Improving Peanut (*Arachis hyphogaea* L.) Productivity by Optimizing Nitrogen and Potassium Fertilization

Abstract

Due to their high nutritious, peanuts (*Arachis hyphogaea* L.) are a popular kind among consumers. For growth and productivity, peanut plants need vital nutrients including N, P, K, Ca, Mg and K. P is especially necessary for the development of blooms, pods, and seeds. A 2 × 4 factorial design was employed in the study, and it was repeated three times. Factor II consists of P fertilizers(SP36: 36 % P_2O_5), specifically 0, 50, 100, and 150 kg P_2O_5/ha. Factor I sources of N are NO_3^- (potassium nitrate) and NH_4^+ (ammonium sulfate). The criteria that were observed were the amount of chlorophyll in the fifth leaf from the tip of the plant, NR activity, yield of the peanut pod, height of the peanut plant, and biomass of the peanut.The nitrogen source treatment has a major impact on ANR levels, yield, plant height, and chlorophyll. There is a greater interaction when using nitrate as a N fertilizer. Higher P_2O_5 NR yields, P up to 150 kg, Chlorophyll, height of peanut plants, peanut biomass, and yield of peanut pods are observed. Similarly, increased application of N fertilizer (ammonium, P up to 150 kg P_2O_5) results in higher NR yields. Height of the peanut plants, biomass, yield of the peanut pods, and chlorophyll.

Key words: peanut, nitrate, ammonium, phosphorus, peanut pod yield..

Introduction

Plants require phosphate minerals, which are macronutrients, in significant amounts for growth. Due to its direct involvement in nearly every biological function, phosphate is frequently referred to as the "key to life." Every living cell contains it, however seeds and growth points typically contain more of it (Khan *et al.*, 2023). The availability of nutrients, such as the element phosphate (P), influences peanut development and yield in addition to the physical state of the soil. Plants benefit greatly from the element phosphate, particularly in the areas of energy transfer, protein synthesis, coenzymes, metabolic acids, nucleic acids, and compounds (Bindrapan*et al*., 2020).

The issue that frequently arises is the phosphate content of the soil. The availability of phosphate in Indonesian agricultural soil is poor, despite the soil's nearly whole high phosphate content. Due to their high nutritious content, peanuts (*Arachis hyphogaea* L.) are a popular kind among consumers. According to Nurmi *et al*. (2023), peanuts have the following nutritional value per 100 grams: 25 grams of protein, 21 grams of carbs, 48 grams of fat, 336 mg of phosphorus, 332 mg of potassium, 184 mg of magnesium, 62 mg of calcium, and trace amounts of iron, sodium, zinc, and vitamins B, E, and K. Peanuts with seed type 3 are those of the Katana 2 variety. The benefits of this variety include resistance to bacterial wilt disease, early maturity of 87 DAP, potential yield of 4.7 tons, and good paddy field adaptation (BSIP Agriculture, 2022). Plants that produce peanuts For growth and production, soil needs vital minerals like N, P, and K, especially P for the development of flowers, pods, and seeds (Zhu *et al*., 2023). Peanut plants with a P nutritional deficit have stunted growth, pale green leaves, and low pod yields (Faza*et al.*, 2019). Both internal and exterior influences might have an impact on a plant's growth and development. Water, light, soil, and humidity are examples of external variables. Genes, anatomical structure, hormones, plant shape, and quantities of chlorophyll and other pigments are examples of internal influences. An essential metric for assessing plant growth, photosynthetic capacity, and general health is chlorophyll. Purbajanti*et al.* (2019) state that because leaf chlorophyll levels are correlated with plant conditions, it is possible to utilize them to estimate the amount of additional fertilizer that plants require. One technique to gauge plant growth and fertility, which may then be connected to forecasts of plant yield, is to measure the amount of chlorophyll.Phosphoric nutrients can be applied to peanut seeds to promote their growth and development (Arista et al, 2015). Peanuts grow to lower heights, with little, pale green leaves and tiny pods, and produce very low yields due to phosphorus deficiency (Rahman *et al*., 2019). Phosphate increases the amount of fat in seeds and is essential for the process of cell formation. The weight of one hundred seeds demonstrates how the variety and capacity of plants for photosynthesis affect the quality of seeds (Suntoro*et al.*, 2017).In agronomy, the idea of essential N concentration is frequently utilized to diagnose N plant health and distinguish between circumstances involving suboptimal and supraoptimal N supply. Several physiological processes in plants are regulated, which affects the link between N and biomass accumulation in plants. N intake, plant C assimilation and consequent growth rates, and the distribution of C and N among organs and plants are some of these activities. Plant uptake of N under Suboptimal Supply N is dependent on the distribution and availability of N-mineral soil as well as the distribution of roots. When there is an adequate supply of nitrogen, a plant's ability to absorb nitrogen is mostly determined by its internal regulation of growth (Xia *et al.*, 2023). In plants with low root elongation rates, mature leaves receive about 70% of the N absorbed; in plants with high root elongation rates, this percentage is just 35%. It was evident that N absorption and allocation affected the activity of root growth. Plants with low levels of root elongation allotted a modest quantity of N to their adult leaves, but plants with high levels of root elongation allocated much more N to their adult leaves. Given that low-level elongation roots may be adult leaves and are supplied by mobilization from other parts, it is now probable that N is required to promote adult leaf growth (Han*et al*., 2023). According to Shi-cheng*et al*. (2021), most plants grow similarly in both N sources at the low end of the N scale, or provisions. Nevertheless, among plants that have evolved in NH_4-rich environments, there are a few noteworthy outliers to this general pattern. The purpose of this study was to determine how fertilizer combinations including N and P affected the growth and yield of peanuts.

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Materials and Methods

The study was conducted in the laboratory of Ecology and Plant Production, Faculty of Agriculture and Animal Husbandry, Diponegoro University, during the dry season (August to December) in 2022. The research station is located at 6° 58' 0" SL 110° 25' 0" EL, and has Oxisol soil with a clay texture, a soil pH of 6.5, 0.18% total N content, 0.15% total P, 0.24% total K, and 1.09% C. Katana2 peanut varieties were used, and the study was carried out using 24 experimental plots measuring 1.5 × 1 m^2, with a spacing of 30 × 20 cm so that each plot contained 16 plants. The research used a 2 × 4 factorial design that was repeated three times.

Factor I : sources of N (NO_3- (potassium nitrate) and NH_4^+ (ammonium sulfate)

Factor II : P fertilizers(SP36: 36 % P_2O_5), namely 0, 50, 100, and 150 kg P2O5/ha.

Each plant was fertilized with manure at 2 tons per hectare and K at 25 kg KCl per hectare. Micronutrients were administered in the form of approximately 5 ml of liquid fertilizer dissolved in 1 L of water and sprayed onto the plants 1 wk after planting.Fertilize P (SP 36) according to the dose, while N fertilizer required is 50 kg N per hectare.The chlorophyll content of the fifth leaf from the tip of the plant, NR activity, peanut pod yield, and peanut plant height and peanut biomass were determined. Chlorophyll content was measured in fresh leaf samples. Leaf samples (0.5 g) were homogenized with acetone (90% v/v), filtered, and made up to a final volume of 50 mL. Chlorophyll concentration was calculated based on the absorbance of the extract measured by a spectrophotometer 645 UV/Vis and 666 UV/Vis (Rajalakshmi and Banu, 2015). Analysis of NR activity was performed according to the methods used by Krywult and Bielec, 2013. The third leaves of peanut plant shoots were harvested between 9 and 10 a.m. and used for further observation. The leaves were washed with distilled water and finely sliced, and 200 mg of the leaf sample was added to 5 ml NaH_2PO_4 and $NaHPO_4$ buffer solutions at pH 7.5 in dark tubes that were covered and maintained for 24 h, after which the buffer solution was replaced with 5 mL of fresh buffer solution. Next, 0.1 mL of 5 M $NaNO_3$ was added to every dark tube. The time of addition of $NaNO_3$ was designated the 0-incubation point, and samples were incubated for 2 h. Meanwhile, another test tube was filled with 0.2 mL 1% sulfanilamide reagent, which was dissolved in 3N HCl and 0.2 mL 0.02% napthylethylendiamide. Then 0.1 mL of the filtrate incubated for 2 h was placed in a test tube containing the sulfanilamide reagent, HCl, and a napthylethylendiamide solution. The test tubes were agitated to mix the filtrate and accelerate the reaction, and allowed to stand for 15 min; this resulted in the reduction of NO_2 with dye reagents to bring up the pink color. Next, 2.5 ml distilled water was added to the test tube as a color diluent. The absorbance of this solution was measured at a wavelength of 540 nm.

Data Analysis

The data were analyzed using ANOVA. If the ANOVA revealed a difference, the analysis was followed by Duncan's multiple range test 5 % as described by Gomez and Gomez,1984.

Result and Discussion

Result

The Effect of N form (NO_3^- and NH_4^+)

NR decreased by 16.20% for the use of NH_4 compared to NO_3. The chlorophyll content of peanut leaves with N form NH_4 decreased 19.26% compared to the NO_3 form. Likewise, plant height decreased by 9.07% when using NH_4 compared to NO_3. The use of ammonium form of nitrogen resulted in biomass decreasing by 110.77% and pod weight decreasing by 23.67%.

The effect phosphor dosages

The NR of peanuts with a P dose of 100 kg P_2O_5 increased by 23.00% and P with a P dose of 150 kg P2O5 increased by 26.82% compared to a P dose of 50 kg P_2O_5. The results of the chlorophyll content increased by 6% when using a P dose of 100 kg P_2O_5, also increased by 43.87% when using P fertilizer of 150 kg P_2O_5 compared to a P dose of 50 kg P_2O_5. This pattern also occurred in plant height, biomass yield and pod weight. Plant height increased by 8.18% because P fertilizer increased from 50 kg P_2O_5 to 100 kg P_2O_5, while it increased by 25.83% because P fertilizer increased from 50 kg P_2O_5 to 100 kg P_2O_5. Peanut biomass yield also increased by 32.03% due to the use of a P dose of 100 kg P_2O_5, and increased by 79.65% due to the use of a P dose of 150 kg P_2O_5 compared to a P dose of 50 kg P2O5.

The Effect of Interaction

If you use N fertilizer in the form of nitrate, the higher the P fertilizer, up to 150 kg P_2O_5, the NR yield will be higher, likewise, if you use N fertilizer in the form of ammonium, the higher the P fertilizer, up to 150 kg P_2O_5, the higher the NR yield (Figure 1).

Use of P fertilizer up to 150 kg P_2O_5 and nitrate fertilizer together resulted in an increase in chlorophyll content. Meanwhile, the application of a mixture of P and ammonium fertilizers up to 150 kg P_2O_5 resulted in an increase in the chlorophyll content (Figure 2). In terms of plant height metrics, the use of P 100 kg P_2O_5 in conjunction with nitrate fertilizer and P fertilizer caused peanut plant height to grow; this combination did not differ significantly from that of P 150 kg P_2O_5 and nitrate fertilizer. In comparison to the combinations of ammonium fertilizer and P 50 kg P_2O_5 and P 100 kg P_2O_5, the combination of ammonium fertilizer and P 150 kg P_2O_5 produced the plants with the highest height (Figure 3).

The usage of nitrate and P fertilizer up to 100 kg P_2O_5, which is not substantially different from the combination of nitrate and P up to 150 kg P_2O_5, has led to an increase in biomass characteristics. In contrast to the combinations of ammonium and P fertilizer up to 100 kg P_2O_5 and manure and P fertilizer up to 50 kg P_2O_5, the combination of ammonium and P fertilizer up to 150 kg P_2O_5 has the highest biomass output (Figure 4).

In comparison to the combinations of nitrate fertilizer and P fertilizer up to 50 kg P_2O_5 and nitrate fertilizer and P fertilizer up to 100 kg P_2O_5, the combination of nitrate fertilizer and P fertilizer up to 150 kg P_2O_5 produced the highest pod weight result. When ammonium and P fertilizer are combined, the pod weight yield is often lower than when nitrate and P fertilizer are combined (Figure 5).

Discussion

Sampara*et al*. (2023) reported that the availability of nutrients encourages the division of meristem cells in plants, which in turn leads to an increase in height. This suggests that the tendency for plant height to increase is influenced by these nutrients. Nitrogen, a macronutrient necessary for the synthesis of the amino acids that make up proteins, is necessary for plant growth. Furthermore, a number of genes' expression is regulated by the presence of nitrogen (Wang *et al*., 2020). The primary enzyme in tissues that actively performs photosynthesis is called nitrate reductase (NR) (Purbajanti*et al*., 2019). This enzyme plays a crucial part in the initial steps of amino acid synthesis. Yanagisawa (2014) states that nitrates in the leaves stimulate the activity of NR biosynthesis, which is dependent on the availability of nitrogen nutrients in the medium. Chlorophyll levels are another factor linked to nitrogen metabolism. NR will convert nitrate, a source of nitrogen, to ammonium (NH_4). The synthesis of glutamine from glutamate requires NH_4; the presence of 2-oxoglutarat increases glutamate, which is essential for the synthesis of several significant amino acids that are components of proteins, including chlorophyll (Purbajanti*et al*., 2019). Plant photosynthetic rate will increase with full solar intensity and large fertilizer dosages (Purbajanti*et al*., 2009). Nitrate reductase, which is utilized in the respiration process, is dependent on the availability of carbohydrates from photosynthesis. Such an ANR pattern on leaf strands is produced by the combination of treatments applied for 45 days in this study.This is due to regulation of activation of NR in the cytosol, among others, determined by numerous parameters, including light, CO2 levels and availability of NADH /

NAD (Broadley *et al.*, 2012). The availability of carbon frames and the rates of photosynthesis are highly correlated with NR activity. Light can boost NR activity, and NO3-inducing NR gene transcription occurs (Berger *et al.*, 2020).

Chlorophyll reveals that peanut plants have higher nitrogen content, which is also used to make chlorophyll. Through the mechanisms of transcription and translation, nutrient N has a variety of roles in the metabolic process, controlling the expression of multiple genes that produce proteins in high-level plants and algae while also preserving the stability of mRNA (Martins *et al.*, 2023). PEP-Case, nitrate reductase (NR), nitrite reductase (NiR), light harvesting complex protein (LHCP), proteins regulating vegetative growth, and chlorophyll a/b are among the proteins in discussion.

With the formulas $y = 0.9135x - 7.7415$ ($R^2 = 0.975$) for the nitrate form of N source and $y = 1.8323x - 91.568$ ($R^2 = 0.4742$) for the ammonium form of N source, the activity of nitrate reductase and peanut pod yield have a positive association. The study's findings demonstrated that phosphate fertilizer application significantly impacted the biomass of peanut plants. the pod weight for each plant in each plot. When coupled with ammonium and nitrate, 150 kg of P2O5 phosphate fertilizer had the best outcomes when compared to other lesser doses. Every stage of a plant's life is significantly impacted by the application of phosphate fertilizer.
This is in line with the findings of Pasaribu*et al*. (2014), which claim that phosphate is essential for multiple processes in the plant body, including: (1) cell division, the synthesis of fat and albumin; (2) the development of flowers, fruit, and seeds; (3) plant maturity, which mitigates the effects of nitrogen; (4) stimulation of root development; (5) improvement of crop yield quality; and (6) resistance to pests and diseases. This demonstrates that by enhancing the chemical characteristics of the soil, P fertilizer can affect the generative phase of peanut plants.

Conclusion

The nitrogen source treatment has a major impact on ANR levels, yield, plant height, and chlorophyll. The interaction between the use of pupuk N bentuk nitrate as low as 150 kg P2O5, the results of NR becoming low, chlorophyll, the height of the peanut plant, peanut biomass, and the yield of the peanut pod. Additionally, the use of pupuk N bentuk ammonium was found to be as high as 150 kg P2O5, as well as high levels of chlorophyll, peanut plant height, peanut biomass, and peanut pod yield.

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 the writing or editing of this manuscript

REFERENCES

Arista, D. ,Suryono, and Sudadi.2015. Effect of N, P and K Fertilizer Combinations to Growth and Yield of Peanut on Alfisols Dry Land .Agrosains 17(2): 49-52, 2015.

BSIP. Pertanian.2022.http: //banten.bsip.pertanian.go.id

Berger,A, A,Boscari ,N. H.Araújo, M. Maucourt, M.Hanchi, S. Bernillon,D.Rolin,A. Puppo,and R.Brouquisse. 2020.Plant Nitrate Reductases Regulate Nitric Oxide Production and Nitrogen-Fixing Metabolism During the *Medicago truncatula–Sinorhizobiummeliloti* Symbiosis. Front. Plant Sci., 04 September 2020. Sec. Plant Pathogen Interactions. Vol. 11 - 2020 | https://doi.org/10.3389/fpls.2020.01313

Bindraban, P.S., Dimkpa, C.O. and Pandey, R..2020. Exploring phosphorus fertilizers and fertilization strategies for improved human and environmental health. *Biol Fertil Soils* **56**, 299–317 (2020). https://doi.org/10.1007/s00374-019-01430-2

Broadley,M., P.Brown , I.Cakmak , Z. Rengel, and F. Zhao. 2012.Chapter 7 - Function of Nutrients: Micronutrients. InMarschner's Mineral Nutrition of Higher Plants (Third Edition)

2012, Pages 191-248. https://doi.org/10.1016/B978-0-12-384905-2.00007-8.

Faza, D. A. , D. R. Lukiwati, and Karno. 2019. Growth and production of peanut (Arachis hypogaea l.) by vesicular-arbuscular mycorrhizal fungi inoculation and phosphorus fertilization. J. Agro Complex 3(1):48-54, February 2019 DOI: https://doi.org/10.14710/joac.3.1.48-54

Gomez**,** K.A. and Gomez, A.A**.** **(**1984**).**Statistical Procedures for Agricultural Research. 2nd Edition, John Wiley and Sons, New York, 680 p.

Han,F., R. Guo, S.Hussain, , S. Guo, T. Cai, P. Zhang, Z. Jia, M. A.Naseer, M.Saqib, X. Chen, and X. Ren. 2023.Rotation of planting strips and reduction in nitrogen fertilizer application can reduce nitrogen loss and optimize its balance in maize–peanut intercropping. European Journal of Agronomy 143 (2023) 126707. https://doi.org/10.1016/j.eja.2022.126707.

Khan,F., A. B.Siddique, S.Shabala, M. Zhou, and C.Zhao.2023.Phosphorus Plays Key Roles in Regulating Plants' Physiological Responses to Abiotic Stresses. Plants (Basel). 2023 Aug; 12(15): 2861. Published online 2023 Aug 3. doi: 10.3390/plants12152861

Krywult, W. and D. Bielec. 2013. Method of measurement of nitrate reductase activity in field conditions. J. Ecological Engineering, 14(1): 7-11

Martins, T., A.N. Barros, E. Rosa, and L.Antunes.2023.Enhancing Health Benefits through Chlorophylls and Chlorophyll-Rich Agro-Food: A Comprehensive Review. Molecules. 2023 Jul; 28(14): 5344. doi: 10.3390/molecules28145344

Nurmi, A. Azis, and S. B. Mooduto.2023.Growth and Yield of peanut plants (Arachis hypogaea, L) with the Application of organic fertilizer from husks charcoal and chicken manure JurnalProduksiTanaman Vol. 11 No. 10, Oktober 2023: 786 – 792 ISSN: 2527-8452 http://dx.doi.org/10.21776/ub.protan.2023.011.10.07

Pasaribu,P.K., A. Barus, Mariati. 2014. Growth and Production of Peanuts (Arachis hypogaea L.) with Cow Manure and Phosphate Fertilizer Application. Jurnal Online Agroekoteknologi . Vol.2, No.4 : 1391 - 1395, September 2014.

Purbajanti, E.D., R.D.Soetrisno, E.Hanudin and S.P.S.Budhi. Photosynthesis and yields of grasses grown in saline condition. J.IndonesianTrop.Anim.Agric. 35(1) March 2010.

Purbajanti,E.D., W. Slamet and E. Fuskhah. 2017. Nitrate reductase, chlorophyll content and antioxidant in okra (Abelmoschus esculentus Moench) under organic fertilizer. Journal of Applied Horticulture, 21(3): 213-217, 2019

Rajalakshmi, K. and N. Banu, 2015. Extraction and estimation of chlorophyll from medicinal plants. International J. of Science and Research, 4(11): 209-212.

Rahman, N., Suntoro, and Sekya, A. T. (2019). Peanut Growth and Gynophore Formation on Boron and Phosphor Applications. Sains Tanah Journal of Soil Science and Agroclimatology, 16(1): 57-66 (doi: 10.20961/stjssa.v16i1.25372)

Sampara,S., S. Syamsia, A. Idhan, Rosanna,and I. Mado.2023. Growth and production of peanuts (arachis hypogaea l) at various doses of organic pottasium and liquid organic fertilizer. J. Agroplantae, Vol.12 No.2 (2023) September: 181 – 191. DOI: https://doi.org/ 10.51978/agro.v12i2.695

Shi-cheng,Z., L. Ji-long, X. Xin-peng, L. Xiao-mao, L. M. Rosso, .Shao-jun, I. Ciampittiand H. Ping. 2021. Peanut yield, nutrient uptake and nutrient requirements in different regions of China. Journal of Integrative Agriculture 2021, 20(9): 2502–2511. doi: 10.1016/S2095-3119(20)63253-1.

Suntoro, J. Syamsiyah, and W. Rahina.2017.Availability and Uptake of Ca in Peanuts in Alfisols Soils Treated with Kelud Volcanic Ash and Manure.Agrosains 19(2): 51-57, 2017

Wang X B, Liu W X, Li Z G, Teng Y, Christie P, and Luo Y M. 2020. Effects of long-term fertilizer applications on peanut yield and quality and plant and soil heavy metal accumulation. Pedosphere. 30(4): 555–562. doi:10.1016/S1002-0160(17)60457-0

Xia, G., Y. Wang, J. Hu, S. Wang, Y. Zhang, Q. Wu, and D. Chi. 2021. Effects of Supplemental Irrigation on Water and Nitrogen Use, Yield, and Kernel Quality of Peanut under Nitrogen-Supplied Conditions. AgriculturalWaterManagement243(2021)106518. https://doi.org/10.1016/j.agwat.2020.106518.

Yanagisawa, S., 2014. Transcription factors involved in controlling the expression of nitrate reductase genes in higher plants. Plant Science. Vol. 229, December 2014, Pages 167-171. https://doi.org/10.1016/j.plantsci.2014.09.006

Zhu, L., N. Zhen-wu, L.Song-ming, Y.Hai-qiu, X. Li-yong, M. Wei-wei, Z. Zheng, and W. Shu-bo. 2023. Millet/peanut intercropping at a moderate N rate increases crop productivity and N use efficiency, as well as economic benefits, under rain-fed conditions. Journal of Integrative Agriculture 2023, 22(3): 738–751. doi: 10.1016/j.jia.2022.08.078.

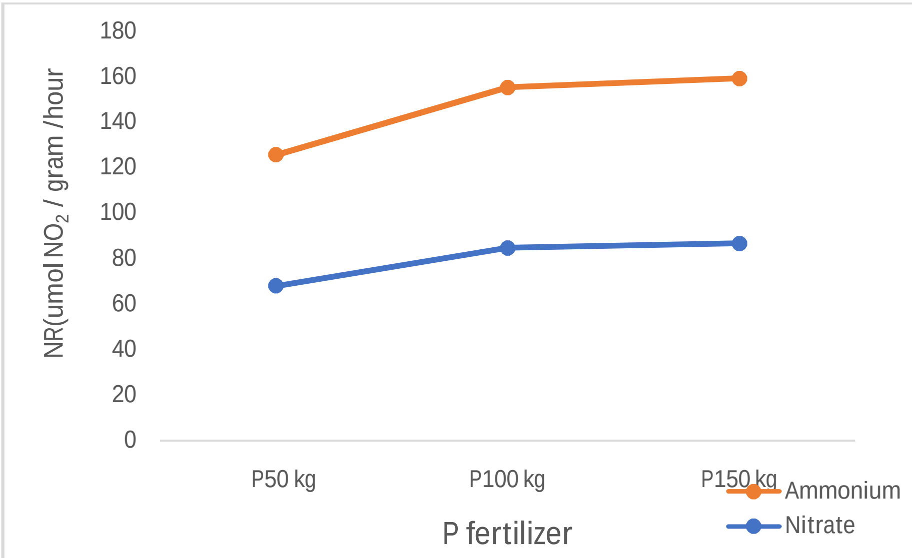

Figure 1. NR activity peanut plant

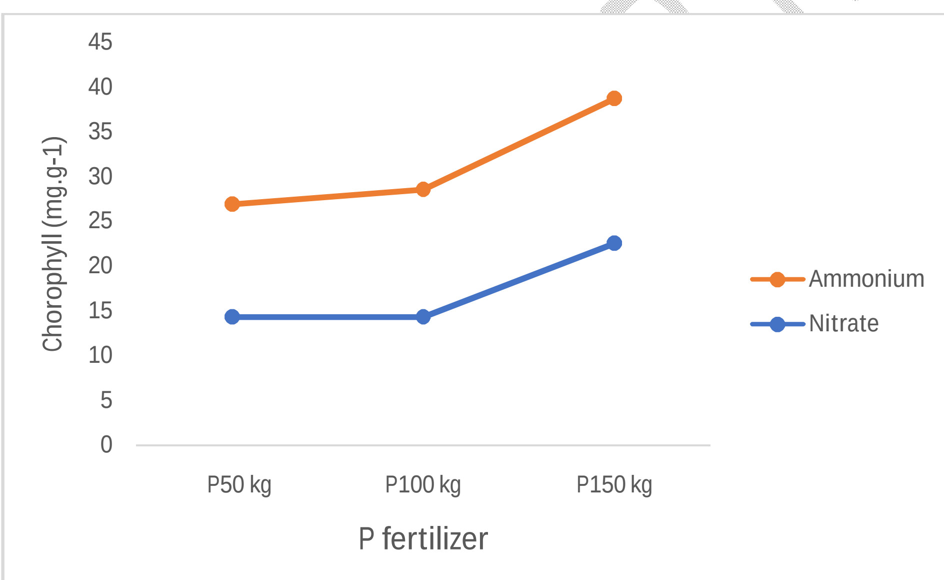

Figure 2. Chlorophyll content in peanut plants due to interactions between nitrogen sources and Phosphorus fertilizer

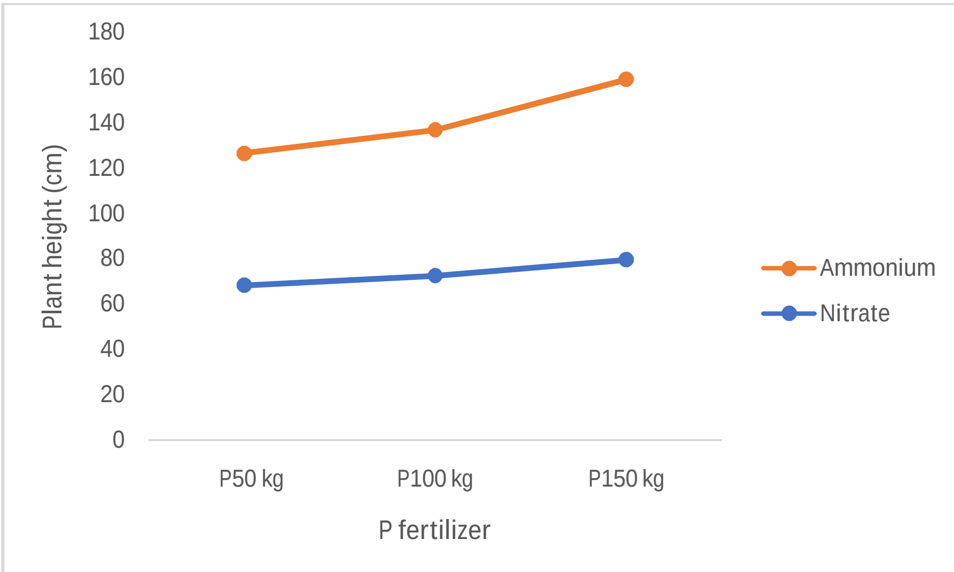

Figure 3. Peanut plant height due to interactions between nitrogen sources and Phosphorus fertilizer

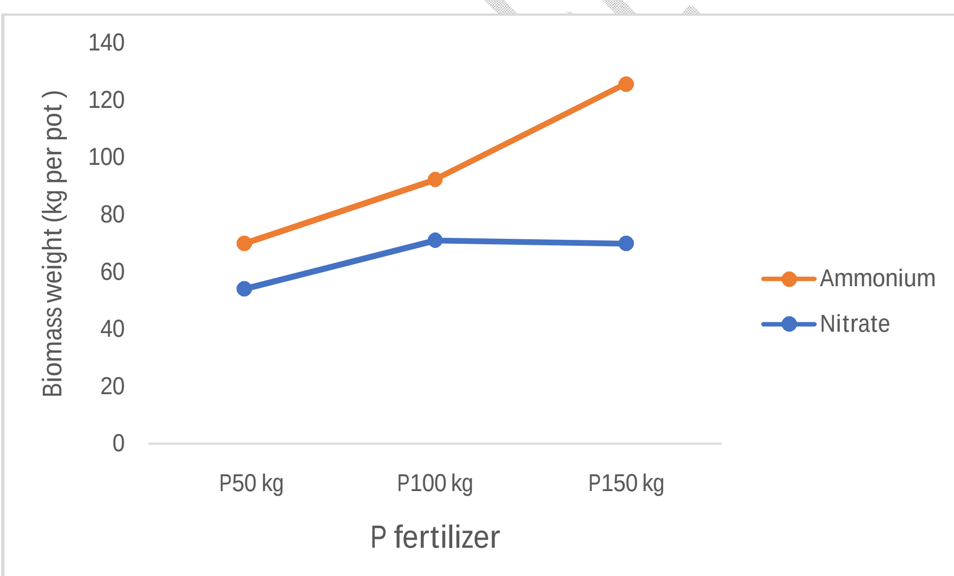

Figure 4. Weight of peanut plant biomass due to interactions between nitrogen sources and Phosphorus fertilizer

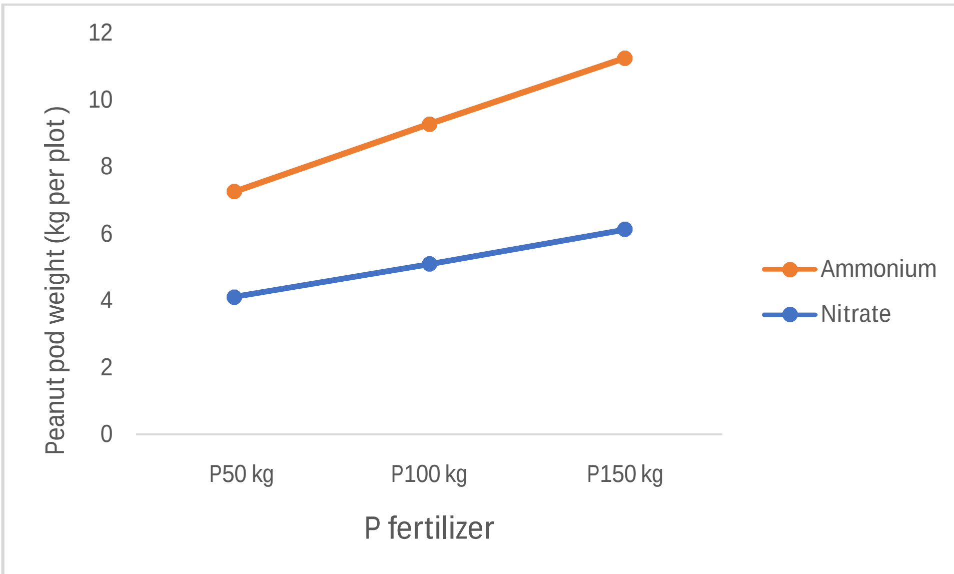

Figure 5. Peanut pod yield due to interactions between nitrogean sources and Phosphorus fertilizer