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Growth, Yield and Quality of Summer Groundnut (*Arachis hypogaea* L.) as Affected by Graded Levels of Phosphorous

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ABSTRACT

India is the largest importer of vegetable oils in the world. Groundnut (*Arachis hypogaea* L.) is one of the important oilseeds of India. There is enough scope for improvement of productivity of oilseeds through adoption of scientific technologies and the crop responds well to added nutrients. Considering the importance of phosphorus among nutrients, a field experiment was carried out at the Bagusala Farm (23°39' N latitude and 87°42' E longitude) of M.S. Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi, Odisha on medium land with good irrigation and drainage facilities. The soil was a typical brown forest soil and sandy loam in texture having moderate water holding capacity. The percentage of sand, silt and clay were 71.5, 16.2 and 12.3, respectively. The experimental soil was with 0.73% organic carbon, 230 kg N ha^{-1}, 32.1kg P_2O_5 ha^{-1} and 346 kg K_2O ha^{-1}. The treatments were comprised of seven levels of phosphorus namely, P_0: control (no P_2O_5), P_1: P_2O_5 @ 20 kg ha^{-1}, P_2: P_2O_5 @ 40 kg ha^{-1}, P_3: P_2O_5 @ 60 kg ha^{-1}, P_4: P_2O_5 @ 80 kg ha^{-1}, P_5: P_2O_5 @ 100 kg ha^{-1} and P_6: P_2O_5 @ 120 kg ha^{-1},allotted randomly in 4 replications. The variety of groundnut was K6. The experimental results revealed that the treatment P_5 (P_2O_5 @ 100 kg ha^{-1}) recorded the maximum plant height, dry matter accumulation, leaf area index and crop growth rate. The highest pod, kernel, haulm and biological yields and harvest index were noted by P_5 (P_2O_5 @ 100 kg ha^{-1}). The higher doses of P_2O_5 application enhanced N, P and K content of kernel and haulm and crude protein content of kernel and established their superiority to control.

Keywords: Groundnut, growth, nutrient management, phosphorus, quality yield.

In a populous and agriculture based country like India, both of the qualitative and quantitative enhancement of agricultural output is a prime concern to assure food and nutrition security. Agriculture is the mainstay of Indian economy despite its shrinking share in the country's gross domestic product (GDP), which was 55.4 per cent in 1950-51 and in 2018-19 it is 17.4 per cent (Tripathy, 2019). India produces different types of crops in diverse agro climatic zones. At present the country is self-sufficient in food grain production. In 2018-19 India produced 281 million tonnes of food grains (Anonymous, 2019). The second most important crops of agricultural economy of India are oilseeds. Though India created yellow revolution during early 1990s, country is presently dependent on imports to meet its edible oil needs and it is the largest importer of vegetable oils in the world. There is enough scope for improvement of productivity of oilseeds in India through adoption of latest and scientific technologies.

Groundnut (*Arachis hypogaea* L.) is an important annual legume in the world mainly grown for oilseed, food and animal feed and it is fourth most important source of edible oil and third most important source of vegetable protein. India ranks second in the groundnut production scenario of the world. In the world the crop is grown in an area of 27.66 million hectares by 84 countries with an annual production of 43.98 million tonnes of nuts-in-shell (pods) with a productivity of 1590 kg ha^{-1} (FAOSTAT, 2018). In India, it is mainly grown in 11 states in an area of 4.6 million ha with a production of 6.73 million tonnes of pods per annum. The average productivity of groundnut in India is about 1465 kg ha^{-1} as against the world's average yield of 1590 kg ha^{-1} (FAOSTAT, 2018; GOI, 2018). However, in Odisha the productivity of groundnut is 1098 kg ha^{-1} which is lower than the national average. The groundnut productivity in Odisha is low due to some production constraints like poor and imbalanced nutrition of crop, growing groundnut on marginal lands and improper agronomic management. Among different agronomic practices, nutrient management is one which accelerates growth and productivity of the crop. Therefore, it is essential to have more focus to the nutrition of the groundnut to enhance its productivity as the crop responds well to added nutrients (Ghatak *et al*. 1997).

Groundnut being a leguminous crop, a major proportion of the nitrogen (N) requirement is met through symbiotic fixation of atmospheric N. Proper doses of phosphorus fertilizer have vital effect on the yield of groundnut. Phosphorus (P) is the essential nutrient element for crop growth and yield. The most obvious effect of P is on the plant root system, enhancement of nodulation (Brady and Well, 2002), synthesis of oil, protein, different acids and is also involved in formation of glucosinolates which on hydrolysis increases the oil content (Kadam *et al.* 2018). The crop response to varying dose and sources of inorganic phosphate fertilizer in India is very wide, due to variation in soil pH, organic matter and iron and aluminum status. The low soil pH of the region makes soil condition quite conducive for P fixation and precipitation. Added inorganic phosphorus as water soluble phosphate fertilizers undergoes complex exchanges between various soil phosphorus pools (Salve and Gunjal 2011). Consequently, large amounts of inorganic fertilizer phosphorus are needed to attain reasonable crop yields (Yadav *et al*. 2017). Recommendations across the country revealed that groundnut showed response to the application of phosphorus @ 40 to 75 kg P_2O_5 ha^{-1}. Groundnut showed greater response to the application of higher rates of P application. However, in soils with medium to high amount of available phosphorus, P fertilizer @ 40 to 50 kg per ha resulted in optimum yields. Hence the present investigation has been conducted with graded levels of phosphatic fertilizers in brown forest soil of south Odisha to obtain proper growth, productivity and quality of groundnut.

MATERIAL AND METHODS

The field experiment was carried out at the Bagusala Farm, M. S. Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi, Odisha. The farm is located at the 23°39′ N latitude and 87°42′ E longitude. The soil was a typical brown forest soil and sandy loam in texture having moderate water holding capacity. The percentage of sand, silt and clay were 71.50, 16.20 & 12.30, respectively with 0.73% organic carbon, 230 kg N ha^{-1}, 32.1kg P_2O_5 ha^{-1} and 346 kg K_2O ha^{-1}. The treatments were comprised of seven phosphorus, namely, P_0: control (no P_2O_5), P_1: P_2O_5 @ 20 kg ha^{-1}, P_2: P_2O_5 @ 40 kg ha^{-1}, P_3: P_2O_5 @ 60 kg ha^{-1}, P_4: P_2O_5 @ 80 kg ha^{-1}, P_5: P_2O_5 @ 100 kg ha^{-1} and P6: P_2O_5 @ 120 kg ha^{-1}. The experiment was laid out in randomized block design with 4 replications. The seeds were sown on 2nd February 2018 at a spacing of 30 cm × 10 cm. A common dose of 20 kg Nha^{-1} and 40 kg K_2O ha^{-1} in all treatments were applied as basal dose through urea and mutiate of potash, however, varied P rates as per the treatments were applied single super phosphate as basal dose. The above treatments were tested on groundnut variety 'K6' to study the growth, yield and quality.

RESULTS AND DISCUSSION

Effect of graded levels phosphorus on growth of groundnut

The periodic observations on growth parameters were noted, analysed statistically and presented (Table 1 and 2). The maximum plant height of groundnut was recorded under treatment P_5 (P_2O_5 @ 100 kg ha^{-1}) and the lowest plant height was obtained under P_0 (no P_2O_5). This might be due to more availability of phosphorus and phosphorus is known as necessary for meristemetic growth and cell division and the results corroborate with the findings of earlier researchers (Chaudhary *et al*. 2015 and Bekele *et al*. 2019). Dry matter accumulation

Table 1: Effect of phosphorus levels on the plant height (cm) and dry matter accumulation (g m^{-2}) of groundnut

Treatment	Plant height (cm)				Dry matter accumulation (g m^{-2})			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
$P_{0,}$ no P_2O_5	7.75	33.06	54.20	76.93	3.93	53.25	146.43	204.75
$P_{1,}$ 20 kg P_2O_5 ha^{-1}	8.31	34.22	59.12	78.01	5.37	54.50	149.87	206.50
$P_{2,}$ 40 kg P_2O_5 ha^{-1}	8.45	34.76	59.45	80.92	5.54	56.51	155.37	221.25
P3, 60 kg P_2O_5 ha-^{1}	8.62	35.49	62.57	83.09	5.85	64.50	177.37	223.75
P_4 80 kg P_2O_5 ha^{-1}	8.56	36.18	64.49	85.53	6.14	66.25	182.18	226.50
$P_{5,}$ 100 kg P_2O_5 ha^{-1}	8.86	37.59	66.51	86.90	6.82	69.54	191.12	237.75
$P_{6,}$ 120 kg P_2O_5 ha^{-1}	8.29	36.25	66.03	86.08	6.17	67.75	186.31	236.75
SEm (±)	**0.21**	**0.91**	**2.13**	**2.20**	**0.19**	**1.97**	**6.48**	**5.79**
CD (P=0.05)	**0.62**	**2.71**	**6.33**	**6.54**	**0.57**	**5.87**	**19.25**	**17.20**
CV (%)	**5.01**	**5.15**	**6.90**	**5.34**	**6.83**	**6.39**	**7.63**	**5.20**

Table 2: Effect of phosphorus levels on the leaf area index (LAI) and crop growth rate (CGR) of groundnut

Treatment	Leaf area index (cm)				Crop growth rate (g m^{-2} day^{-1})			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
$P_{0,}$ no P_2O_5	0.55	2.03	3.20	2.39	3.93	53.25	146.43	204.75
$P_{1,}$ 20 kg P_2O_5 ha^{-1}	0.62	2.18	3.88	2.48	5.37	54.50	149.87	206.50
$P_{2,}$ 40 kg P_2O_5 ha^{-1}	0.65	2.21	3.97	2.55	5.54	56.51	155.37	221.25
P3, 60 kg P_2O_5 ha-^{1}	0.69	2.49	4.17	2.91	5.85	64.50	177.37	223.75
P_4 80 kg P_2O_5 ha^{-1}	0.73	2.60	4.25	3.06	6.14	66.25	182.18	226.50
$P_{5,}$ 100 kg P_2O_5 ha^{-1}	0.79	2.69	4.42	3.17	6.82	69.54	191.12	237.75
$P_{6,}$ 120 kg P_2O_5 ha^{-1}	0.76	2.60	4.37	3.12	6.17	67.75	186.31	236.75
SEm (±)	**0.03**	**0.07**	**0.15**	**0.09**	**0.19**	**1.97**	**6.48**	**5.79**
CD (P=0.05)	**0.11**	**0.21**	**0.44**	**0.27**	**0.57**	**5.87**	**19.25**	**17.20**
CV (%)	**10.84**	**6.10**	**7.44**	**6.54**	**6.83**	**6.39**	**7.63**	**5.20**

increased with the increase in age of the plant and the highest dry matter accumulation was obtained under P_5 (P_2O_5 @ 100 kg ha^{-1}) among all treatments at different growth stages. The lowest dry matter accumulation was obtained under P_0 (no P_2O_5). The increases in dry weight due to phosphorus application might be due to the fact that phosphorus is known to help in the development of more extensive root system (Gobarah *et al*. 2006) and thus enables plants to absorb more water and nutrients from deeper layer of the soil. This in turn could enhance the ability of plants to produce more assimilates which were reflected in the enhanced biomass production. Similar trend was also observed by Hemalatha *et al*. (2013) and Mouri *et al*. (2018). The leaf area index (LAI) showed a sharp increase in its value with time, irrespective of the levels of phosphorus. The LAI was increased up to 90 DAS and after that declined due to natural senescence of older leaves towards maturity. The data clearly indicated that there was enhancement in LAI with application of phosphorus at all growth stage over control. However, the highest value of LAI was recorded with P_5 (P_2O_5 @ 100 kg ha^{-1}) and the lowest value of LAI was obtained with P_0 (no P_2O_5). The result is in agreement with the findings of Mouri *et al*. (2018) who reported positive response of leaf area increases in groundnut with increasing levels of phosphorus. The crop growth rate (CGR) showed an increasing trend from 0-30 DAS up to 60-90 DAS and then decreased from 90 DAS to harvest. The highest value of CGR (g m^{-2} day^{-1}) was recorded with P_5 (P_2O_5 @ 100 kg ha^{-1}). The treatment P_0 (no P_2O_5) recorded the lowest value of CGR (g m^{-2} day^{-1}).The increasing level of phosphorus fertilizer also enhanced the CGR probably because of greater vegetative growth facilitated by proper nutrient supply and also could be positive impact of Phosphorus fertilization (Kabir *et al*. 2013).

Effect of graded levels phosphorus on yield of groundnut

The yield of groundnut was also influenced by graded levels of phosphatic fertilizers (Table 3). The pod yield showed an increase with the increasing levels of phosphorus levels up to P_5 (P_2O_5 @ 100

Table 3: Effect of phosphorus levels on the pod yield(kg ha^{-1}), kernel yield (kg ha^{-1}), haulm yield (kg ha^{-1}), biological yield (kg ha^{-1}) and harvest index (%)of groundnut

Treatments	Pod yield (kg ha^{-1})	Kernel yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
$P_{0,}$ no P_2O_5	1469	1018	3475.0	4943.5	26.6
$P_{1,}$ 20 kg P_2O_5 ha^{-1}	1502	1090	3719.0	5220.3	27.1
$P_{2,}$ 40 kg P_2O_5 ha^{-1}	1683	1113	3758.5	5441.5	27.6
P3, 60 kg P_2O_5 ha-^{1}	1716	1233	2787.0	5503.0	29.1
$P_{4,}$ 80 kg P_2O_5 ha^{-1}	1931	1240	3669.5	5600.0	28.6
$P_{5,}$ 100 kg P_2O_5 ha^{-1}	2112	1370	4038.0	6150.0	32.1
$P_{6,}$ 120 kg P_2O_5 ha^{-1}	2030	1315	3670.5	5700.0	30.9
SEm (±)	**77**	**57**	**65**	**98**	**0.98**
CD (P=0.05)	**229**	**168**	**193**	**293**	**2.90**
CV (%)	**8.6**	**9.5**	**7.3**	**6.5**	**NS**

kg ha^{-1}) and then decreased with further increase of phosphorus levels, P_6 (P_2O_5 @ 120 kg ha^{-1}). The highest pod yield (2112 kg ha^{-1}) was achieved with P_5 (P_2O_5 @ 100 kg ha^{-1}) followed by (2029.5 kg ha^{-1}) P_6 (P_2O_5 @ 120 kg ha^{-1}) and P_5 differed significantly with some treatments like P_0 (no P_2O_5), P_1 (P_2O_5 @ 20 kg ha^{-1}), P_2 (P_2O_5 @ 40 kg ha^{-1}) and P_3 (P_2O_5 @ 60 kg ha^{-1}).The lowest pod yield (1468.50 kg ha^{-1}) was recorded by P_0 (no P_2O_5) which was 30.47% less than the best treatment P_5 (P_2O_5 @ 100 kg ha^{-1}). The application of phosphorus increases pod yield due it role in root growth, photosynthesis, metabolic activities in plant which increased more production of assimilates and absorption of metabolites which ultimately enhanced pod yield. The results are in conformity with the observations of Amruth *et al*. (2017) and Bekele *et al*. (2019).The kernel yield showed a similar trend like pod yield. The highest kernel yield (1370 kg ha^{-1}) was recorded with P_5 (P_2O_5 @ 100 kg ha^{-1}) followed by P_6 (1315 kg ha^{-1}) and it differed significantly with some other treatments except P_6 (P_2O_5 @ 120 kg ha^{-1}), P_4 (P_2O_5 @ 80 kg ha^{-1}) and P_3 (P_2O_5 @ 60 kg ha^{-1}).The results corroborate the findings of Mouri *et al.* (2018).The different levels of phosphorus had a significant effect on the haulm yield. Among the different treatments, the treatment with P_5 (P_2O_5 @ 100 kg ha^{-1}) recorded the highest haulm yield (4038 kg ha^{-1}), however, it was on par with all other treatments (3670 to 3719 kg ha^{-1}) except control (3475 kg ha^{-1}). Earlier researchers also noted enhancement of haulm yield with application of phosphatic fertilizers (Shuaibu *et al*. 2019). Further,the treatment P_5 (P_2O_5 @ 100 kg ha^{-1}) recorded the highest biological yield (6150 kg ha^{-1}), however, it was on par with some other treatments (5220 to 5700 kg ha^{-1}) except control (4943 kg ha^{-1}). The higher biological yield is obtained with the treatments with P fertilization was probably greater values of pod and haulm yields than the treatment with no phosphorus. The results are in conformity with the findings of Kabir *et al*. (2013). The application of different levels of phosphorus showed significant impact on harvest index. Among the different treatments, the treatment with P_5 (P_2O_5 @ 100 kg ha^{-1}) recorded highest harvest index (32.1), however, the control recorded lowest harvest index of 26.6. The harvest index is the partitioning of assimilates into economically important parts (pods) that determines the productivity of the crop. The results are in conformity with the findings of Melese and Dechassa (2017) and Shuaibu *et al.* (2019).

Effect of graded levels phosphoruson quality of groundnut

The application of phosphorus resulted in a significant impact on quality of kernel and haulm of groundnut (Table 4). In case of N content in kernel of groundnut, application of 20 kg P_2O_5 ha^{-1} (P_1) and 40 kg P_2O_5 ha^{-1} (P_1) remained statistically at par with no phosphatic fertilizer treatment (P_0). But higher level of phosphorus application registered significantly more N content in kernels of groundnut than control (P_0). The treatments with 60 kg P_2O_5ha^{-1} (P_3), 80 kg P_2O_5 ha^{-1} (P_4) and 100 kg P_2O_5 ha^{-1} (P_5) were noted with significantly higher N content in kernels of groundnut. Further, application of 20 kgP_2O_5 ha^{-1} (P_1) did not show remarkable increase in N content in haulm over P_0. However, higher dose of P_2O_5 application enhanced N content of haulm significantly. The treatments like P_3 (P_2O_5

Table 4: Effect of phosphorus levels on quality of groundnut

Treatments	N content (%)		P content (%)		K content (%)		Protein content (%) in kernel
	Haulm	Kernel	Haulm	Kernel	Haulm	Kernel	
P_0, no P_2O_5	**1.56**	**4.20**	**0.25**	**0.50**	**1.53**	**0.65**	**26.3**
P_1, 20 kg P_2O_5 ha^{-1}	1.57	4.23	0.27	0.53	1.54	0.70	26.4
P_2, 40 kg P_2O_5 ha^{-1}	1.66	4.33	0.28	0.54	1.57	0.72	27.1
P3, 60 kg P_2O_5 ha-^{1}	1.67	4.44	0.28	0.55	1.61	0.72	27.8
P_4, 80 kg P_2O_5 ha^{-1}	1.68	4.51	0.29	0.56	1.63	0.74	28.3
P_5, 100 kg P_2O_5 ha^{-1}	1.72	4.61	0.29	0.59	1.64	0.76	28.8
P_6, 120 kg P_2O_5 ha^{-1}	1.71	4.62	0.27	0.58	1.61	0.73	26.6
SEm (±)	**0.02**	**0.08**	**0.01**	**0.02**	**0.01**	**0.01**	**0.28**
CD (P=0.05)	**0.06**	**0.23**	**0.03**	**0.06**	**0.06**	**0.03**	**0.83**
CV (%)	**5.2**	**3.5**	**8.2**	**6.8**	**4.1**	**4.3**	**4.1**

@ 40 kg ha^{-1}), P_4 (P_2O_5 @ 60 kg ha^{-1}), P_5 (P_2O_5 @ 80 kg ha^{-1}) and P_6 (P_2O_5 @ 100 kg ha^{-1}) were significantly superior to P_2 (P_2O_5 @ 40 kg ha^{-1}) and P_1 (P_2O_5 @ 20 kg ha^{-1}) in registering more N content in haulm of groundnut. Like nitrogen, phosphorus content of kernel and haulm was influenced by application of graded levels of phosphatic fertilizer (Table 4). The treatments like P_5 (P_2O_5 @ 100 kg ha^{-1}) and P_6(P_2O_5 @ 120 kg ha^{-1}) exhibited significantly more P content than P_0.Moreover, the lowest P content in haulm of groundnut was noted with P_0 and it was remained statistically at par with P_1 (P_2O_5 @ 20 kg ha^{-1}), P_2 (P_2O_5 @ 40 kg ha^{-1}), P_3 (P_2O_5 @ 60 kg ha^{-1}) and P_6 (P_2O_5 @ 120 kg ha^{-1}). But P_4 (P_2O_5 @ 60 kg ha^{-1}) and P_5 (P_2O_5 @ 80 kg ha^{-1}) resulted in significantly higher P content in haulm than P_0 (no P_2O5).The potassium content of kernel of groundnut was greatly influenced by application of phosphatic fertilizers and higher levels of phosphatic fertilizers recorded greater values in K content of kernel and haulm of groundnut. The results are in conformity with the findings of Hemalatha *et al*. (2013). Further, among the treatments, the highest crude protein content (28.8%) was recorded under P_5 (P_2O_5 @ 100 kg ha^{-1}) and it differed significantly with P_0 (no P_2O_5) which recorded the lowest crude protein content (26.3%). The source of phosphatic fertilizers was single super phosphate (SSP) and it contains sulphur which contributes in synthesis of some essential amino acids like cysteine, cystine and methionone. The results corroborate with the findings of Mirva *et al*. (2006) and Yadav *et al*. (2017).

CONCLUSION

From the study, it may be mentioned that among the different levels of phosphorus, application of P_2O_5@ 100 kg ha^{-1} resulted in reasonable enhancement in growth, pod, kernel, haulm and biological yields and quality. Hence, it can be concluded that summer groundnut can be cultivated in Gajapati district of Odisha with the application of P_2O_5 @ 100 kg ha^{-1} to obtain higher productivity and quality.

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