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# Response of Organic and Inorganic Sources of Nutrients on Growth and Yield of Okra (*Abelmoschus esculentus* L. Moench) in Bihar, India

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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

**Aims:** To assess the effect of integrated and sole applications of organic and inorganic fertilizers on the growth, yield and yield attributes of okra in okra- cabbage-bottle gourd crop sequence.
**Study Design:** The experiment consists of seven treatments *viz.,* $T_1$-100%NPK through inorganic fertilizers (IFs) 120, 60 and 40 Kg N, $P_2O_5$ and $K_2O$); $T_2$-50%NPK through IFs+50%N through farm yard manure (FYM); $T_3$-50% N through FYM+50% N through vermicompost (VC); $T_4$-1/3 of N each through FYM + VC + neem cake (NC); $T_5$-50% N through FYM + PSB + azotobactor; $T_6$-50% N through FYM+50% N through VC+PSB + azotobactor and $T_7$-1/3 of N each through FYM + VC + NC +PSB + azotobactor. These seven treatments were replicated thrice in Randomized Block Design. Recommended agronomical package of practices were followed excluding fertilizers and manures.
**Place and Duration of Study:** This experiment was conducted at Nalanda College of Horticulture, Noorsarai, Nalanda (25.269606 °N, 85.457869 °E) Bihar India, during *Kharif* 2016 and 2017.
**Results:** Results revealed that $T_1$-100%NPK through inorganic fertilizers (IFs) recorded significantly highest plant height (51.45cm, 128.35 cm, and 165.25 cm) at 30, 60 and 90 days after sowing respectively, over rest of the treatments, but found at par with $T_6$-50% N as FYM + 50% N as VC + PSB + azotobactor at 60 and 90 DAS. Number of fruits per plant and yield also differed significantly due to different treatments. $T_1$-100%NPK through inorganic fertilizers (IFs) recorded significantly more number of fruits over $T_5$, $T_6$ and $T_7$, but found at parwith $T_2$ $T_3$ and $T_4$. $T_1$-100%NPK through inorganic fertilizers (IFs) recorded significantly higher yield over rest of the treatment but was at par with $T_2$-50% NPK through IFs + 50 % N through FYM.
**Conclusion:** On the basis of this two years experimental finding, it has been concluded that the best strategy for producing okra in a sustainable manner is integrated use of inorganic fertilizers and manures as $T_2$ (50% NPK through IFs and 50% nitrogen through FYM).


*Keywords: Okra; FYM; vermicompost; neemcake; azotobactor; PSB; organic; inorganic; integrated.*

## 1. INTRODUCTION

"Lady's finger or Okra (*Abelmoschus esculentus* (L.) Moench) is a popular and extensively consumed vegetable that is high in unsaturated fatty acids and essential nutrients. Tightly packed with economic potential, this tropical crop is grown in tropical and subtropical locations worldwide" [1,2]. "Okra is cultivated commercially for the seed pod, which is harvested before it matures and is still tender. Okra has a high amount of bioactive substances like flavonoids and is a rich source of dietary fibers, polysaccharides, minerals (potassium, calcium, phosphorus, and magnesium), and vitamins (as well as vitamins A, K, C, and $B_9$)" [3]. However, today's uncontrolled use of synthetic fertilizers and pesticides is degrading the quality of agricultural products. Nonetheless, pesticides are crucial to the production of food. Crops are protected from insects, weeds, fungi, and other pests by the use of pesticides. Pesticides have the potential to be hazardous to humans and, depending on how much and how they are exposed, can have both short-term and long-term health consequences. The exclusive use of inorganic fertilizers in intensive agriculture has proven detrimental due to accelerated soil degradation, including organic matter loss leading to soil acidity, nutrient imbalances, and reduced crop yields. In contrast, nutrients from organic manures are released slowly and remain in the soil longer, ensuring a sustained residual effect. Many countries have adopted the practice of combining organic manures with mineral fertilizers, which has been shown to effectively manage soil fertility. Achieving high and consistent crop yields often involves judicious application of balanced NPK fertilization alongside organic amendments. Considering above, the prudent management of resources and the conservation of soil in intensive cropping systems have become critical areas of agronomic research. Consequently, this study aimed to compare the effects of using organic and inorganic fertilizers alone versus their complementary application on the growth and yield of okra.

## 2. MATERIALS AND METHODS

### 2.1 Experimental Site and Soil

This experiment was carried out in the *kharif* of 2016–2017 at the Research Farm of Nalanda

College of Horticulture Noorsarai (25.269606 °N, 85.457869 °E) in Nalanda, Bihar. Nalanda College of Horticulture falls under Zone III (B) of Bihar (Middle Gangetic Plain of India).Okra is one of the mandates of Nalanda College of Horticulture, Noorsarai (NCOH), Nalanda Bihar. "The soil in the experimental plot was a clay loam with available N, P, and K contents of 262 kg, 14.60 kg, and 142 kg $ha^{-1}$, respectively, with a pH of 7.47, 0.21 EC ($dSm^{-1}$), and 0.62 % soil organic carbon. The Walkley and Black method" Walkley and Black [4] was used to determine organic matter, while the glass electrode pH meter method Jackson, [5] was used to measure the pH of the soil (1:2.5 soil: water). The Olsen method Olsen et al., [6] was used to determine available P, and the semi-micro Kjeldahl method Bremner and Mulvaney [7] was used to determine the level of total N. After extraction with 1 N $NH_4OAc$ at pH 7, the exchangeable K was measured using a flame photometer [Knudsen et al., 1982]. The available S was calculated by extracting soil samples with a CaCl2 solution (0.15%) and then measuring the turbidity using a spectrophotometer [8].

## 2.2 Experimental Details

The experiment consists of seven treatments *viz.,*$T_1$-100%NPK through inorganic fertilizers (IFs) 120:60 and 40 Kg N: $P_2O_5$ and $K_2Oha^{-1}$); $T_2$-50%NPK through IFs+50%N through farm yard manure (FYM); $T_3$-50% N through FYM+50% N through vermicompost (VC); $T_4$-1/3 of N each through FYM + VC + Neemcake (NC); $T_5$-50% N through FYM + PSB + azotobactor; $T_6$-50% N through FYM+50% N through VC;+PSB + azotobactor and $T_7$-1/3 of N each through FYM + VC + NC+PSB + azotobactor. Vermicompost (having 1.21%N, 0.61**%** $P_2O_5$and 0.91**%** $K_2O$) and farm yard manure (having 0.45%N, 0.23**%** $P_2O_5$ and 0.42**%**$K_2O$) were produced at college's farm and neem cake were purchased from the market (having 4.91%N, 1.0**%** $P_2O_5$ and 1.21**%** $K_2O$). These seven treatments were replicated thrice in Randomized Block Design (RBD) having 15 square meters plot size. Among inorganic sources, urea, diamonium phosphate (DAP) and muriate of potash (MOP) were used while, well rotten farm yard manure (FYM), vermicompost (VC), neem cake (NC) and biofertilizers (15 ml per plot of 15 $m^2$) namely azotobactor and PSB were applied as per treatments.

## 2.3 Agronomic Practices

"Recommended agronomical package of practices were followed excluding fertilizers and manures. Organic fertilizers were applied in field 10 days before sowing. It was uniformly spread in the plots and incorporated into the soil manually. Irrigation was given as per crop demand. Weeding was done manually at 25 days after sowing. Harvesting of matured fruit started as they attain maturity in each experimental plot on treatment basis, and observations such as plant height, number of branches and number of fruits, fruit weight per plot and yield per hectare were measured. After harvesting, soil samples were taken from each plot for routine laboratory analysis. Soil pH and EC" [9], organic carbon determined by Walkley and Black's rapid titration method [5]. The determination of available nitrogen was done by alkaline permanganate method [10], available phosphorus by Olsen's [6] method as described Houba *et al.,* [11], and potassium by flame photometer described by Jackson [5]. The data collected on different aspect of experimentation, were analyzed with the analysis of variance technique given by Gomez and Gomez (1984). Economics of the treatments had been calculated on the local market price of the crop produce and the materials used.$T_1$-100%NPK through inorganic fertilizers (IFs) 120, 60 and 40 Kg N, $P_2O_5$ and $K_2O$); $T_2$-50%NPK through IFs+50%N through farm yard manure (FYM); $T_3$-50% N through FYM+50% N through vermicompost (VC); $T_4$-1/3 of N each through FYM + VC + neem cake (NC); $T_5$-50% N through FYM + PSB + azotobactor; $T_6$-50% N through FYM+50% N through VC+PSB + azotobactor and $T_7$-1/3 of N each through FYM + VC + NC +PSB + azotobactor.

# 3. RESULTS AND DISCUSSION

## 3.1 Plant Growth

The effect of fertility levels was noticed on various growth parameters. Plant height (Table 1) differed significantly due to different fertilizer treatments. Among all the treatments, $T_1$-100% NPK through inorganic fertilizers recorded highest plant height (51.45, 128.35 and 165.25 cm) at 30, 60 and 90 days after sowing respectively and was significantly taller than rest of the treatments except $T_6$ (110.15 and 150.10 cm) at 60 and 90 days after sowing. At 60 and 90 days after sowing $T_1$ recorded significantly tall plant over all the treatments. This may be attributed to the fast supply and availability of nutrients of mineral fertilizers applied in split doses that caused more vegetative growth. These findings are in close agreement with those

**Table 1. Effect of Organic and inorganic nutrient application on Plant height and number of branches of Okra**

| Treatments | Plant Height (cm) | | | No of Branches | | |
|---|---|---|---|---|---|---|
| | 30DAS | 60DAS | 90DAS | 30DAS | 60DAS | 90DAS |
| $T_1$-100%NPK through inorganic fertilizers (IFs) | 51.45 | 128.35 | 165.25 | 3.70 | 6.70 | 7.70 |
| $T_2$-50%NPK through IFs+50%N through farm yard manure (FYM) | 41.80 | 108.65 | 143.30 | 2.50 | 6.50 | 6.55 |
| $T_3$-50% N through FYM+50% N through vermicompost (VC) | 42.40 | 108.55 | 134.35 | 2.95 | 6.40 | 7.05 |
| $T_4$-1/3 of N each through FYM + VC + neem cake (NC) | 42.45 | 105.75 | 132.35 | 2.75 | 6.45 | 7.00 |
| $T_5$-50% N through FYM + PSB + azotobactor | 38.75 | 102.65 | 130.10 | 2.80 | 5.80 | 6.70 |
| $T_6$-50% N through FYM+50% N through VC+PSB + azotobactor | 41.35 | 110.15 | 150.10 | 2.50 | 5.90 | 6.80 |
| $T_7$-1/3 of N each through FYM + VC + NC +PSB + azotobactor. | 39.70 | 108.40 | 131.60 | 2.85 | 5.85 | 6.60 |
| **SEm±** | **2.65** | **6.00** | **10.00** | **0.45** | **0.90** | **0.80** |
| **C D (P= 0.05)** | **5.75** | **13.05** | **21.75** | **0.95** | **1.95** | **1.75** |

**Table 2. Effect of Organic and inorganic nutrient application on number of fruits, yield and economics**

| Treatments | Number of fruits per plant | | Yield (q $ha^{-1}$) | Gross return | Net return | Benefit: cost Ratio |
|---|---|---|---|---|---|---|
| | 60DAS | 90DAS | | | | |
| $T_1$-100%NPK through inorganic fertilizers (IFs) | 6.95 | 20.25 | 245.85 | 1.97 | 1.57 | 3.99 |
| $T_2$-50%NPK through IFs+50%N through farm yard manure (FYM) | 5.80 | 19.35 | 216.80 | 1.73 | 1.29 | 2.88 |
| $T_3$-50% N through FYM+50% N through vermicompost (VC) | 5.85 | 16.50 | 179.65 | 1.44 | 0.91 | 1.72 |
| $T_4$-1/3 of N each through FYM + VC + neem cake (NC) | 5.80 | 15.45 | 166.25 | 1.33 | 0.82 | 1.58 |
| $T_5$-50% N through FYM + PSB + azotobactor | 5.00 | 11.65 | 114.85 | 0.92 | 0.47 | 1.04 |
| $T_6$-50% N through FYM+50% N through VC+PSB + azotobactor | 6.05 | 16.70 | 184.95 | 1.48 | 0.92 | 1.65 |
| $T_7$-1/3 of N each through FYM + VC + NC +PSB + azotobactor. | 4.75 | 15.30 | 166.60 | 1.33 | 0.79 | 1.44 |
| **SEm±** | **0.80** | **1.70** | **25.65** | | | |
| **C D (P= 0.05)** | **1.75** | **3.65** | **55.90** | | | |

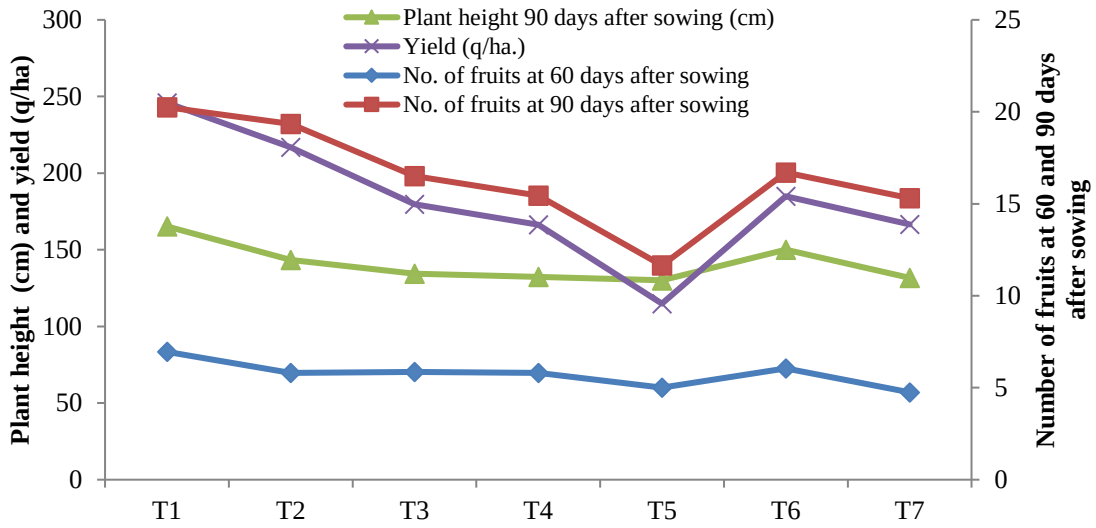


**Fig. 1. Graphical representation of response of organic and inorganic sources of nutrients on growth and yield of okra**

of Sachan *et al.,* [12]. There were no significant difference were found in number of branches. However, highest number of branches were recorded in$T_1$ (3.70, 6.70 and 7.70) at 30, 60 and 90 days after sowing respectively. Although, it was observed that the number of branches varied from plant to plant within the plot, regardless of changes in fertilizer doses. A positive effect of organic fertilizer on vegetative growth was reported by Kumar *et al.,* [13].

## 3.2 Yield Attributes and Yield

Plants can receive more nutrients from the soil when sufficient nutrients are applied. The data clearly shows that the different organic and inorganic treatments had a significant impact on the yield-attributing characteristics of okra. The highest number of fruits (Table 2) was found in $T_1$ (6.95 and 20.25) at 60 and 90 days after sowing respectively, which was significantly higher over $T_7$ (having 4.75 fruits per plant) and found at par with rest of the organic treatments at 60 days after sowing. While, at 90 days after sowing $T_1$ become significant over $T_3$,$T_4$, $T_5$ and $T_7$ but found at par with $T_2$-50 % NPK as IFs + 50 % N as FYM. The fruit yield per hectare also recorded highest in $T_1$ (245 q $ha^{-1}$) which was statistically at par with $T_2$-50 % NPK as IFs + 50 % N as FYM (216.80 q $ha^{-1}$). Similar finding were also observed by Chaudhary et al., [14] where 50 % NPK through mineral fertilizer + 50%N through FYM produced statistically at par with 100 % mineral fertilizers. The application of organic manure may have led to a slow release of nutrients, which could have resulted in reduced plant growth [15]. Although, “increase in yield in integrated source $T_2$ (50% NPK as IFs + 50% N as FYM) can be attributed to the solubilization of plant nutrients from the added FYM, which enhanced the uptake of NPK” [16]. “Management of nutrients through integrated source can offer an excellent options and economic choices to supply primary, secondary and micro-nutrients of plants and also contribute to reducing the dependence on externally purchased chemical fertilizers besides protecting soil health” Selim and Al-Owied, [17], Selim, [18], Wang et al., [19], Song et al., [20]. In this experiment also Fig. 1 clearly indicated that the $T_6$ having 100 % organic sources found statistically at par with integrated sources of nutrients in terms of plant height, number of fruit at 90 days after sowing and finally yield of okra. Additionally, “FYM likely improved the soil's nutrient status and water-holding capacity. The importance of organic manuring in promoting sustainable agriculture is well recognized” [21].

## 3.3 Economics

Economic studies have also been performed (Table 2) which was found highly variable due to different fertilizers and manure sources. Cost of organic manures estimated more as compared to inorganic sources of fertilizers, consequently cost of cultivation in organically treated plots observed relatively high. Results revealed that highest gross return (lakh $ha^{-1}$), net return (lakh $ha^{-1}$) and B:C ratio was recorded in $T_1$-100 % inorganic fertilizer sources (Rs. 1.97, Rs. 1.57 and 3.99 respectively, followed by $T_2$-50%NPK through inorganic fertilizer +50%N through FYM (Rs. 1.73, Rs. 1.29 and 2.88) [22,23]. Among 100% organics, $T_6$-50% N through FYM and 50% N through VC +biofertilizers (PSB and azotobactor) recorded highest gross return (Rs 1.48 lakh $ha^{-1}$), net return (0.92 lakh $ha^{-1}$) and benefit: cost ratio (1.65) [24,25]. Since all of the manures utilized in this experiment were bought from the local market, the lowest cost of inorganic fertilizers relative to organic manures may have contributed to the highest net return, which was seen in $T_1$ and $T_2$ [26]. The reason for the low B:C ratio in organically treated plots is the higher cost of organic manures bought from the nearby market and the similar selling price of products produced organically compared to those produced in inorganically treated plots [27,28].

## 4. CONCLUSION

The findings showed that, of all the treatments examined, 50% NPK through IFs and 50% nitrogen through FYM exhibited vegetative growth, yield attributes, and okra yield statistically comparable to 100% IFs. Thus, it has been concluded that the best strategy for producing okra in a sustainable manner is integrated use of inorganic fertilizers and manures as T2 (50% NPK through IFs and 50% nitrogen through FYM). Although this study has only lasted two years, but Fig. 1 suggests that okra may performed best when grown entirely organically in the long run as observed in $T_6$.

## DISCLAIMER (ARTIFICIAL INTELLIGENCE)

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

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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