

## Research Article

# Effect of N:P:K (15:15:15) on the Growth of *Punica granatum* L. Seedlings

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This study was conducted to determine the effect of NPK (15:15:15) fertilizer on some growth parameters of *Punica granatum* seedlings towards establishing the fertilizer amount optimal for the growth of *P. granatum*. Planting bags containing 23.3 kg of soil were used for planting the seeds of *Punica granatum*, and the soil was treated with different amounts of NPK 15:15:15 fertilizer ( $T_1 = 0$  g,  $T_2 = 1$  g,  $T_3 = 2$  g,  $T_4 = 3$  g, and  $T_5 = 4$  g) and watered daily with borehole water. The experiment was laid out in a completely randomized design with four replicates. Data were taken on the number of leaves (NOL), height of plant (HOP), and area of leaves (AOL) every three weeks for fifteen (15) weeks after planting. Results obtained using the Ochekwu Comparative Treatment Average (OCTA) trend showed that all the parameters under investigation increased significantly with an increase in fertilizer amount compared to the control. The optimum growth was observed to range between  $T_3$  and  $T_4$  for the number of leaves, height of plant, and area of leaves parameters studied. It was also observed that the increment of fertilizer amounts beyond this optimum point reduced biological yield previously obtained. Hence, for the optimum growth of *P. granatum* seedlings, NPK (15:15:15) fertilizer should be applied within the range of  $T_3$  and  $T_4$  or any other measurement that falls within the concentration range of  $T_3$  (0.09 g NPK  $\text{kg}^{-1}$  soil) and  $T_4$  (0.13 g NPK  $\text{kg}^{-1}$  soil) in the Niger Delta of Nigeria.

## 1. Introduction

Well established for its significance in the Israeli, Egyptian, Persian, and Greek culture and religions, the pomegranate (*Punica granatum*) is a fruiting shrub of the family Lythraceae and grows between 5 and 10 m tall. *P. granatum* is widely cultivated for its edible fruit or delicious juice, which is mostly employed in baking, cooking, juice blends, meal garnishes, smoothies, and alcoholic beverages. *P. granatum* has been employed for its several medicinal uses, some of which include the antioxidant, hepatoprotective, analgesic, antidiabetic, antibacterial, antiobesity, antitumor, neuroprotective, and nephron-protective effects among others [1]. Other reports [2] have shown that pomegranate could possibly increase libido and fertility in mammals. These and a lot more of other benefits makes it a crop worthy of commercialization in Nigeria, owing to the myriad of economic advantages that could be harnessed from it in the food and drug industry.

It has been severally established that crop yield depends on certain factors, some of which include the climate and agricultural techniques employed [3]. Of the agricultural techniques employed, optimal nutrient supply is the most important factor for higher crop yield, and of all the essential plant nutrients, N, P, and K, have been found to be the most limiting macronutrients for plant growth and development.

Nitrogen is known to be one of the major limiting factors of crop production, so to grow crops, it is necessary to know the effect of sources of nitrogen fertilization on its yield [4]. Nitrogen is an essential element recognized for its presence in the structure and function of key macromolecules such as proteins, nucleic acids, some lipids, and chlorophylls [5], as it also plays a role in the synthesis of the plants constituents through the action of different enzymes [6]. Phosphorus is also a component of nucleic acids, phospholipids, and ATP [7]. It has been established that seeds have the highest concentration of phosphorus in a mature plant, and

phosphorus is required in large quantities in young cells, such as shoots and root tips, due to the high metabolic and mitotic rates. Phosphorus helps in root development, flower initiation, and fruit development, and  $P_2O_5$  has been known to the incidence of diseases in some plants [8]. Potassium (K), as the third most essential macronutrient of plant, is an important macronutrient and the most abundant cation in higher plants. It plays a central role in many fundamental metabolic processes, such as turgor driven movements, osmoregulation, control of membrane polarization and protein biosynthesis [9], and enzyme activation [10, 11]. Nitrogen fertilizers are known to boost or increase the growth of plants generally, and though in certain high amounts, some of these fertilizers can be detrimental to the growth of the plant.

NPK fertilizers consist of N, P, and K. Among the several benefits, N is known for its effectiveness in helping plants grow quickly. It also accelerates the seed as well as fruit production, whilst bettering the forage crops and leaf quality. It is a chlorophyll component, and chlorophyll gives green color to plant. Phosphorus is a major player when it comes to photosynthesis and has great significance helping plant grow. It supports in the process of forming oils, starches, and sugars. Other than these, P aids the conversion of solar into chemical energy. Moreover, P supports and promotes root growth and blooming, respectively. K helps greatly in photosynthesis, improving the quality of fruits, protein building, and disease reduction. On the whole, K is an important element for the plant health, growth, and nutrition.

Therefore, this study is aimed at understanding the effect of the different concentrations of the nitrogen fertilizer (NPK 15:15:15) on the growth of the plant *P. granatum*, which could lead to the establishment of the optimum concentration of the fertilizer of NPK 15:15:15 that is optimal for the growth of *P. granatum* in the tropical soils of the Niger Delta of Nigeria.

## 2. Materials and Methods

**2.1. Experimental Site.** The potted experiment (five liter plastic pots of 17.5 cm diameter with 25 cm depth) was conducted at the Center for Ecological Studies in the Department of Plant Science and Biotechnology, University of Port Harcourt, Rivers State, Nigeria. It is on geographical coordinates: latitude  $4^{\circ}52'N$  and  $4^{\circ}55'N$ , longitudes  $6^{\circ}54'E$  and  $6^{\circ}56'E$  in Obio/Akpor Local Government Area (LGA), Rivers State. It is situated in the Niger Delta wetland of Southern Nigeria.

The climatic conditions of the area is characterized by tropical monsoon climate with a mean monthly minimum temperature of  $21.8^{\circ}C$ , and  $31.3^{\circ}C$  is the maximum monthly temperature, while the mean annual minimum temperature is  $22.5^{\circ}C$ , and the mean annual maximum temperature is  $31.0^{\circ}C$ . Monthly rainfall is 203.0 mm, and annual rainfall is over 200.5 mm. The monthly solar radiation is  $10.6 mJm^{-2}/day$  while mean annual solar radiation is  $9.3 mJm^{-2}/day$ . The mean maximum humidity is 112.5% while mean annual minimum humidity is 69.1% [12].

**2.2. Source of Materials.** The seeds of the test crop (*Punica granatum*) were obtained from the Sheikl Commercial Market, Dubai, United Arab Emirates (UAE) and identified in the Department of Plant Science and Biotechnology, University of Port Harcourt. The soil samples obtained were filled in 20 planting bags to a weigh of 20.3 kg. The soil samples were obtained behind the University of Port Harcourt Farm House, Faculty of Agriculture, and the area has no history of pollution. The NPK (15:15:15) fertilizer was purchased at ADP Rumuokoro, Obio-Akpor L.G.A., Rivers State, Nigeria.

**2.3. Viability Test on Seeds.** Viability test was carried to ensure the seeds were viable. Ten seeds of the test crop (*P. granatum*) were plated in Petri dishes lined with the Whatman No. 1 filter paper and kept for 7 days with 10 ml of distilled water every 3 days at  $25^{\circ}C$ .

Nine seeds out of the ten seeds sprouted (plumule and radicle) showed 90% viability, thus showing that the seeds are good enough for planting as against <70% viability, which would have indicated that the seeds may not be viable.

**2.4. Planting Procedures.** The bags were filled with loam soil, which weigh 23.3 kg per bag and labeled according to the treatment of the NPK fertilizer such as 0 g (control), 1 g, 2 g, 3 g, and 4 g. After two weeks of planting, NPK fertilizer of different treatments was applied to each bag. The plants were watered daily.

**2.5. Experimental Design.** The seeds of *Punica granatum* were planted in bags arranged in a completely randomized design with each bag weighing an average of 23.3 kg with 5 treatments (0 g, 1 g, 2 g, 3 g, and 4 g) and 4 replicates giving a total of 20 bags.

**2.6. Measurement of Growth Parameters.** Growth parameters examined were plant height (cm), leaf area ( $cm^2$ ), and number of leaves (NOL).

(1) Plant height (HOP)

The plant height was measured using meter rule from the base of the plant to the tip of the leaf.

(2) Number of leaves (NOL)

The number of leaves was obtained by visual counting of the leaves.

(3) Leaf area (AOL)

The leaf area was measured as the product of the length and the width of the leaves.

$$\text{Formula of AOL (cm}^2\text{)} = \text{length of leaf (cm)} \times \text{width of leaf (cm)}. \quad (1)$$

**2.7. Soil Physicochemical Analysis.** The soil physicochemical characterization was carried out at the International Institute for Tropical Agriculture, Analytical Service Laboratory, Ibadan, Oyo State, Nigeria (Table 1).

2.8. *Statistical Analysis.* Mean values were taken, and ANOVA (analysis of variance) was calculated for each treatment using data analysis of Microsoft Excel Sheet.

The effects of the various treatments were compared parametrically using the Ochekwu Comparative Treatments Average (OCTA) trend. OCTA is an analytical tool for the reference comparison of treatments in biological experiments [13].

### 3. Results

The results of the study on the effect of the different treatments (0 g (control), 1 g, 2 g, 3 g, and 4 g) of NPK fertilizer on the number of leaves (NOL), plant height (HOP), and leaf area (AOL) of *Punica granatum* within a period of 15 weeks are represented in Figures 1–3, respectively.

The addition of NPK fertilizers in different concentrations generally increased the number of leaves of *Punica granatum*. The 3 g treatment had the highest effect on the number of leaves as compared to the other treatments. The lowest effect was observed for the 4 g treatment, as this treatment was observed to be of a lower effect than the control treatment. It could, in other words, be said that generally, the number of leaves of *Punica granatum* observed an increase in the number of leaves with an increase in the concentration of the nitrogen fertilizer, up to the 3 g treatment, until whence it started decreasing at the 4 g treatment.

The addition of NPK fertilizers in different concentrations generally increased the plant height of *Punica granatum*. The 2 g treatment had the highest overall effect on the height of plant as compared to the other treatments. The lowest effect was observed for the 4 g treatment, as this treatment was observed to be of a lower effect than the control treatment. It could, in other words, be said that generally, the height of plant of *Punica granatum* increased with an increase in the concentration of the nitrogen fertilizer, up to the 3 g treatment, until whence it started decreasing at the 4 g treatment.

The addition of NPK fertilizers in different concentrations generally increased the area of leaves of *Punica granatum*. The 2 g treatment had the highest overall effect on the area of leaves as compared to the other treatments. The lowest effect was observed for the 4 g treatment, as this treatment was observed to be of a lower effect than the control treatment. It could, in other words, be said that generally, the area of leaves of *Punica granatum* increased with an increase in the concentration of the nitrogen fertilizer, up to the 3 g treatment, until whence it started decreasing at the 4 g treatment.

3.1. *OCTA Analyses.* Using the Ochekwu Comparative Treatment Average (OCTA) to determine the relative OCTA trend, which would show how the respective treatments are compared against each other for the particular parameter over the duration under study, the following plots were deduced:

The relative OCTA trend for number of leaves for *P. granatum* showed that the treatments increased the number of leaves for *P. granatum*. The OCTA trend peaked at T4 (3 g treatment) with an OCTA index of 0.287 and observed the lowest (trough) at T5 (4 g treatment) recording an OCTA index of -0.29 (Figure 4).

The relative OCTA trend automatically explains that T4 increased the number of leaves (NOL) of *P. granatum* by 28.7% while T5 reduced the number of leaves (NOL) of *P. granatum* by 29% as compared to the control (T1).

The relative OCTA trend for height of plant for *P. granatum* showed that the treatments increased the height of plant for *P. granatum*. The OCTA trend peaked at T3 (2 g treatment) with an OCTA index of 0.623 and observed the lowest (trough) at T5 (4 g treatment) recording an OCTA index of -0.128 (Figure 5).

The relative OCTA trend automatically explains that T3 increased the height of plant (HOP) of *P. granatum* by 62.3% while T5 reduced the height of plant (HOP) of *P. granatum* by 12.8% as compared to the control (T1).

The relative OCTA trend for height of plant for *P. granatum* showed that the treatments increased the area of leaves for *P. granatum*. The OCTA trend peaked at T3 (2 g treatment) with an OCTA index of 0.78 and observed the lowest (trough) at T5 (4 g treatment) recording an OCTA index of -0.068 (Figure 6).

The relative OCTA trend automatically explains that T3 increased the area of leaves (AOL) of *P. granatum* by 78% while T5 reduced the area of leaves (AOL) of *P. granatum* by 6.8% as compared to the control (T1).

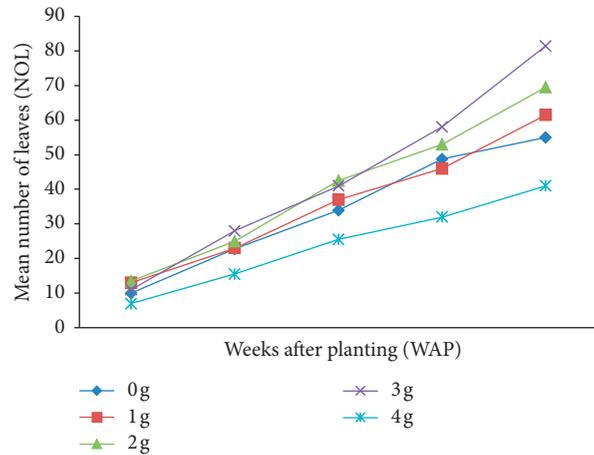
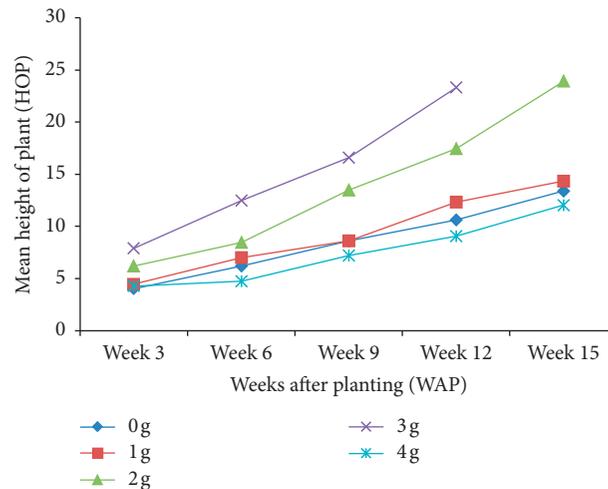
### 4. Discussion

The study showed that, within the study period, the application of nitrogenous fertilizer positively affected the NOL, HOP, and AOL of *P. granatum*, though to a certain point at which a reversal occurred. The increase in the growth parameters of *P. granatum* with increase in the amount of nitrogenous fertilizer is in line with the works of Khalid and Shedeed[14] who explained that the application of the nitrogenous fertilizer coupled with foliar nutrition significantly improved the growth of *Nigella sativa*. Working with *Allium cepa* within the Amhara region of Ethiopia, similar observation was reported [15], stating that the application of a nitrogenous (NPS) fertilizer improved the overall growth parameters (number of leaves, leaf area, and height of plants) of the plant between 0.09 g NPK kg<sup>-1</sup> soil and 0.13 g NPK kg<sup>-1</sup> soil compared to the control experiment. These improvements of the growth parameters of the plant, *P. granatum*, due to NPK application could be traced to the essential functions, and these elements serve in cellular enzyme activation [6, 14] and the synthesis of proteins, nucleic acids, lipids, chlorophylls [5], and ATP [7].

The sudden reversal of growth with increasing concentration of nitrogenous fertilizer may be linked to the establishment of the optimum concentration of the NPK 15:15:15 at T4, which improved on all the growth parameters under investigation. This supposition has been previously established by the works of Moro et al. [16] who, while

TABLE 1: Physicochemical characterization of the soil.

Id no.	pH	O	N	P	Ca	Mg	K	Na	Al	Cation exchange capacity	Clay	Silt	Sand
Unit	(1:1) H <sub>2</sub> O		%							Cmol/kg		%	
Value	4.40	2.51	0.260	42.711	20.362	0.662	0.091	0.692	0.00	22.126	14.0	21.4	64.6

FIGURE 1: The mean number of leaves of *Punica granatum* at different treatments over 15 weeks after planting (WAP).FIGURE 2: Mean plant height of *Punica granatum* with different treatments.

working with rice fields under the ‘‘Sawah’’ system in Ghana, observed that optimum grain yield was observed at 60 kg P<sub>2</sub>O<sub>5</sub>/ha and 60 kg K<sub>2</sub>O/ha. They explained that the application of higher rates of N (>90 kg/ha) did not reflect in yield improvement and, therefore, was not economically beneficial. Also Okonwu and Mensah [17], while working with pumpkin, reported that the use of NPK fertilizer at an application range between 400 and 450 kg NPK ha<sup>-1</sup> was optimal for growing of *C. moschata*. This recommendation is against the higher concentration of 500 kg NPK ha<sup>-1</sup>. Reports have shown that increasing the concentration of fertilizers to beyond optimal levels could lead to possible cases of plant lodging [18] and resultant disruptions in the essential soil microbiota (and chemical depletion) [19],

thereby leading to observable reduction in growth compared to the optimally grown plants and sometimes. As is evident in the work of Liu et al. [20], beyond optimal applications of organic nitrogen fertilizers can lead to increased concentration of nitrate residues in vegetables; this leads to the suspicion that such higher concentrations could lead to nitrogen toxicity within the plant, thereby accounting to the observed reductions in the growth parameters (number of leaves, leaf area, and height of plants).

OCTA trend showed that for all parameters, T5 showed negative values (indicative of reduction). This, therefore, goes to further explain that the optimum concentration of NPK 15:15:15 for growing *P. granatum* is as obtained within the range of T3-T4, established at OCTA values of

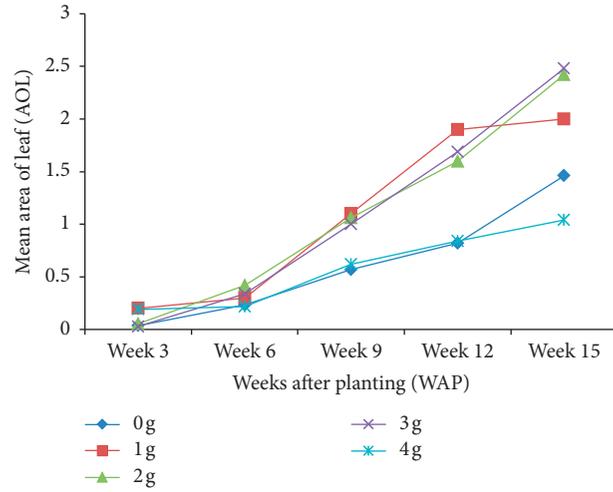


FIGURE 3: Mean leaf area of *Punica granatum* 15 weeks after planting.

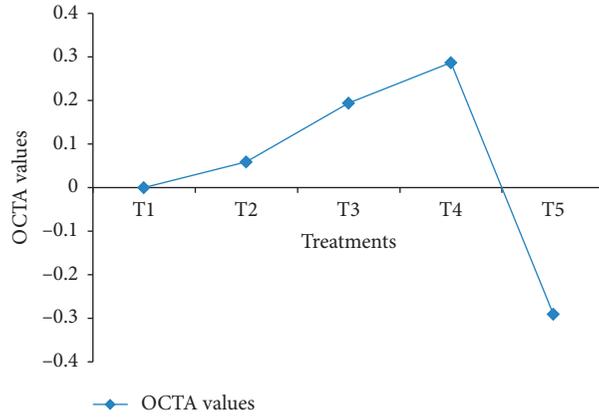


FIGURE 4: OCTA trend for the number of leaves (NOL).

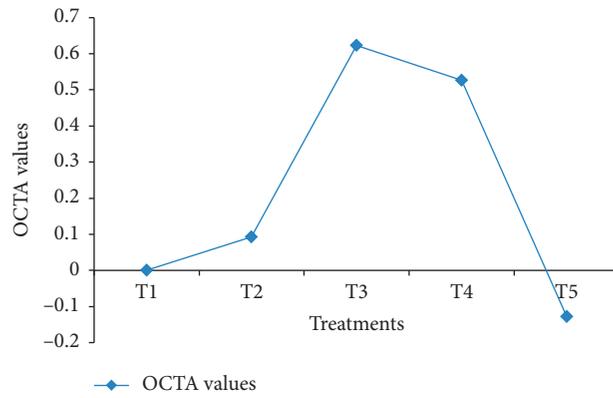


FIGURE 5: OCTA trend for height of plants (HOP).

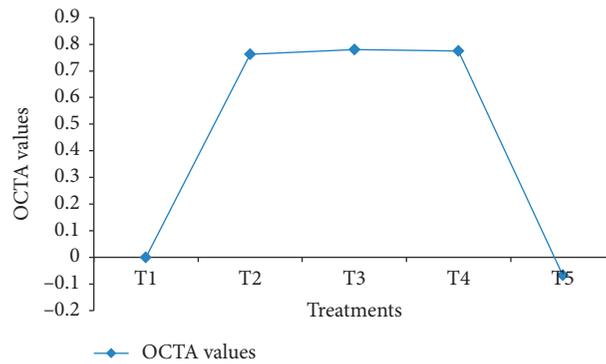


FIGURE 6: OCTA trend for AOL (Area of leaf).

0.287 for the mean number of leaves (NOL), 0.623 for the mean height of plant (HOP), and 0.78 for the mean area of leaf (AOL).

## 5. Conclusion

Within the seedling stages, *P. granatum* grown in seedling bags (containing 23.3 kg soil) were able to survive with NPK (15:15:15) fertilizer application in different amounts (T1 = 0 g, T2 = 1 g, T3 = 2 g, T4 = 3 g, and T5 = 4 g). The optimum amount for fertilizer application fell within the range of T3 (0.09 g NPK kg<sup>-1</sup> soil) and T4 (0.13 g NPK kg<sup>-1</sup> soil) for different parameters studied. *P. granatum* has also been employed for its several medicinal uses, some of which include the antioxidant, hepatoprotective, analgesic, anti-diabetic, antibacterial, antiobesity, antitumor, neuro-protective, and nephron-protective effects among others. Fertilizer application beyond these concentrations resulted to growth reductions, which were captured as negative (-ve) values on the Ochekwu Comparative Treatment Average (OCTA) trend, and therefore would not be of economic benefit.

## Data Availability

The data used to support the findings of this study are included within the supplementary information file.

## Conflicts of Interest

The authors declare that they have no conflicts of interest.

## Supplementary Materials

Information about the means and standard deviation of different treatments are given in the supplementary table. (*Supplementary Materials*)

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