%RDF + Zn EC@ 1.0 t ha$^{-1}$ + $ZnO_2$ @0.1%+ NAA@40ppm | 34.19 | 20.81 | 3.49 |
| S. Ed | | 0.57 | 0.41 | 0.05 |
| CD (P=0.05) | | 1.14 | 0.80 | 0.11 |

## 3.3 Boll weight (g)

The combined application of 75% RDF + Zn EC @ 1.0 t ha$^{-1}$ + $ZnO_2$ @ 0.1%+ NAA @ 40 ppm ($T_9$) recorded highest boll weight of 3.49g in cotton. Exogenous application of phyto-hormones accelerates biomass accumulation, reduce boll drop and promotes the initiation and growth of fibre cells as a result boll weight got increased. Similar results were observed by Ahmed et al. [26].

Application of foliar nutrients in plants increases the boll setting ratio, increases the weight and size of bolls. Similar finding was noticed by Srivastava et al. [27].

### 3.3.1 Seed cotton yield (q ha$^{-1}$)

The highest seed cotton yield (1813.73 q ha$^{-1}$) was observed with application of 75% RDF + Zn EC @ 1.0 t ha$^{-1}$ + $ZnO_2$ @ 0.1%+ NAA @ 40 ppm ($T_9$). An increase in seed cotton yield was due to increased plant height and leaf area index which resulted in increased photosynthetic activity thereby, increased translocation of photosynthates from the source to sink. Table 9 presents the data regarding seed cotton yield.

Foliar application of NAA resulted in high vegetative growth and by a series of reproductive parameters *viz.,* maximum retention of squares plant$^{-1}$, higher number of bolls plant $^{-1}$ and higher mean boll weight which in turns reflected in higher seed cotton yield. These findings were observed by Jadhav et al. [15] and Sabale et al. [23].

Application of potassium in cotton is also believed to extend N absorption, which causes vigorous vegetative growth and ultimately increased yield. Similar findings were recorded by Hussain et al. [17].

The increase in seed cotton yield is also due to higher number of leaves that provides the photo assimilates and as a result of delayed senescence of leaves for an extended period. These results are similar with Russel (2006). Application of NAA with micronutrient significantly increased the seed cotton yield. These results are reported by Hallikeri et al. [28].

Balanced fertilizer application of N, P2O5 and K2O + NAA is essential to sustain long term cotton yield by increased number of bolls plant -1 and boll weight. Similar result was reported by Rajendran et al. [11].

The yield is a dependent variable and is the resultant of growth parameters, yield attributes and nutrient uptake. Higher seed cotton yield could be due to the greater and consistent nutrient availability throughout crop growth period due to conjunctive use of enriched compost (ready source of macro and micronutrients) and inorganic sources of nutrients that registered improved growth parameters (dry matter production) and yield attributes. These results are in line with those Ananthakrishnan et al. [29].

Application of zinc enriched organic manures increases higher yield attributes by the supply of zinc and nitrogen till harvest stage and larger supply of mineralized nitrogen to the plants [30].

**Table 9. Effect of inorganic fertilizers, Zn-enriched compost and phyto-hormone on seed cotton yield (kg ha$^{-1}$) at harvest stage of cotton *cv*. Sabari**

| Treatment No. | Treatment Details | Seed cotton yield (kg ha$^{-1}$) |
|---|---|---|
| $T_1$ | Control | 981.64 |
| $T_2$ | 100% RDF(N:$P_2O_5$:$K_2O$) (60:30:30 kg ha$^{-1}$) | 1628.35 |
| $T_3$ | 75%RDF + Zn EC@ 1.0 t ha$^{-1}$ | 1235.27 |
| $T_4$ | 75%RDF + $ZnO_2$ @ 0.1% | 1107.35 |
| $T_5$ | 75%RDF + NAA @ 40 ppm | 1354.37 |
| $T_6$ | 75%RDF + Zn EC @ 1.0 t ha$^{-1}$+ $ZnO_2$ @0.1% | 1380.94 |
| $T_7$ | 75%RDF + $ZnO_2$ @0.1% + NAA@40 ppm | 1503.72 |
| $T_8$ | 75%RDF + Zn EC@ 1.0 t ha$^{-1}$+ NAA@40 ppm | 1694.40 |
| $T_9$ | 75%RDF + Zn EC@ 1.0 t ha$^{-1}$ + $ZnO_2$ @0.1%+ NAA@40ppm | 1813.73 |
| S. Ed | | 47.96 |
| CD (P=0.05) | | 95.96 |

Zinc also has an important role for the increase in photosynthate, which translocate and produced higher number of pods and consequently increase in number of seeds in green gram [31,32].

## 4. 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 growth, yield, 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) was on 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.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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