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The effect of different concentrations of inorganic fertilizer on vegetative growth of groundnut (*Arachis hypogea* L.)

Isyaku Ibrahim Muhammad, Aisha Wada Abubakar, Anas Hamisu, Abubakar Iliya and Syed Khalil Ullah

Isyaku Ibrahim Muhammad
Department of Botany, School of Bioengineering and Bioscience, Lovely Professional University, Phagwara, Punjab, India

Aisha Wada Abubakar
Department of Biological Sciences, Federal University Dutse, P.M.B. 7156, Dutse Jigawa State, Nigeria

Anas Hamisu
Department of Botany, School of Bioengineering and Bioscience, Lovely Professional University, Phagwara, Punjab, India

Abubakar Iliya
Department of Biotechnology, School of Bioengineering and Bioscience, Lovely Professional University, Phagwara, Punjab, India

Syed Khalil Ullah
Department of Bioinformatics and Bioscience, Faculty of Health and Life Sciences, Capital University of Science and Technology, Islamabad, Pakistan

Correspondence
Isyaku Ibrahim Muhammad
Department of Botany, School of Bioengineering and Bioscience, Lovely Professional University, Phagwara, Punjab, India

Abstract
A field study was conducted at the Botanical Garden of the Biological Sciences Department, Federal University Dutse, to assess the impact of varying concentrations of single super phosphate fertilizer on Groundnut (*Arachis hypogea* L.). The study included four treatment levels of single super phosphate: 0 g P/polythene bag (SSP1), 2.0 g P/polythene bag (SSP2), 4.0 g P/polythene bag (SSP3), and 6.0 g P/polythene bag (SSP4). The experiment followed a randomized complete design (RCD) with five replications. The results of the field study demonstrated that groundnut responded positively to all levels of single super phosphate fertilizer, and these responses were statistically significant ($p<0.05$) for all the recorded parameters. As the concentration of phosphate fertilizer increased, there was a corresponding increase in growth parameters, including fresh and dry weight, number of leaves, number of branches, number of flowers, and plant height. Notably, at 3, 4, and 5 weeks after planting (WAP), the values for plant height, number of leaves, branches, flowers, fresh and dry weight obtained in SSP2, SSP3 and SSP4 were significantly better than the control group (SSP1), which as depicted in table 3, 4, 5, 6, 7 and 8 respectively. However, SSP4 recorded the highest value for all the assessed parameters, which were significantly different from the control treatment. In conclusion, the study suggests that a single super phosphate fertilizer at a rate of 6.0 g/polythene bag is suitable for promoting the vegetative growth of Groundnut in the study area. This fertilizer concentration led to significant improvements in plant height, number of leaves, and number of branches, which are important indicators of plant health and productivity.

Keywords: *Arachis hypogea* L. single super phosphate fertilizer, vegetative growth, fertilizer requirements

Introduction

Groundnut (*Arachis hypogaea* L.), commonly referred to as peanut, is a self-pollinating, annual tropical legume that is a member of the *fabaceae* or *Leguminoceae* family (Ntare *et al*., 2008) [27]. Worldwide, it is utilized as animal feed, food, and oilseed. Developing and underdeveloped nations are in urgent need of additional or innovative plant-based foods to adequately address the dietary requirements of their rapidly expanding populations (McClements *et al*., 2020) [15]. According to (Akubor *et al.* 2000) [2] a significant portion of the people in developing nations are malnourished. The low protein content grains are supplemented by popular legumes like cowpea, beans, and groundnuts; animal proteins, including meat, milk, and eggs, are costly and difficult to afford. However, research on these legume seed flours' desired functional qualities is crucial for their effective use and market acceptability. Groundnuts provide the majority of digestible protein (25-34%), cooking oil (44-56%), and vitamins (Thiamine, riboflavin, and niacin) for individuals in many underdeveloped nations (Savage and Keenan, 1994) [19]. Haulms, or straw stems, and groundnut cake are fed to animals in several nations. As a legume, groundnuts also increase soil fertility through fixing nitrogen, which boosts semi-arid cereal cropping systems' productivity (Islam and Noor, 1992) [12]. Nigeria's lowland regions have a great deal of potential for producing more oil crops, such groundnuts. One of the five oilseed crops that are grown extensively in Nigeria is groundnut. It is employed in the extraction of oil, provides a sizable amount of cash revenue for a number of small-scale producers, and brings in foreign exchange profits for the nation through exports (Gezahagn, 2013) [9]. Groundnut is planted in regions of Nigeria that receive rain, such as the Western and Southern regions, as well as the Irrigated regions of the Central and Eastern regions (Sulfab, 2010) [21].

Phosphorus and nitrogen are essential nutrients for peanut production. Dim soil one of the main factors limiting crop productivity in Nigeria is nitrogen. Thus, a sufficient supply of nitrogenous fertilizer is necessary for crop growth and output. Perhaps the only renewable soil fertility input available to farmers at a reasonable cost is nitrogen from rhizobium-legume symbiosis. Farmers can improve output and profitability by optimizing biological nitrogen fixing through biofertilization. Grain legumes are thought to be able to seasonally fix between 15 to 210 kgN/ha in Africa (Dakora and Keya, 1997) [6]. According to estimates made by Adlan and Mukhtar (2004) [1], the nitrogen fixed by Rhizobium, groundnut symbiosis in Sudan is estimated to account for 70% to 80% of the crop's nitrogen requirements. Since native Rhizobia were unable to meet groundnut's whole nitrogen requirements, inoculating the plant with effective competitive Rhizobia was thought to be advantageous (Hadad *et al*., 1986) [29]. Similar to this, it was proposed that low nodulation and competition from native, inefficient strains were the causes of India's low groundnut yield (Basu and Bhadoria, 2008) [4]. In order to have a robust root system and abundant nodulation, which can impact the ability for nitrogen gas fixation, phosphorus is basically necessary for healthy growth (Kawari, 2005) [13]. Because there is not enough readily available soluble phosphate in the soil, phosphorus is thought to be a limiting element in plant nutrition (Uma Maheswar and Sathiyavani, 2012) [23]. On the other hand, phosphobacterium is a type of bacterium that solubilizes phosphate and can change the unavailable phosphate in the soil into an accessible form. Phosphate solubilizing bacteria have been used as inoculants to boost symbiotic nitrogen fixation (Dametario *et al*., 1972) [7], improve nodulation (Ghosh and Poi, 1998) [24], and increase P uptake by plants (Rodriquez and Fraga, 1999) [18]. El Hassan *et al*. (2010) [8] analysed responses to inoculation in research studies conducted in Sudan and conclusively shown that inoculation is warranted for a variety of legumes in the country.

The growth and yield of crops are contingent on the provision of essential mineral nutrients, which are typically supplied through the application of fertilizers. Fertilizers can be broadly classified into two categories: organic and inorganic. In the context of enhancing crop productivity, inorganic fertilizers have received considerable attention, and there have been numerous reports highlighting their effectiveness in promoting crop growth and increasing yields. This suggests that there is a discernible preference for inorganic fertilizers due to their demonstrated positive impact on crop performance.

It is worth noting that different crops may exhibit varying degrees of responsiveness to the type of fertilizer applied. In this regard, there appears to be a level of specificity in the adaptation of crops to particular fertilizer types, which plays a crucial role in optimizing their growth and yield potential. This concept is underscored by research conducted by (Nweke *et al*., 2013 [17], which underscores the importance of tailoring fertilizer choices to specific crops to maximize their agricultural productivity. It is in view of this that this investigation was conducted to study the response of groundnut to phosphate fertilizer levels in Federal University Dutse, North West Nigeria.

Materials and Methods

Experimental Site: The field experiments were conducted at botanical garden of Federal University Dutse. Dutse is a city located in North-western part of Nigeria, it lies within latitude of 11^{o} 42'22.25"N to a longitude of 9^{o} 20'20.26"E. The area is characterized with undulating topography and hilly walls. The inhabitants of Dutse are predominantly farmers.

Meteorological Data

Data on rainfall, temperature and relative humidity were determined in the study area for the purpose of this study. This was determined using rain gauge, thermometer and anemometer.

Soil Characteristics

Soil samples were taken from several spots at depth of 0-30cm and bulked together. However, prior to phosphorus fertilizer application, the physico-chemical properties which include Soil texture, available phosphorus P, total nitrogen N, pH, organic carbon and exchangeable ions were analyzed in the department of soil science Federal University Dutse.

Experimental design

A Randomized Complete Design (RCD) with four treatments and five replications for the experiment were used. Polythene bags were filled to ¾ with the soil and watered before planting. The polythene bag were separated from one another by a distance of 40 cm. Individual rows were separated from one another by 50 cm.

Seed Sowing/Planting

The seeds were sown with hand to a depth of about 3cm. Three seeds per stand were sown and thinned to two seed per stand at 21 days after planting (DAP) given a plant population of 12-plants per each row. The seeds were collected from Kano state Agricultural and Rural Development Authority (KNARDA).

Fertilizer Application

The single super phosphate fertilizer (SSP) was applied on the groundnut plant, planted in polythene Bag. The fertilizer requirement of groundnut is 200 kg/hectare as this gives maximum growth and yield. The single super phosphate fertilizer was quantitatively measured. However, to meet the SSP requirement of the groundnut plant, the following calculations were made. If 200kg of SSP is required per hectare then, 6.0g of SSP is required per 0.3m^2 which is the area of the polythene bag. To meet the proportion in the treatment, the weight of the SSP were varied as follows;

The treatments were consisted four levels of single super phosphate fertilizer as follow:

1. Level of single super phosphate fertilizer (SSP1) at 0.0 g (i.e control)
2. Level of single super phosphate fertilizer (SSP2) at 2.0 g
3. Level of single super phosphate fertilizer (SSP3) at 4.0 g
4. Level of single super phosphate fertilizer (SSP4) at 6.0 g

Management Practices

Soil was placed inside polythene bags after the land had been cleared. Two weeks following planting, the ring method was used to apply the single super phosphate fertilizer levels to their corresponding rows. Two weeks after germination, each polythene bag received a blanket treatment of 4.0 g of urea in order to boost the crops' vegetative growth (ring method). The soil used in the drought stress experiment was filled with a polythene bag and continually irrigated until it reached maturity. The surface was weeded three times by hand.

Data Collection

Crop Parameters

Plant height: The height from the ground level to the highest point of the 3 tagged plants was measured at 3, 4 and 5 weeks after planting with a meter rule and the average was calculated.

Number of leaves

The number of leaves of the 10 tagged plants was counted and recorded at 3, 4, and 5 weeks after planting.

Number of flowers

The number of flowers of the 10 tagged plants was counted and recorded at 3, 4, and 5 weeks after planting.

Number of branches

The number of branches of the 10 tagged plants was counted and recorded at 3, 4, and 5 weeks after planting.

Shoot fresh weight

At 5, 6 and 7 weeks after planting the shoot of groundnut of each treatments from the soil level was cut and weight using a digital electronic weighing balance and recorded.

Shoot dry weight

At 5, 6, and 7 weeks after planting the dry weight of each shoot cuts was determined using electronic weighing balance after it was sun dried for seven (7) days and recorded.

Data analysis

The data were analyzed using Analysis of variance (One way ANOVA) using graph pad prism. Treatment were separated using least significance Differences (LSD) at 5% level of probability.

Result and Discussions

Meteorological Data

The table below shows the Meteorological data obtained during the period of trial

Table 1: Meteorological Observation during Dry Season at FUD, 2017.

Months	June	July
Rainfall	100mm	600mm
Temperature	28.2 °C	26.2 °C
Relative humidity	8.00	13.00

Soil analysis

The experimental site's sandy-loam soil is revealed by the soil analysis results, which are displayed in Table 2. The primary nutritional elements are present in low amounts and the soil has an acidic pH. It was found that vital plant nutrients were missing from the research area's soil. Ibedu *et al*. (1988) [11] established standards for evaluating soil fertility, and soil that has less than 0.20% N, 25.0 ppm P, exchangeable K of 0.40 mg/100 g, and exchangeable Mg of 3.0 mg/100 g is considered deficient in these nutrients. As a result, it was discovered that the experimental site's soils had these vital plant nutrients at amounts below the recommended levels, making them impoverished in these nutrients (Table 2). Major plant nutrients were discovered to be in poor condition in the research area's soil. As per the standards set forth by Ibedu *et al*. (1988) [11] for evaluating soil fertility, soil that has less than 0.20% N, 25.0 ppm P, 0.40 meg/100 g of exchangeable K, and 3.0 meg/100 g of exchangeable Mg is considered deficient in these nutrients. Thus, it was discovered that the trial site's soils had lower concentrations of these vital plant nutrients than the allowed limits, making them poor in these nutrients.

Table 2: Physico-chemical Properties of Soils of the Experimental site at FUD, 2017.

Soil composition	Physico-chemical	Properties
PH in water	5.87	Slightly acidic
Organic carbon	0.57%	Low O and C
Total Nitrogen	0.46%	Low N
Cation Exchange Capacity	5.2	Low CEC
Electric Conductivity	5.2	
Sodium Na	0.002	
Phosphorous P	0.4	
Magnesium Mg	0.005	

Plant Height (cm)

With all amounts of applied phosphate fertiliser (i.e., 2.0 g/polythene bag, 4.0 g/polythene bag, and 6.0g/polythene bag), a single super phosphate (18% P_2O_5) application markedly enhanced the values of plant height assessed at 3, 4, and 5 weeks after planting. However, 6.0g (SSP4) showed the highest plant height value, which was roughly 6.69 cm. Yet, as tables 3 and figure 1 demonstrate, the plant height values acquired in SSP2 and SSP3 at 3WAP were statistically comparable and considerably greater than the control.

Table 3: The Effect of Single Super Phosphate Fertilizer on plants Height (cm) of Groundnut grown at FUD Botanical garden during rainy season in 2017.

Treatments	Average mean ± standard deviation		
	3WAP	4WAP	5WAP
SSP1	2.32±0.43	2.69±0.43	3.29±0.45
SSP2	3.18±0.36*	3.59±0.36*	3.99±0.48*
SSP3	3.89±0.44*	4.19±0.44*	4.80±0.59*
SSP4	5.21±1.03**	5.62±1.37**	6.69±1.30**
P-value (5%)	0.0001		
F-test	30.01		

Means within each column with * are significantly different as compared with Control (SSP1) using graph pad prism at $p<0.05$ level

Key

SSP1 (Control) = 0.0 g p/polythene bag

SSP2 = 2.0g p/polythene bag

SSP3 = 4.0g p/polythene bag

SSP4 = 6.0g p/polythene bag

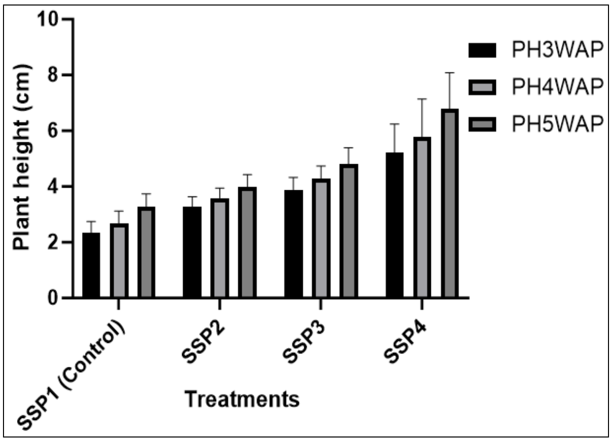

Fig 1: Effect of SSP fertilizer on plants height

Number of Leaves

With the application of a single super phosphate fertilizer (18% P_2O_5) and all three levels of phosphate fertilizer (2.0g/polythene bag, 4.0g/polythene bag, and 6.0g/polythene bag), the number of plant leaves counted at 3, 4, and 5WAP greatly increased. The plant with the greatest number of leaves (81.70) at five weeks after planting was 6.0g (SSP4). On the other hand, as table 4 and figure 2 show, the quantity of leaves obtained in SSP2 and SSP3 at 3WAP were statistically distinct and significantly better than the control. The outcome additionally demonstrated that the values rise when the phosphate level increases at a faster rate.

Table 4: The Effect of Single Super Phosphate Fertilizer on the Number of leaves of Groundnut Grown at FUD Botanical garden during dry season in 2017.

Treatments	Average mean ± standard deviation		
	3WAP	**4WAP**	**5WAP**
SSP1	25.0±7.01	31.8±6.87	36.60±6.87
SSP2	47.8±10.0*	53.4±9.13*	58.10±8.32*
SSP3	55.6±2.70**	61.5±2.30**	66.30±2.50**
SSP4	56.4±7.54**	62.1±7.05**	81.70±4.80**
P-value (5%)	0.0001		
F-test	1063		

Means within each column with * are significantly different as compared with Control (SSP1) using graph pad prism at p<0.05 level

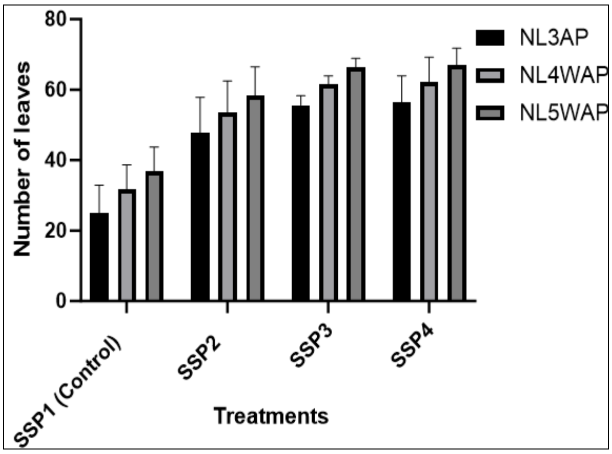

Fig 2: Effect of SSP fertilizer on number of leaves

Number of Branches

A single super phosphate (18% P_2O_5) application, with all amounts of applied phosphate fertilizer (2.0 g/polythene bag, 4.0 g/polythene bag, and 6.0 g/polythene bag) significantly enhanced the number of branches counted at 3, 4, and 5 weeks after planting. The maximum number of branches (16.80) was observed by 6.0 g (SSP4) five weeks after planting. However, the amount of leaves collected at 3WAP for SSP2 and SSP3 was significantly higher than the control and statistically similar (table 5 and figure 3). The outcome also demonstrates that the values rose as the rate of phosphate level increase increased.

Table 5: The Effect of Single Super Phosphate Fertilizer on the Number of Branches of Groundnut Grown at FUD Botanical garden during dry season in 2017.

Treatments	Average mean ± standard deviation		
	3WAP	**4WAP**	**5WAP**
SSP1	5.80±0.84	8.0±0.00	9.0±1.00
SSP2	10.0±2.34*	11.60±3.91*	13.4±2.07*
SSP3	12.8±1.79**	14.90±1.82**	15.6±1.51**
SSP4	13.8±2.17**	16±1.87**	16.8±1.48**
P-value (5%)	0.0006		
F-test	149.3		

Means within each column with * are significantly different as compared with Control (SSP1) using graph pad prism at p<0.05 level

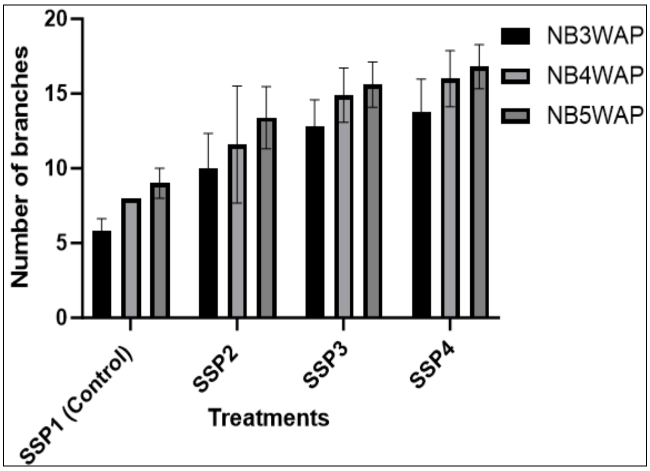

Fig 3: Effect of SSP fertilizer on number of branches

Number of Flowers

The number of flowers also increased as the week after planting (WAP) and treatment levels increases. But the SSP4 at 5 weeks after planting recorded the highest number of flowers (6.80) as presented in table 6 and figure 4 respectively.

Table 6: The Effect of Single Super Phosphate Fertilizer on the Number of Flower of Groundnut grown at FUD Botanical Garden during dry season in 2017.

Treatments	Average mean ± standard deviation		
	3WAP	**4WAP**	**5WAP**
SSP1	0.00±0.0	0.00±0.0	1.5±0.5
SSP2	0.00±0.0	2.40±0.5	2.70±0.7
SSP3	0.00±0.0	2.90±1.1	5.80±1.8*
SSP4	0.00±0.0	4.00±1.0*	6.80±1.4*
P-value (5%)	0.0371		
F-test	9.981		

Means within each column with * are significantly different as compared with Csontrol (SSP1) using graph pad prism at p<0.05 level

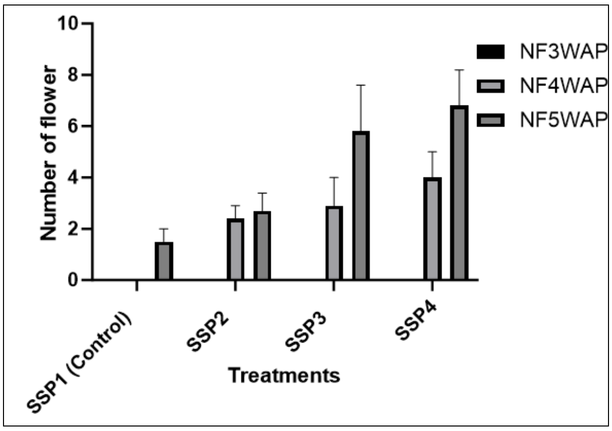

Fig 4: Effect of SSP fertilizer on number of flower

Fresh weight (gram)

The shoot fresh weight measured at 6, 7 and 8 weeks after planting were significantly increased by single super phosphate (18% P_2O_5) application, with all the levels of applied Phosphate fertilizer (i.e 2.0 g/polythene bag, 4.0 g/polythene bag and 6.0g/polythene bag). But 6.0 g (SSP4) recorded the highest value of fresh weight (15.50 g). On the other hand the fresh weight obtained in SSP2 and SSP3 at 3WAP were statistically different and significantly higher than the control as shown in table 7 and figure 5. The result also show that the values increase with increase rate in the phosphate level.

Table 7: The Effect of Single Super Phosphate Fertilizer on Fresh weight (g) of Groundnut grown at FUD Botanical garden during dry season in 2017.

Treatments	Average mean		
	6WAP	7WAP	8WAP
SSP1	3.80	5.32	8.60
SSP2	5.16	8.02	12.10
SSP3	7.50*	9.20*	14.70*
SSP4	8.11**	10.01**	15.50**
P-value (5%)	0.0004		
F-test	90.91		

Means within each column with * are significantly different as compared with Control (SSP1) using graph pad prism at $p<0.05$ level

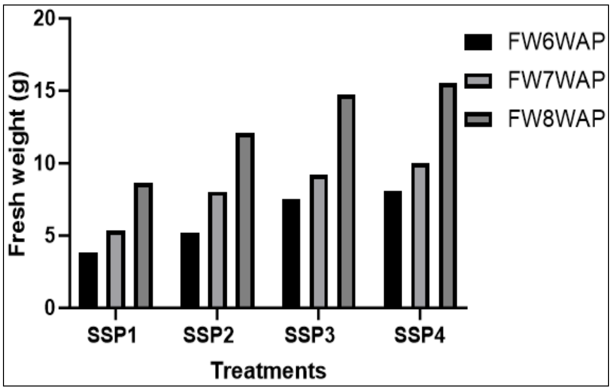

Fig 5: Effect of SSP fertilizer on fresh weight

Dry Weight (gram)

A single super phosphate (18% P_2O_5) application, with all amounts of applied phosphate fertilizer (i.e., 2.0 g/polythene bag, 4.0 g/polythene bag, and 6.0 g/polythene bag) significantly improved the shoot dry weight (g) assessed at 6, 7 and 8 weeks after planting. However, the maximum dry weight measurement (4.40 g) was obtained by 6.0 g (SSP4). Table 8 and Figure 6 show that the dry weight attained in SSP2 and SSP3 at 3WAP was statistically different and considerably greater than the control. The outcome additionally demonstrated that the values rise when the phosphate level increases at a faster rate.

Table 8: The Effect of Single Super Phosphate Fertilizer on Dry weight (g) of Groundnut Grown at FUD Botanical Garden during dry season in 2017.

Treatments	Average mean		
	6WAP	7WAP	8WAP
SSP1	1.10	1.90	2.60
SSP2	1.60	2.10	3.40
SSP3	2.10*	2.50*	3.80*
SSP4	2.50*	3.01*	4.40*
P-value (5%)	0.001		3.40
F-test	116.5		

Means within each column with * are significantly different as compared with Control (SSP1) using graph pad prism at $p<0.05$ level

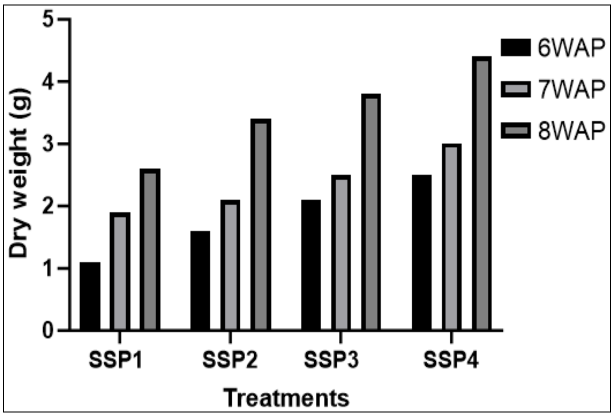

Fig 6: Effect of SSP fertilizer on plants height

Discussion

All doses of applied single super phosphate fertilizer were found to considerably enhance groundnut plant height, branch count, and leaf count relative to the control treatment. This suggests that a single super phosphate fertilizer promotes the groundnut's vegetative growth and that the groundnut reacts differently to varying dosages of phosphate nutrient additions. Similar observations were made by Buah and Mwinkaara (2009) [25], who noted that Bambara groundnuts respond differently to various nutritional additions and that these nutrients need to be refilled. The outcome showed that the number of flowers increased as the amount of phosphate fertilizer increased. This is consistent with the findings of Baryeh (2001) [3], who noted that flowering begins 28 days after germination and may not end until the plant dies. The observed notable rise in these parameters concerning the application of phosphate fertilizer may be attributed to the interaction between nitrogen and phosphorus in the soil's root zone. This is because the availability of phosphorus increases the amount of nitrogen that plants can absorb (Benedyeka *et al*., 1992; Shaheem *et al*., 2007) [5, 26]. Nitrogen is important for promoting vegetative growth because it provides the essential building blocks of protein and nucleic acid. Indeed, the release of nitrogen from legume dead roots and symbiotic nodules requires an increase in nitrogen availability in the examined soil. According to Tindall (1968) [22], key elements are rapidly provided by inorganic fertilizers during the early stages of plant growth and development. So satisfy the need of the plant. In terms of these characteristics, the results of the control experiment (SSP1) might be explained by the findings of Stewart *et al*. (2005) [20], who reported that plants growing in soil deficient in phosphorus nutrients develop more slowly, produce fewer new shoots, and grow vertically, demonstrating a deficiency of easily available nutrients for plant uptake in the control experiment (Soil devoid of P fertilizer). Consequently, compared to their Phosphorus-fertilized counterparts, the plants had lesser plant height, leaf development, branches, and flowers. Based on the SSP4 results, it can be concluded that the groundnut shoot growth in the research area can be supported by 6.0g P/polythene bag, or 60 kg/ha. According to the findings, a higher rate of phosphate fertilizer application has been linked to enhanced root growth and nodulation, allowing the plant to search a larger area of the soil for moisture, nutrients, and nitrogen availability. According to Layzell and Moloney (1994) [14], soils exhibiting such symbioses may be able to achieve up to 300% N_2 fixation. The amount of nitrogen fixed (nodulation) indicates that groundnut (*Arachis hypogea* L.) may be the plant from which highly effective NO_3 tolerant symbioses can be identified with appropriate phosphate fertiliser management. Thus, it might not be required to use NO_3 tolerant nodulating mutants. The findings also imply that groundnuts might be utilised as an inexpensive source of organic fertilizer to maintain soil fertility and achieve steady and sustained crop production. It may provide residual nitrogen for the upcoming farming season. This is due to the fact that inorganic nitrogen sources are more costly and lose more of their nitrogen than fertilizers made of biological nitrogen. Nonetheless, SSP2 and SSP3 performed statistically differently, albeit noticeably better than the control (SSP1), in terms of both fresh and dry weight. The findings imply that SSP4 is sufficient to effectively and optimally raise the fresh and dry weight of groundnuts in the research region. The results of the study's vegetative development demonstrate that groundnuts responded effectively to all concentrations of phosphate fertilizer used, demonstrating the importance of phosphorous in a variety of morphological and physiological processes. The outcome showed that the application of inorganic phosphate fertilizer has a significant impact on the development of groundnut growth. The environmental factors, such moisture and temperature, may have an impact. The fertilizer application rates (0 g P/polythene bag, 2.0 g P/polythene bag, 4.0 g P/polythene bag, 6.0 g P/polythene bag), the ring method of application, the chemical form (18% P_2O_5 of ($Ca(H_2PO_5)2$) orthophosphate), and the amount of plant-available Phosphorus already present in the soil under study are shown in Table 2. Band method of fertilizer application increase the efficiency of Phosphorus utilization by crops grown on low Phosphorus soil as it reduces the contact between the soil and fertilizer, with a subsequent reduction in Phosphorus adsorption (Fixation) in soil (Margenot *et al*., 2016) [28]. With regard to all levels of phosphate fertilizer applied (0 g P/polythene bag, 2.0 g P/polythene bag, 4.0 g P/polythene bag, and 6.0 g P/polythene bag), the SSP4 demonstrates significant differences in the performance of groundnuts in all parameters (Plant height, number of leaves, number of branches, shoot fresh weight, and dry weight) evaluated in this trial. Thus, the outcome suggests that the groundnut's *(Arachis hypogea* L.) growth can proceed at the SSP4 level of 6.0 g/polythene bag.

Conclusion

The application of single super phosphate fertilizer at a rate of 6.0gP/polythene, or 60 kg/ha, was found to produce the greatest improvements in all evaluated parameters. As a result, it is advised for the growth of groundnut in the agro-ecological zone of Dutse, Jigawa state, Nigeria.

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