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# Effect of Nano Fertilizer on Growth, Quality and Yield of Bottle Gourd (*Lagenaria siceraria)* var. Sarita under Prayagraj Agro Climatic Conditions

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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

An experiment was conducted on bottle gourd to study the effect of nano-fertilizer *viz.*, NPK (19:19:19) in open field conditions of Prayagraj during 2022 for various parameters such as growth, earliness, yield and fruit quality. A F1 hybrid variety was used in this experiment named **"**SARITA**"** from the local market of Prayagraj. Total eight treatments were used which includes one RDF (recommended dose of conventional fertilizer) and seven concentrations of nano- fertilizer as foliar spray. For the vegetative characters, $T_7$ (9g nano-NPK/L) was found significantly superior as maximum vine length (328.33cm at 60 DAT) and maximum number of primary branches(12.89 at 60DAT) were recorded, and the earliest flower initiation was also observed in $T_7$ (26.33 days for male and 30 days for female flower after transplanting). Among the fruit characters *viz.*, fruit length

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and average fruit weight were found superior by $T_6$ (7.5g nano-NPK/L) *i.e.* 44.34cm & 1003g respectively , and for the yield parameters *i.e.,* yield/vine and yield/ha was also maximum in $T_6$ *i.e.* 12.55 & 251.75q respectively. Also for the quality parameters $T_6$ shows best results in TSS (4.51), ascorbic acid content (10.03mg/100g) and moisture percentage (95.90%), where as $T_1$ shows highest dry matter content (7.38%). The Benefit cost ratio was also found to be highest in $T_6$ *i.e.* 3.26. Based on these observations, it could be suggested that $T_7$ (9g nano-NPK/L) was the best treatment combination for overall vegetative characters and $T_6$ (7.5g nano-NPK/L) shows the best results for yield & quality of fruits hence, more profitable. This study aims to investigate the advantages of using modern nano fertilizers and the economics involved.

*Keywords: Bottle gourd; Nano-NPK treatments; fertilization; Prayagraj.*

## 1. INTRODUCTION

Bottle gourd (*Lagenaria siceraria)* belongs to the family Cucurbitaceae which comprises about 90 genera and 750 species [1]. Among all the cucurbits bottle gourd is an important vegetable available throughout the year. India has produced approximately 3142.71 tons of bottle gourd (NHB, 1st Adv. Estimate, 2022-23). It is commonly grown in various parts of the country and popularly known as lauki, ghia, kaddu, doodhi, ghai kaddu etc, in which Uttar Pradesh is the 2nd highest in production. Green and tender stage of fruits are used as vegetable and for preparation of some kind of sweets, rayata, pickles etc. it contains vitamin B & C and a fair source of minerals *viz*., P, Ca and Fe. It has a cooling effect, prevents constipation and several health benefits.

The production of bottle gourd depends on certain factors like irrigation, fertilizer management, weeding, plant protection measures etc. Among them, nutrient management is one of the most important factors of production and shares about 30% of the total production (Chaurasia *et al.,*1991). The recent use of chemical fertilizers has resulted in many serious environmental problems such as accumulation of heavy metals in soil and plant system (Wahab *et al*., 2017). Chemical fertilizer used in crop fertilization contains a small number of minerals that dissolve rapidly in wet soils and provide the plants large doses of minerals (Vernon, 1999). The plants during growth stages need chemical compounds to enhance its growth. These chemical compounds are named mineral fertilizers. Artificial fertilizers are inorganic fertilizers prepared in ideal concentrations of macro and micro nutrients. The NUEs (Nutrient use efficiency) of major macronutrients such as N, P, K are quite low, with current levels being 30-35%, 18-20%, and 35-40%, respectively, which means more than half of the applied fertilizers are lost. By necessity, low NUEs lead to higher inputs of conventional fertilizers to maintain agricultural outputs. The energy and materials associated with this strategy increase the economic burden on farmers and impede the development of sustainable agriculture, particularly in developing countries. In addition, the heavy use and runoff of fertilizers distort the nutrient and food chain balance in ecosystems, causing a variety of environmental problems, including eutrophication of water bodies and soil structure disturbance. Therefore we should rely more on sustainable agricultural practices which are environmental friendly based on biological and physical treatments in crop production [2-5].

Nanotechnology has been defined as relating to materials, systems and processes which operate at a scale of 100 nanometers (nm) or less. One of the most important uses of nanotechnology is nanofertilizer, which improves the ability of plants to absorb nutrients [6-8]. Nano fertilizers have an important role in the biochemical and physiological processes of yields by rising the availability of nutrients as Nano-fertilizers have a high surface area, sorption capacity, and controlled-release moving to targeted sites, and have been measured as smart delivery systems (Kumar and Nagesh, 2019).

With the increasing population pressure on land for cultivation, one way to boost production is to improve nutrient delivery systems which will increase per hectare productivity. Plus bottle gourd is a profitable crop, but yield of crops are far below their potential yield [9-12]. Therefore, there is an urgent need to boost the yields of crops through nutrient management. In the light of the above, the present study was undertaken. This investigation was conducted to study growth, yield, quality and economics of bottle gourd grown under different level of nano NPK fertilization, under foliar spraying.

## 2. MATERIALS AND METHODS

### 2.1 Experimental Site

Field experiments for studying the effects of nano NPK on growth, yield and quality of bottle gourd were performed during February to April in 2022 at the Horticultural Research Field, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (25.43° N latitude 81.84° E longitude) India. The soil at the location is Loam and Sandy Loam. Prayagraj district has a sub-tropical climate and the average maximum temperature ranges between 43 °C – 47 °C which may go as high as 48 °C during peak summers. The minimum average temperature is 2 - 4 °C which may fall as low as 1.5 °C during peak winter months (Dec.-Jan.). The average rainfall of the district is 960 mm and the monsoon season is spread between July-September. The experiment was carried out with the objectives to find out the suitable dose of nano NPK on growth, yield and quality of Bottle gourd and to study economics of various treatments [13].

### 2.2 Experimental Details

The experiment was carried out in open field conditions. The variety used in the experiment was F1 Hybrid (SARITA). Plants were sown in nursery beds in the on February 16th, 2022 and transplanted to open field on February 25th, 2022 with a spacing of 2.5 m row to row and 2 m plant to plant. Nano NPK was made available by Geolife Agritech India Pvt. Ltd. It is applied through foliar spray. The experiment was designed in Randomized Block Design with three replications. The application of nano NPK was given as per the treatment where total eight treatments were used which includes one RDF (recommended dose of conventional fertilizer) and seven concentrations of nano- fertilizer as foliar spray. Basal dose of was done at the time of transplanting while Foliar application was given after 15, 30, 45 and 60 days after transplanting. The treatments details are given in Table 1.

The recommended dose of fertilizers was applied to the crop with a dose of Nitrogen at 100 kg/ha, Phosphorus at 50 kg/ha, Potassium at 60 kg/ha. The half dose of nitrogen was applied as a basal dose and rest as soil drenching. FYM at 20 t/ha was applied 15 days before transplanting [14-16].

### 2.3 Observations

Growth Parameters (Vine length, Number of primary branches), Earliness Parameters (Days to 1st female flowering, Days to first fruit setting, Days to first fruit picking), Yield Parameters (No. of fruits per plant, Fruit yield per hectare, Fruit yield per plant, Average Fruit weight, Average fruit length), Qualitative Parameters (Total soluble solids, Ascorbic Acid, dry matter content, moisture content) and Economic Parameters (Cost of cultivation, Benefit Cost Ratio) were observed in the population.

## 3. RESULTS AND DISCUSSION

The performances of bottle gourd under different levels of nano NPK was recorded through parameters of crop growth, earliness, quality, yield and economics are as follows: -

### 3.1 Growth Parameters

**Growth parameters such as vine length (cm) are given in Table 2 (a):** The length of plant significantly varied among different treatment combinations. The maximum vine length at 15, 30, 45 and 60 DAT was observed with treatment $T_7$ (9g Nano NPK/L) as 77.33cm, 158.56cm, 234.56cm & 328.33cm respectively and minimum vine length was observed in $T_1$ (RDF) as 41.98cm, 101.22cm, 161.78cm & 218.22cm respectively while the remaining treatments were moderate in their growth habit.

**Table 1. Treatment details**

| Treatment notation | Treatment combination |
|---|---|
| $T_1$ | Recommended dosage of conventional fertilizer |
| $T_2$ | 1.5g nano NPK (0.5g N+ 0.5g P+ 0.5g K) |
| $T_3$ | 3g nano NPK (1g N+ 1g P+ 1g K) |
| $T_4$ | 4.5g nano NPK (1.5g N+ 1.5g P+ 1.5g K) |
| $T_5$ | 6g nano NPK (2g N+ 2g P+ 2g K) |
| $T_6$ | 7.5g nano NPK (2.5g N+ 2.5g P+ 2.5g K) |
| $T_7$ | 9g nano NPK (3g N+ 3g P+ 3g K) |
| $T_8$ | 10.5g nano NPK (3.5g N+ 3.5g P+ 3.5g K) |

**Table 2(a). Growth parameters (Vine length)**

| Vine Length (cm) | | | | | |
|---|---|---|---|---|---|
| **Treatments** | **Treatment combinations** | **15 DAT** | **30 DAT** | **45 DAT** | **60 DAT** |
| $T_1$ | Recommended dosage of conventional fertilizer | 41.98 | 101.22 | 161.78 | 218.22 |
| $T_2$ | 1.5g nano NPK (0.5g N+ 0.5g P+ 0.5g K) | 47.58 | 109.33 | 171.67 | 236.89 |
| $T_3$ | 3g nano NPK (1g N+ 1g P+ 1g K) | 53.44 | 117.89 | 184.78 | 251.78 |
| $T_4$ | 4.5g nano NPK (1.5g N+ 1.5g P+ 1.5g K) | 58.44 | 125.89 | 190.78 | 266.67 |
| $T_5$ | 6g nano NPK (2g N+ 2g P+ 2g K) | 64.56 | 134.00 | 204.44 | 281.22 |
| $T_6$ | 7.5g nano NPK (2.5g N+ 2.5g P+ 2.5g K) | 70.55 | 141.89 | 212.55 | 296.22 |
| $T_7$ | 9g nano NPK (3g N+ 3g P+ 3g K) | 77.33 | 158.56 | 234.56 | 328.33 |
| $T_8$ | 10.5g nano NPK (3.5g N+ 3.5g P+ 3.5g K) | 76.44 | 149.45 | 223.89 | 313.33 |

The larger surface area of nano-sized particles enhances nutrient absorption and uptake by the plant, ensuring better nutrient availability, also foliar application allows for direct delivery of nutrients to the leaves, bypassing potential losses in the soil, making it a more efficient method. Similar findings were reported by Shah *et al.* (2018) and Lopes *et al.* (2018) in their Journal of Bionanoscience.

**Growth Parameters such as No. of primary branches are given in Table 2 (b):** The number of primary branches significantly varied among different treatment combinations. The maximum number of primary branches at 15, 30, 45 & 60 DAT was observed with treatment $T_7$ (9g Nano NPK/L) as 3.11, 5.78, 8.89 & 11.89 respectively and minimum number of primary branches was observed in $T_1$ (RDF) as 2.33, 3.56, 5.0 & 6.78 respectively while the remaining treatments were moderate in their growth habit.

Nano NPK particles may act as growth promoters, influencing cell division and elongation processes in plants. They can stimulate the activity of enzymes involved in cell division, resulting in increased meristematic activity and subsequent branch development. Similar findings were reported by Singh *et al.* [17] and Mishra *et al.* [18].

## 3.2 Earliness Parameters

Earliness Parameters such as Days to 1$^{st}$ female flowering and days to fruit setting & picking recorded are given in Table 3.

Nano NPK formulations can influence plant hormone balance and signaling pathways. Certain forms of nano-sized nutrients have been reported to enhance the production and transport of plant hormones such as auxins, cytokinins, and gibberellins, which are crucial for flowering induction and regulation. Similar results were recorded by Sharma *et al.* [19]. Study evaluated the effect of nano-nutrients, including Nano NPK, on the growth and yield of bottle gourd. It reported positive effects on early flowering, suggesting the potential of

Nano NPK in promoting early reproductive development in bottle gourd also, Gurjar *et al.* [20] showed the influence of nano fertilizers on early flowering and eventually fruiting of bottle gourd (Lagenaria siceraria (Molina) Standl.).

## 3.3 Yield Parameters

Yield Parameters such as, Number of fruits per vine, fruit weight (gm) and Fruit yield per hectare (q/ha) were observed and listed in Table 4.

The data pertaining to number of fruits per vine, fruit weight and yield per hectare varied significantly. Maximum results were observed in $T_6$ (7.5g nano NPK/L) with 12.55 fruits, 1003g weight and 251.75 q/ha while the minimum was recorded under $T_1$ (RBD) with 5.56 fruits, 603.11g weight and 67.07 q of yield per hectare.

Nano NPK fertilizers provide a readily available source of essential nutrients to the plant. The nano-sized particles can release nutrients more readily, making them easily accessible to the plant's roots and foliage. Adequate nutrient availability is crucial for fruit development, and supplying nano NPK via foliar application can support optimal nutrient levels for fruit production. Similar results were observed by Sharma *et al.* (2015) and Singh *et al*. [21].

## 3.4 Qualitative Parameters

Qualitative Parameters such as TSS (°Brix), Ascorbic Acid (mg/100g), dry matter(gm) and moisture(%) content were recorded and give in Table 5.

**Table 2 (b). Growth Parameter (No. of primary branches)**

| | | No. of primary branches | | | |
|---|---|---|---|---|---|
| **Treatments** | **Treatment combinations** | **15 DAT** | **30 DAT** | **45 DAT** | **60 DAT** |
| $T_1$ | Recommended dosage of conventional fertilizer | 2.33 | 3.56 | 5.00 | 6.78 |
| $T_2$ | 1.5g nano NPK (0.5g N+ 0.5g P+ 0.5g K) | 2.56 | 5.22 | 6.56 | 8.22 |
| $T_3$ | 3g nano NPK (1g N+ 1g P+ 1g K) | 3.00 | 5.33 | 7.11 | 9.00 |
| $T_4$ | 4.5g nano NPK (1.5g N+ 1.5g P+ 1.5g K) | 2.78 | 5.33 | 7.22 | 9.22 |
| $T_5$ | 6g nano NPK (2g N+ 2g P+ 2g K) | 2.44 | 5.00 | 7.45 | 9.78 |
| $T_6$ | 7.5g nano NPK (2.5g N+ 2.5g P+ 2.5g K) | 2.67 | 5.22 | 8.00 | 10.22 |
| $T_7$ | 9g nano NPK (3g N+ 3g P+ 3g K) | 3.11 | 5.78 | 8.89 | 11.89 |
| $T_8$ | 10.5g nano NPK (3.5g N+ 3.5g P+ 3.5g K) | 2.89 | 5.44 | 8.18 | 10.44 |

**Table 3. Earliness Parameters**

| **Treatments** | **Treatment combinations** | **Days to 1$^{st}$ female flowering** | **days to fruit setting** | **days to fruit picking** |
|---|---|---|---|---|
| $T_1$ | Recommended dosage of conventional fertilizer | 31.55 | 39.67 | 48.89 |
| $T_2$ | 1.5g nano NPK (0.5g N+ 0.5g P+ 0.5g K) | 31.44 | 38.67 | 47.44 |
| $T_3$ | 3g nano NPK (1g N+ 1g P+ 1g K) | 30.78 | 37.89 | 47.67 |
| $T_4$ | 4.5g nano NPK (1.5g N+ 1.5g P+ 1.5g K) | 28.22 | 37.67 | 48.33 |
| $T_5$ | 6g nano NPK (2g N+ 2g P+ 2g K) | 27.89 | 37.55 | 45.11 |
| $T_6$ | 7.5g nano NPK (2.5g N+ 2.5g P+ 2.5g K) | 27.45 | 37.22 | 45.89 |
| $T_7$ | 9g nano NPK (3g N+ 3g P+ 3g K) | 26.33 | 33.22 | 41.22 |
| $T_8$ | 10.5g nano NPK (3.5g N+ 3.5g P+ 3.5g K) | 27.33 | 36.33 | 45.00 |

**Table 4. Yield parameters**

| **Treatments** | **Treatment combinations** | **No. of fruits per vine** | **Fruit weight (gm)** | **Yield (q/ha)** |
|---|---|---|---|---|
| $T_1$ | Recommended dosage of conventional fertilizer | 5.56 | 603.11 | 67.07 |
| $T_2$ | 1.5g nano NPK (0.5g N+ 0.5g P+ 0.5g K) | 6.44 | 645.54 | 83.15 |
| $T_3$ | 3g nano NPK (1g N+ 1g P+ 1g K) | 7.67 | 747.27 | 114.63 |
| $T_4$ | 4.5g nano NPK (1.5g N+ 1.5g P+ 1.5g K) | 7.78 | 804.42 | 125.17 |
| $T_5$ | 6g nano NPK (2g N+ 2g P+ 2g K) | 9.88 | 886.80 | 175.23 |
| $T_6$ | 7.5g nano NPK (2.5g N+ 2.5g P+ 2.5g K) | 12.55 | 1003.0 | 251.75 |
| $T_7$ | 9g nano NPK (3g N+ 3g P+ 3g K) | 11.78 | 981.23 | 231.18 |
| $T_8$ | 10.5g nano NPK (3.5g N+ 3.5g P+ 3.5g K) | 10.33 | 965.38 | 199.45 |

**Table 5. Qualitative Parameters**

| **Treatments** | **Treatment combinations** | **TSS (°Brix)** | **Ascorbic Acid (mg/100g)** | **Moisture content (%)** |
|---|---|---|---|---|
| $T_1$ | Recommended dosage of conventional fertilizer | 2.90 | 7.72 | 92.62 |
| $T_2$ | 1.5g nano NPK (0.5g N+ 0.5g P+ 0.5g K) | 3.19 | 8.12 | 92.85 |
| $T_3$ | 3g nano NPK (1g N+ 1g P+ 1g K) | 3.31 | 8.35 | 93.14 |
| $T_4$ | 4.5g nano NPK (1.5g N+ 1.5g P+ 1.5g K) | 3.51 | 8.52 | 93.75 |
| $T_5$ | 6g nano NPK (2g N+ 2g P+ 2g K) | 3.62 | 8.81 | 94.34 |
| $T_6$ | 7.5g nano NPK (2.5g N+ 2.5g P+ 2.5g K) | 4.51 | 10.03 | 95.90 |
| $T_7$ | 9g nano NPK (3g N+ 3g P+ 3g K) | 4.20 | 9.54 | 95.31 |
| $T_8$ | 10.5g nano NPK (3.5g N+ 3.5g P+ 3.5g K) | 3.80 | 9.73 | 94.83 |

**Table 6. Economic parameters**

| Treatments | Treatment combinations | Gross return (₹) | Net return (₹) | Benefit Cost ratio (₹) |
|---|---|---|---|---|
| $T_1$ | Recommended dosage of conventional fertilizer | 152707.5 | 80,873.45 | 2.13 |
| $T_2$ | 1.5g nano NPK (0.5g N+ 0.5g P+ 0.5g K) | 166292 | 86,807.96 | 2.09 |
| $T_3$ | 3g nano NPK (1g N+ 1g P+ 1g K) | 229261.4 | 1,42,127.4 | 2.63 |
| $T_4$ | 4.5g nano NPK (1.5g N+ 1.5g P+ 1.5g K) | 250336.5 | 1,55,552.5 | 2.64 |
| $T_5$ | 6g nano NPK (2g N+ 2g P+ 2g K) | 350462 | 2,48,028 | 3.42 |
| $T_6$ | 7.5g nano NPK (2.5g N+ 2.5g P+ 2.5g K) | 503504.3 | 3,93,420.3 | 4.57 |
| $T_7$ | 9g nano NPK (3g N+ 3g P+ 3g K) | 462353.5 | 3,44,619.5 | 3.93 |
| $T_8$ | 10.5g nano NPK (3.5g N+ 3.5g P+ 3.5g K) | 398895.5 | 2,73,511.5 | 3.18 |

The data pertaining Total Soluble Solid, Ascorbic acid, dry matter and moisture content varied significantly. Maximum results were observed in $T_6$ (7.5g nano NPK/L) with 4.51 $^0$Brix, 10.03 mg/100g ascorbic acid and 95.37 % moisture while results were recorded minimum under $T_1$ (RDF) with 2.90 $^0$Brix, 7.72 mg/100g ascorbic acid and 92.62 moisture content.

Nano NPK formulations often contain compounds that enhance the plant's ability to utilize water efficiently, reducing the risk of water stress and ensuring optimal fruit development. Additionally, the balanced supply of nitrogen, phosphorus, and potassium through nano NPK foliar application promotes the necessary nutrient balance for various metabolic processes. This balance is crucial for sugar synthesis and accumulation in the fruit, ultimately leading to an increase in the total soluble solids content, ascorbic acid and moisture percentage in bottle gourd. Similar results were observed by Kumar *et al.* (2015) and Patel *et al.* (2016).

### 3.5 Economic Parameters

Economic Parameters such as Gross Return, Net Income/Return, and Benefit Cost Ratio were calculated and listed in Table 6. Maximum gross returns, net returns and benefit cost ratio was recorded in treatment $T_6$ (7.5g nano NPK/L) and the minimum was recorded in treatment $T_1$ (RDF).

## 4. CONCLUSION

Based on the findings of the present experiment, it can be concluded that $T_7$ (9g Nano NPK/L) performs best in terms of vine length, number of primary branches, days to emergence of first female flower, days to fruit setting and days to fruit picking. Whereas, $T_6$ (7.5g Nano NPK/L) performs best in terms of total number of fruits per vine, fruit weight, yield per hectare, TSS, ascorbic acid and moisture percentage with highest gross return, net return and highest B:C rato.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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