*International Journal of Plant & Soil Science*

***Volume 35, Issue 20, Page 1086-1092, 2023; Article no.IJPSS.106746***
***ISSN: 2320-7035***

# Effect of Various Levels of Phosphorus on Growth Attributing Characters, Yield and Nutrient Uptake by Cottonin in Vertisol

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***Authors' contributions***

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

***Article Information***

DOI: 10.9734/IJPSS/2023/v35i203905

**Open Peer Review History:**
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/106746

***Original Research Article***

***Received: 28/07/2023***
***Accepted: 03/10/2023***
***Published: 07/10/2023***

## ABSTRACT

This study was carried out at Research Farm of Cotton Research Unit of Dr. Panjabrao Deshmukh Krishi Vidyapeeth Akola during the kharif season of 2021-2022 to evaluate the "Effect of various levels of phosphorus on growth attributing characters yield and nutrient uptake by cotton in Vertisol". The experiment used Randomized Block Design, with eight treatments replicated thrice. The prescribed fertilizer dose of 120:60:60 NPK kg ha$^{-1}$ was administered according to the treatments. The research experiment used the cotton variety PDKV JKL116. Similarly, Depending

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on the treatment, nano DAP was applied during seed treatment and foliar spray at 30 DAS. Before and after harvesting, samples of the soil and cotton plants were collected and analyzed using procedures'. The results concluded that the application of 100% NPK achieved the highest plant height, branch number boll number seed cotton yield, and cotton stalk yield.

*Keywords: Phosphorus; cotton; vertisol; nano DAP.*

## 1. INTRODUCTION

Cotton (*Gossypium hirsutum* L.), named after the Arabic word "quotn," is a member of the Gossypium genus, which was named after the Arabic word "goz," which means "soft substance." G. herbaceum and G. arboreum are examples of old world cotton, whereas G. hirsutum and G. barbadense are examples of new world cotton. It is the world's most prevalent natural fibre generating crop. "White gold" is another name for it. Cotton fibre serves as the foundation of the textile and other industries [1]. Apart from fibre, cotton seed is a major source of vegetable oil for soup, medicine, cosmetics, and seed cake is used as animal feed since cotton seed is high in both oil (18-24%) and protein (20-40%). India holds the distinction of having the most cotton cultivation area, accounting for around 45 % of the world's cotton cultivation area (12.96 million hectors). The current global cotton production is 24.09 million tonnes [2], with India accounting for 6.30 million tons. India is one of the world's top cotton producers, accounting for around 26% of global cotton production. One of Vidarbha's most significant income crops, cotton has a comparatively low average yield per hectare. Nitrogen stress is an important nutritional component that influences cotton production problems. Since phosphorus significantly affects the growth and yield qualities, it plays a key role in determining the cotton production [3].

"Phosphorus (P) is the second most abundant macronutrient in plants after nitrogen it stimulates early root and plant growth. It hastens ripening/maturity, improves the quality of fruit/grain and strengthens the plant stalk and stem. P has a low availability due to sluggish diffusion and rapid fixation in soils" [4]. P can be a crucial limiting factor in plant growth. Mostly due to P fixation in the soil. It is the most studied element, yet it is also the least understood because of its complicated chemistry in soil. Most agricultural soils contain more fixed P than accessible P, a significant portion of which has accumulated as a result of regular P fertilizer applications [5], Soils ability to deliver phosphorus to plants is known to vary greatly. Only a small portion of total P in soil is available to plants. Its bioavailability in soil is influenced by a variety of parameters such as soil pH, texture, moisture, lime concentration, added nutrients, and so on. Aside from them, the fact that phosphorus exists in different forms in soil is another aspect that complicates its availability. [6]. Different levels of phosphorus have been applied for improved growth and cotton in Vertisol soil due to the low levels of phosphorus that are available in the soil.

## 2. MATERIALS AND METHODS

During 2021-22, a field experiment was carried out on the cotton research farm of Dr. PDKV, Akola. The experimental site has a subtropical climate with an average maximum high temperature of 37.8$^{o}$C and a minimum low temperature of 13.5$^{o}$ C. "The soil consisted of Vertisols from the smectite, hyperthermic family of Typic Haplusterts. The texture of the soil was clay, with a slightly alkaline pH (8.12), EC (0.22 d Sm$^{-1}$), organic carbon (4.72 g kg$^{-1}$), available N (174.86 kg ha$^{-1}$), P (12.84 kg ha$^{-1}$) and available K (378.14 kg ha$^{-1}$)" [7]. The experiment involved eight different treatments. These treatments included a control group, different combinations of nutrients, and the application of a specific type of fertilizer. The experiment was conducted with three replications using a randomized block design. To conduct the experiment, the recommended amount of fertilizer was applied to the soil at the time of sowing, and an additional spray of a particular type of nano fertilizer was applied 30 days after sowing. The cotton variety "PDKV JKAL 116 Bt" was planted in 7$^{th}$ July 2021, and the cotton was harvested in December 2021 and January 2022.During growth period of the crop different agronomic observation were taken. Before the cotton harvest, plant samples and seed samples were collected from the plots and analyzed for nutrient uptake. The collected data were analyzed statistically using a specific procedure described by Gomez and Gomez [8].

## 3. RESULTS AND DISCUSSION

### 3.1 Number of Monopodia Branches

At 60 days after sowing, the application of different phosphorus levels did not significantly influence the number of monopodial branches in cotton plants (Table 1). When applying 100% NPK fertilizer, the highest number of monopodial branches (2.4) were observed. The application of $N_{75}$ $P_{75}$ $K_{100}$ + Nano DAP fertilizer (ST @ 5 ml / kg seed & FS @ 0.2% at 30 DAS) also resulted in a relatively high number of monopodial branches, while the absolute control plot had the lowest number of monopodial branches (1.8) at 60 DAS. However, at 90 days after sowing, the different phosphorus levels had a significant impact on the number of monopodial branches. The highest number of monopodial branches (3) were observed with the application of 100% NPK fertilizer. This was similar to the number of monopodial branches (2.7) recorded when using N75 P75 K100 + Nano DAP fertilizer (ST @ 5 ml / kg seed & FS @ 0.2% at 30 DAS) and N50 P50 K100 + Nano DAP fertilizer (ST @ 5 ml / kg seed & FS @ 0.2% at 30 DAS). The absolute control plot had the lowest number of monopodial branches.

### 3.2 Number of Sympodial Branches

The number of fruting branches in the cotton plants, known as sympodial branches, was significantly affected by the application of different levels of phosphorus at both 60 and 90 days after sowing (DAS) (Table 1). The highest number of sympodial branches (13.9 at 60 DAS and 28.5 at 90 DAS) was observed when 100% NPK fertilizer was used. This result was similar to the number of branches (13.1 at 60 DAS and 27.5 at 90 DAS) recorded when using N75 P75 K100+ Nano DAP fertilizer (ST @ 5 ml / kg seed & FS @ 0.2% at 30 DAS). On the other hand, the control group without any fertilizer application had the lowest number of sympodial branches at both 60 and 90 DAS. These findings align with similar results reported by Patil et al. [9] and Kakade et al. [10].

### 3.3 Number of Bolls Per Plant

Effect of various levels of phosphorus positively affected the number of bolls of the cotton plant the highest number of cotton bolls per plant (36.2) were observed when applying 100% NPK fertilizer, according to Table 1. Conversely, the lowest number of cotton bolls were found in the absolute control group (11.8) with no fertilizer application. Applying N75 P75 K100 + Nano DAP fertilizer (ST @ 5 ml / kg seed & FS @ 0.2% at 30 DAS) resulted in a relatively highest number of bolls (34.6), followed by treatment T7. These findings are consistent with the results reported by Patil et al. [9] and Kakade et al. [10].

### 3.4 Yield

The seed cotton and cotton stalk yield was ranged from 8.28 to 16.93 q $ha^{-1}$ (Table.2) and 12.43 to 29.62 q $ha^{-1}$ respectively. The highest seed and stalk yield of cotton was recorded in the treatment T3 while the lowest yield was observed under the treatment $T_1$. The seed cotton and cotton stalk yield was 104.46 % and 138.29 % higher in treatment best as compare to control. The increased in the seed and stalk yield of cotton with the application of different levels of phosphorus was might be due to application of N and P nutrient to the crop at different rates which significantly increase its yield contributing characters which increases the yield. These results are analogous with the findings of Saleem et al. [11], Iqbal et al. [12] and Begum et al. [13].

### 3.5 Uptake

#### 3.5.1 Nitrogen uptake

The application of 100% NPK fertilizer resulted in the highest uptake of nitrogen by the cotton seeds, as shown in Table 3. On the other hand, the absolute control group had the lowest seed nitrogen uptake. The treatment with the best results showed a 119.31% higher seed nitrogen uptake compared to the absolute control. Similarly, the application of 100% NPK fertilizer led to the significantly highest uptake of nitrogen by the cotton stalks, while the absolute control group had the lowest seed nitrogen uptake. The treatment with the best results showed a 363.89% higher stalk nitrogen uptake compared to the absolute control. Moreover, the total nitrogen uptake by cotton was significantly highest (83.29 kg $ha^{-1}$) with the application of 100% NPK fertilizer, while the absolute control had the lowest total nitrogen uptake (29.39 kg $ha^{-1}$). The application of 100% NPK fertilizer had a 183.40% higher uptake compared to the absolute control. These increases in nitrogen uptake in cotton can be attributed to the higher nitrogen doses in different treatments, which ultimately increased the yield and uptake. Similar results have been reported by Gadhia et al. [14] and Sharma et al. [11].

**Table 1. Effect various levels of phosphorus on growth attributes**

| Treatments | | Monopodia | | Sympodia | | No of bolls/ plant |
|---|---|---|---|---|---|---|
| | | 60 DAS | 90 DAS | 60 DAS | 90 DAS | |
| **T1** | N0P0K0 | 1.8 | 2.0 | 9.6 | 20.9 | 11.8 |
| **T2** | N0P0K100 | 2.1 | 2.3 | 10.2 | 21.9 | 15.2 |
| **T3** | N100 P100 K100 | 2.4 | 3.0 | 13.9 | 28.5 | 36.2 |
| **T4** | N50 P50 K100 | 1.9 | 2.2 | 10.4 | 23.2 | 21.8 |
| **T5** | N50 P50 K100 + Nano DAP (ST @ 2 .5 ml / kg seed & FS @ 0.2 %at 30 DAS) | 2.1 | 2.5 | 12.9 | 24.7 | 26.8 |
| **T6** | N50 P50 K100+ Nano DAP (ST @ 5 ml / kg seed & FS @ 0.2 %at 30 DAS) | 2.3 | 2.4 | 11.3 | 23.3 | 29.3 |
| **T7** | N75 P75 K100+ Nano DAP (ST @ 2 .5 ml / kg seed & FS @ 0.2 %at 30 DAS) | 2.1 | 2.6 | 12.6 | 25.9 | 33.4 |
| **T8** | N75 P75 K100+ Nano DAP (ST @ 5 ml / kg seed & FS @ 0.2 %at 30 DAS) | 2.3 | 2.7 | 13.1 | 27.5 | 34.6 |
| | SE (M) ± | 0.15 | 0.14 | 0.46 | 0.55 | 0.40 |
| | CD at 5 % | NS | 0.41 | 1.39 | 1.65 | 1.21 |

**Table 2. Effect various levels of phosphorus on seed yield and stalk yield of cotton**

| Treatments | | Yield q $ha^{-1}$ | |
|---|---|---|---|
| | | Seed | Stalk |
| **T1** | N0P0K0 | 8.28 | 12.43 |
| **T2** | N0P0K100 | 9.86 | 15.18 |
| **T3** | N100 P100 K100 | 16.93 | 29.62 |
| **T4** | N50 P50 K100 | 13.95 | 23.16 |
| **T5** | N50 P50 K100 + Nano DAP ( ST @ 2 .5 ml / kg seed & FS @ 0.2 %at 30 DAS) | 14.70 | 24.42 |
| **T6** | N50 P50 K100+ Nano DAP ( ST @ 5 ml / kg seed & FS @ 0.2 %at 30 DAS) | 14.63 | 25.86 |
| **T7** | N75 P75 K100+ Nano DAP ( ST @ 2 .5 ml / kg seed & FS @ 0.2 %at 30 DAS) | 14.80 | 26.02 |
| **T8** | N75 P75 K100+ Nano DAP ( ST @ 5 ml / kg seed & FS @ 0.2 %at 30 DAS) | 15.05 | 26.60 |
| | SE (M) ± | 0.60 | 0.96 |
| | CD at 5 % | 1.80 | 2.89 |

### 3.5.2 Phosphorus uptake

The highest uptake of phosphorus by cotton seeds (7.29 kg $ha^{-1}$) was observed with the application of 100% NPK fertilizer, as shown in Table 3. Conversely, the absolute control group had the lowest seed phosphorus uptake. The application of 100% NPK fertilizer resulted in a 355.62% higher seed phosphorus uptake compared to the absolute control. Similarly, the significantly highest uptake of phosphorus by cotton stalks (9.18 kg $ha^{-1}$) was recorded with the application of 100% NPK fertilizer, while the absolute control had the lowest stalk phosphorus uptake (3.12 kg $ha^{-1}$). The treatment with the best results showed a 363.89% higher stalk phosphorus uptake compared to the absolute control. Furthermore, the application of 100% NPK fertilizer resulted in the significantly highest total phosphorus uptake by cotton (16.47 kg $ha^{-1}$), while the absolute control had the lowest total phosphorus uptake (4.72 kg $ha^{-1}$). The total phosphorus uptake was 249% higher in the treatment with the best results compared to the absolute control. These significant increases in phosphorus uptake by cotton may be attributed

to the higher doses of phosphorus in the different treatments, which ultimately increased the yield and uptake. Similar results have been reported by Saleem et al. [11], Sharma et al. [4].

### 3.5.3 Potassium uptake

The application of 100% NPK fertilizer resulted in the highest uptake of potassium by cotton seeds, as shown in Table 3. The absolute control group had the lowest seed potassium uptake. The application of 100% NPK fertilizer led to a 161% higher seed potassium uptake compared to the absolute control. Similarly, the significantly highest uptake of potassium by cotton stalks was recorded with the application of 100% NPK fertilizer, while the absolute control had the lowest stalk potassium uptake. The treatment with the best results showed a 224.75% higher stalk potassium uptake compared to the absolute control. Furthermore, the application of 100% NPK fertilizer resulted in the significantly highest total potassium uptake by cotton, while the absolute control had the lowest total potassium uptake. The total potassium uptake was 206.37% higher compared to the absolute control. These significant increases in potassium uptake by cotton may be attributed to the higher doses of potassium in the different treatments, which ultimately increased the yield and uptake. Similar results have been reported by Gadhia [14] and Saleem [15].

### 3.5.4 Sulphur uptake

The highest uptake of sulphur by cotton seeds (5.90 kg $ha^{-1}$) was observed with the application of 100% NPK fertilizer, as shown in Table 4. On the other hand, the absolute control group had the lowest seed sulphur uptake (2.70 kg $ha^{-1}$). The application of 100% NPK fertilizer resulted in a 320% higher seed sulphur uptake compared to the absolute control. Similarly, the significantly highest uptake of sulphur by cotton stalks (4.45 kg $ha^{-1}$) was recorded with the application of 100% NPK fertilizer, while the absolute control had the lowest stalk sulphur uptake (1.72 kg $ha^{-1}$). The treatment with the best results showed a 273% higher stalk sulphur uptake compared to the absolute control.

**Table 3. Effect various levels of phosphorus on N and p uptake of nutrient by cotton**

| Treatments | | N uptake kg $ha^{-1}$ | | | P uptake kg $ha^{-1}$ | | |
|---|---|---|---|---|---|---|---|
| | | seed | stalk | total | seed | stalk | total |
| **T1** | N0P0K0 | 21.69 | 7.70 | 29.39 | 1.60 | 3.12 | 4.72 |
| **T2** | N0P0K100 | 26.13 | 13.35 | 39.48 | 2.08 | 3.49 | 5.57 |
| **T3** | N100 P100 K100 | 47.57 | 35.72 | 83.29 | 7.29 | 9.18 | 16.47 |
| **T4** | N50 P50 K100 | 37.94 | 25.47 | 63.41 | 4.50 | 6.17 | 10.67 |
| **T5** | N50 P50 K100 + Nano DAP ( ST @ 2 .5 ml / kg seed & FS @ 0.2 %at 30 DAS) | 40.72 | 27.35 | 68.07 | 5.33 | 6.32 | 11.65 |
| **T6** | N50 P50 K100+ Nano DAP ( ST @ 5 ml / kg seed & FS @ 0.2 %at 30 DAS) | 43.45 | 30.08 | 73.53 | 5.92 | 6.79 | 12.71 |
| **T7** | N75 P75 K100+ Nano DAP ( ST @ 2 .5 ml / kg seed & FS @ 0.2 %at 30 DAS) | 43.40 | 32.15 | 75.57 | 5.98 | 7.14 | 13.12 |
| **T8** | N75 P75 K100+ Nano DAP ( ST @ 5 ml / kg seed & FS @ 0.2 %at 30 DAS) | 44.42 | 32.67 | 77.09 | 6.04 | 7.37 | 13.18 |
| | SE (M) ± | 0.88 | 0.93 | 1.29 | 0.38 | 0.64 | 1.06 |
| | CD at 5 % | 2.64 | 2.81 | 5.89 | 1.16 | 1.92 | 3.17 |

**Table 4. Effect various levels of phosphorus on K and S uptake of nutrient by cotton**

| Treatments | | K uptake kg ha$^{-1}$ | | | S uptake kg ha$^{-1}$ | | |
|---|---|---|---|---|---|---|---|
| | | **Seed** | **Stalk** | **Total** | **seed** | **stalk** | **Total** |
| **T1** | N0P0K0 | 4.03 | 9.94 | 13.97 | 2.70 | 1.72 | 4.43 |
| **T2** | N0P0K100 | 6.06 | 15.78 | 21.84 | 3.34 | 2.16 | 5.49 |
| **T3** | N100 P100 K100 | 10.52 | 32.28 | 42.80 | 5.90 | 4.45 | 10.35 |
| **T4** | N50 P50 K100 | 8.71 | 24.54 | 33.25 | 4.75 | 3.36 | 8.11 |
| **T5** | N50 P50 K100 + Nano DAP ( ST @ 2 .5 ml / kg seed & FS @ 0.2 %at 30 DAS) | 8.17 | 26.12 | 35.29 | 5.02 | 3.71 | 8.73 |
| **T6** | N50 P50 K100+ Nano DAP ( ST @ 5 ml / kg seed & FS @ 0.2 %at 30 DAS) | 8.59 | 28.27 | 36.86 | 5.25 | 4.16 | 9.41 |
| **T7** | N75 P75 K100+ Nano DAP ( ST @ 2 .5 ml / kg seed & FS @ 0.2 %at 30 DAS) | 8.96 | 28.18 | 37.14 | 5.39 | 3.97 | 9.37 |
| **T8** | N75 P75 K100+ Nano DAP ( ST @ 5 ml / kg seed & FS @ 0.2 %at 30 DAS) | 9.16 | 28.81 | 37.97 | 5.45 | 4.24 | 9.69 |
| | SE (M) ± | 0.40 | 1.08 | 1.40 | 0.45 | 0.32 | 0.76 |
| | CD at 5 % | 1.21 | 3.24 | 4.22 | 1.35 | 0.96 | 2.29 |

Furthermore, the application of 100% NPK fertilizer resulted in the significantly highest total sulphur uptake by cotton (10.35 kg ha$^{-1}$), while the absolute control had the lowest total sulphur uptake (4.43 kg ha-1). The total sulphur uptake was 133.63% higher compared to the absolute control. These significant increases in sulfur uptake by cotton may be attributed to the higher doses of sulphur in the different treatments, which ultimately increased the yield and uptake. Similar results have been reported by Bharambe and Tomar et al. [16] and Sharma et al. [11].

## 4. CONCLUSION

According to the findings of the present investigation, cotton grows more vegetatively and productively when the necessary NPK dose is applied. It also increases cotton's ability to absorb nutrients and maximizes the amount of seed and stalk yields.

## ACKNOWLEDGEMENTS

I wish to thank Dr. A. B. Age sir, the entire faculty of the department of soil science and agricultural chemistry, and Dr. PDKV, Akola for their ongoing support in allowing me to conduct this complete experimental research project.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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