Effect of Phosphorus Application on Groundnut (*Arachis hypogaea* L.): A Review

Abstract: The phosphorus in legumes plays an essential role as part of the membrane system of the cell, chloroplast and the mitochondria. Groundnut, being a legume oilseed crop, requires a significant amount of phosphorus. Plants use it for energy transfer in metabolic processes such as photosynthesis (in the form of ATP and ADP), starch and sugar transformation and nutrient movement. In addition to promoting cell division and the development of good root systems phosphorus plays an important role for ensuring timely and uniform ripening of crops, promoting carbohydrate breakdown for energy release, and hastening maturity, it is an essential component for ensuring the growth and maturity of plants. Phosphorus is one of the principal nutrients, which boosts root growth, thus facilitating water and nutrient uptake from deeper layers of the soil. The groundnut crop calls for sensible supply of phosphorus for its regular growth. Phosphorus has been found to improve the crop's effective use of soil nutrients and increase biological N fixation by increasing nitrogenase activity. Various research in this paper clearly indicate that application of phosphorus significantly affects the growth, phenology, yield attributes, yield, quality, nutrient uptake and economics of groundnut.

Keywords: Growth, Phenology, Phosphorus, Uptake, Yield, Economics

Introduction: Groundnut (*Arachis hypogaea* L.) is one of the best-known oilseed crops which belongs to the family Leguminosae and sub-family Papilionaceae. It is believed that it has been originated in South America. (Hussainy *et al.*, 2023). The groundnut crop calls for sensible supply of phosphorus for its regular growth. In India, Groundnut is considered the “king of oilseeds”. This oil seed crop is primarily found in tropical and subtropical regions, and is also known as peanut, earthnut, monkey nut and poor men's cashew nut. The global area, production and productivity of groundnut is 29.7 million ha, 50.8 million tonnes and 17.1 quintal ha^{-1}, respectively. China is the world’s largest producer of groundnut with 4.6 million ha area, 17 million tonnes production and productivity of 37.0 quintal ha^{-1} followed by India. Groundnut covers an area of 4.8 million ha with production of 9.9 million tonnes and productivity of 20.6 quintal ha^{-1} in India during 2019-20 (Anonymous 2020). Groundnut account for 31.7% of India total oilseed production and about 28.3 % of the cultivated area of total oilseeds (Ali *et al.*, 2021). The major groundnut producing states in India are Gujrat, Rajasthan and Tamil Nadu. Phosphorus is considered a crucial mineral fertilizer for the flourishing production of the crop (Hasan *et al.*, 2021). Both organic and inorganic forms of phosphorus are found in soils, and the relative amounts of each form vary substantially amongst soils. Because it is strongly bound to soil colloids, organic P is typically not available for plant uptake unless it is broken down and released during the mineralization process (Filippelli, 2002). Plants can access phosphorus in its inorganic forms ($H_2PO_4^-$ and HPO_4^-), but very little of it is present in soil solution (Weil and Brady, 2017). Moisture and temperature have a major impact on the chemistry of P cycling in soils, which is quite complex. To meet the nutrient requirements of plants at each stage of their growth cycle, Labile P one of many potential forms of phosphorus must be supplemented regularly. By adding inorganic P fertilisers, the concentration of phosphorus in the soil solution is increased (Sikka *et al.*, 2022). For the synthesis of chlorophyll, phosphorus is an essential component. For cell division and the growth of meristematic tissue, phosphorus is considered an essential component of the cell nucleus (Kumar *et al*., 2016). By fixing atmospheric nitrogen within its root nodules, the groundnut crop improves soil fertility. Application of phosphorus determines plant reproductive efficiency and promotes plant growth, development and yield (Kamal *et al.*, 2023). Available literature on the effect of phosphorus in groundnut is presented under following sub-heads.

Effect of Phosphorus on

Growth parameters

Jat *et al*. (2023) conducted a study at MPUAT, Udaipur and purported that application of 80 kg P_2O_5 ha^{-1} significantly increased chlorophyll content (1.535 mg/g) in groundnut, which was significantly higher over 60 kg P_2O_5 ha^{-1}, 40 kg P_2O_5 ha^{-1}, 20 kg P_2O_5 ha^{-1} and 0 kg P_2O_5 ha^{-1}. Hinduja *et al.* (2020) avouched that application of 70 kg/ha Phosphorus + 40 kg/ha Sulphur in groundnut significantly increase plant height (60.3 cm), number of nodules (79.88 $plant^{-1}$) and dry matter accumulation (32.02 g $plant^{-1}$) in groundnut which was significantly higher over 40 kg/ha phosphorus + 20 kg/ha sulphur by 3.8, 16.1 and 14.8 per cent, respectively. Tekulu *et al*. (2020) conducted study in Ethiopia and observed that application of 30 kg N and 69 kg P_2O_5 ha^{-1} was highly correlated and produced highest plant height (56.1 cm), which was significantly higher over other treatment combinations in groundnut. Lro *et al*. (2019) conducted a field experiment in Nigeria and revealed that application of 60 kg P_2O_5 ha^{-1} significantly improved plant height of groundnut (34.6 cm) over 40 kg P_2O_5, 20 kg P_2O_5 and 0 kg P_2O_5 ha^{-1} by 19.0, 33.3, 62.9 per cent, respectively.

Sibhatu *et al.* (2016) conducted research at Ethiopia and professed that application of 30 kg P_2O_5 ha^{-1} in groundnut produced highest plant (23.5 cm), which was statistically at par with application of 40 kg P_2O_5 ha^{-1} and significantly higher over 20 kg, 10 kg and 0 kg P_2O_5 ha^{-1} by 19.8, 22.1 and 46.1 per cent, respectively. Jeetarwal *et al.* (2014) conducted a field experiment at S.K.N. College of Agriculture, Jobner (Rajasthan) and averred that application of 60 kg P_2O_5 ha^{-1} in groundnut produce higher plant height (22.70 cm), dry matter (450.6 g/m row length), number of branches (10.15 $plant^{-1}$), chlorophyll content (0.67 mg/g) and number of nodules (58.10 $plant^{-1}$), which were statistically at par with 40 kg P_2O_5 ha^{-1} and significantly higher over 20 kg P_2O_5 ha^{-1} and 0 kg P_2O_5 ha^{-1}.

Singh *et al.* (2014) conducted an experiment on groundnut at Morena (MP) and reviewed that application of 20 kg N + 40 kg P_2O_5 ha^{-1} produce higher plant height (66.5 cm), number of primary branch (9.2 $plant^{-1}$), number of secondary branch (21.5 $plant^{-1}$), number of root nodules (174 $plant^{-1}$), dry weight of root nodules (549 mg $plant^{-1}$), tap root length (14.1 cm) and dry weight of root (6.68 g $plant^{-1}$), which were significantly higher over control by 34.1, 33.3, 35.2, 43.8, 44.0, 74.0 and 54.2 per cent, respectively.

Kabir *et al.* (2013) conducted a study at Bangladesh Agricultural University, Mymensingh and stated that application of 50 kg P_2O_5 ha^{-1} in groundnut produce higher plant height (59.6 cm), number of branches (7.5 $plant^{-1}$), dry weight (32.0 $plant^{-1}$), crop growth rate (21.0 g/m^2/day) between 70-100 DAS and leaf area index (1.7), which were significantly higher over control by 26.4, 20.9, 15.6, 15.5 and 17.3 per cent, respectively. Singh *et al.* (2013) opined that application of 20 kg N + 60 kg P_2O_5 + 40 kg K_2O/ha progressively increased root length, shoot length and seedling length of groundnut, which were significantly higher over control by 43.1, 48.7 and 42.7 per cent, respectively. Kamara *et al.* (2011) adduced that in groundnut application of 40 kg P_2O_5/ha produced highest plant height (42.3 cm), which was significantly higher over control by 14.0 percent. Karunakaran *et al.* (2010) conducted a field experiment at Tamil Nadu in groundnut and testified that application of 125 % RDF (17 kg N + 34 kg P_2O_5 + 54 kg K_2O/ha) increase height of plant (51.8 cm) as compare to RDF (48.3 cm). Salve *et al.* (2010) conducted a field experiment at MPKV, Rahuri and averred that application of 75 kg P_2O_5 ha^{-1} in groundnut produce highest plant height (34.34 cm) and number of branches (48.45 $plant^{-1}$), which were statistically at par with 50 kg P_2O_5 ha^{-1} and significantly higher over 25 kg P_2O_5 ha^{-1}. Shiyam (2010) concluded that increasing the levels of phosphorus up to 50 kg ha^{-1} has a significant effect on plant height, and the highest plant height (56 cm) was found with the application of 50 kg P ha^{-1} in groundnut.

Rao and Shaktawat (2001) carried out an experiment at Udaipur, Rajasthan and averred that application of 60 kg P_2O_5 ha^{-1} in groundnut produced higher number of branches $plant^{-1}$ (4.70), leaf area index (4.41), root dry weight $plant^{-1}$ (0.72 g), which were significantly higher over 40 kg P_2O_5 ha^{-1} and 20 kg P_2O_5 ha^{-1} by 2.2, 2.5, 1.3 and 9.3, 8.6, 9.8 per cent, respectively.

Phenology

Tekulu *et al.* (2020) conducted study in Ethiopia and purported that individual N and P fertilizer rates, as well as combinations of N and P fertilizer rates, had no effect on groundnut phenological parameters such as flowering time and maturity. This could be because biological N fixation provided enough nitrogen for the groundnut plant to begin flowering and maturation.

Lro *et al.* (2019) did a field experiment in Nigeria on groundnut and professed that non significant variation in germination percentage was recorded between phosphorus fertilizer application rates. However, the control has a greater germination percentage (68.9 %) than the other treatments (20, 40, and 60 kg P_2O_5 ha^{-1}) and also concluded that phosphorus rates have a significant effect on days to 50% flowering. The application rate of 60 kg P_2O_5 ha^{-1} resulted minimum number of days for groundnut to reach 50% flowering (27.7 days), 40 kg P_2O_5 ha^{-1} and 20 kg P_2O_5 ha^{-1} reached 50% flowering at the same time (29.5 days), and the control (0 kg P_2O_5 ha^{-1}) reached 50% flowering at 30.5 days.

Melese and Dechassa (2017) purported that applying phosphorus and manure to groundnut genotypes Werer 962 and Oldhale had no influence on flowering and maturity. Sibhatu *et al.* (2016) averred that the highest days to 90% physiological maturity of groundnut (99.0) was obtained with application of 30 kg P_2O_5 ha^{-1}, while significantly lower days to 90 % physiological maturity (91.3) were obtained in no application of phosphorus So, the crop fertilized with higher application of phosphorus took long time to mature while less phosphorus fertilizer shortened maturity date.

Bala *et al.* (2011) investigated that days to 50% flowering were increased by the application of 30 kg N + 39 kg P_2O_5 + 39 K_2O ha^{-1} as compared to 10 kg N + 13 kg P_2O_5 + 13 K_2O ha^{-1} in groundnut. Kamara *et al.* (2011) conducted research and inferred that in groundnut the application of 40 kg P_2O_5 ha^{-1} resulted in the highest percent field emergence (85.33), while the application of 0 kg P_2O_5 ha ^{1} resulted in the shortest days to 50% flowering (25) and the shortest days to maturity (89). Khan *et al.* (2009) reviewed that the application of 27 kg N ha^{-1}+ 69 kg P_2O_5 ha^{-1} in groundnut significantly increased the emergence of plants (11.71 plants m^{-2}), days to 50% flowering (33.33) and days to maturity (183.28) in comparison with the control treatment.

Yield attributes, Yield and Quality

Jat *et al*. (2023) conducted a study at MPUAT, Udaipur and purported that application of 80 kg P_2O_5 ha^{-1} significantly increased kernel yield (1179 kg ha^{-1}) and biological yield (4894 kg ha^{-1}) in groundnut, which were statistically at par with application of 60 kg P_2O_5 ha^{-1} and significantly higher over 40 kg, 20 kg P_2O_5 ha^{-1} and control. Kumar *et al*. (2019) conducted a field experiment at Odisha in groundnut and averred that application of 100 kg P_2O_5 ha^{-1} produced higher number of higher number of pods/plant (15.55), pod yield (2112 kg/ha), kernel yield (1370 kg/ha), oil content (47.92 %) and oil yield (998.99 kg/ha), which were significantly higher over control by 76.7, 43.8, 34.7, 12.6 and 51.0 per cent, respectively.

Choudhary and Yadav (2017) conducted a field experiment at Anand, Gujarat in groundnut and anticipated that application of 50 kg P_2O_5 ha^{-1} produced higher pod yield (2657 kg ha^{-1}) and haulm yield (4467 kg ha^{-1}) which were significantly higher over control by 20.3 and 18.9 per cent, respectively. Ikenganyia *et al.* (2017) purported that application of 75 kg P_2O_5 ha^{-1} produced higher pod yield of groundnut compared to 50 kg P_2O_5, 25 kg P_2O_5 ha^{-1} and control by 15, 32 and 54 per cent, respectively. Sagvekar *et al.* (2017) observed that NP fertilizer ratio 0.40 significantly increased number of pods (30.6 $plant^{-1}$), pod yield (3500 kg ha^{-1}) and kernel yield (2630 kg ha^{-1}) in groundnut over rest of NP ratio.

Sibhatu *et al.* (2016) conducted research at Ethiopia in groundnut and concluded that increasing the levels of phosphorus up to 20 kg ha^{-1} produced higher number of pod (22.6 $plant^{-1}$), seed (3.5 pod^{-1}), 100-kernel weight (42.2 g), shelled seed yield (1269 kg ha^{-1}) and dry matter yield (3765 kg ha^{-1}), which were significantly higher over 10 kg and 0 kg P_2O_5 ha^{-1} by 31.2, 7.53, 1.5, 7.0, 2.0 and 33.9, 24.8, 3.9, 34.0, 16.6 per cent, respectively.

Kumar *et al.* (2015) reviewed that use of N@7 kg/ha by urea at 60 DAS and NP fertilizer ratio will be 0.57 significantly increased total pods per plant (29.53), filled pods per plant (24.27), 100-kernel weight (41.16 g), 100-pod weight (135.33 g) and pod yield (4361 kg ha^{-1}) in groundnut over other NP fertilizer ratios. Yadav *et al.* (2015) asserted that increasing the level of phosphorus up to 27 kg ha^{-1} in groundnut progressively increased the number of pods (70.8 $plant^{-1}$), number of kernels (2.0 pod^{-1}), pod yield (2.09 t ha^{-1}) and haulm yield (3.58 t ha^{-1}), which were significantly higher over control by 60.9, 17.6, 38.4 and 39.2 per cent, respectively.

Jeetarwal *et al.* (2014) conducted a field experiment at S.K.N. College of Agriculture, Jobner (Rajasthan) averred that application of 60 kg P_2O_5 ha^{-1} in groundnut produce higher number of pods/plant (20.4), number of kernels/pod (1.95), seed index (59.2 g), pod yield (2.83 t/ha), haulm yield (6.85 t/ha), kernels yield (1.98 t/ha) and shelling (69.96 %), which were statistically at par with 40 kg P_2O_5 ha^{-1} and significantly higher over 20 kg P_2O_5 ha^{-1} and 0 kg P_2O_5 ha^{-1}. Singh *et al.* (2014) conducted an experiment at Morena (MP) in groundnut and reviewed that application of 20 kg N + 40 kg P_2O_5 ha^{-1} produced higher number of pod (27.7 $plant^{-1}$), pod yield (2535 kg ha^{-1}), haulm yield (3103 kg ha^{-1}), oil content (43.8 %) and protein content (27.04 %), which were significantly higher over control by 33.8, 48.2, 33.9, 3.9 and 11.8 per cent, respectively.

Kabir *et al.* (2013) conducted a study at Bangladesh Agricultural University, Mymensingh and averred that application of 50 kg P_2O_5 ha^{-1} in groundnut gave higher number of pods (18.9 $plant^{-1}$), 100-pod weight (110.8 g), shelling (64.2 %), pod yield (2.8 t ha^{-1}), biological yield (10.8 t ha^{-1}), straw yield (8.02 t ha^{-1}) which was significantly higher over 25 kg P_2O_5 and 0 kg P_2O_5 ha^{-1} by 6.4, 0.8, 1.7, 15.3, 6.1, 3.0 and 14.0, 2.4, 10.6, 36.6, 21.5, 17.2 per cent, respectively.

Akbari *et al.* (2011) carried out a field experiment at Gujarat and reckoned that application of 50 kg P_2O_5 ha^{-1} significantly increased haulm yield, pod yield, shelling out percentage and harvest index of groundnut compared to lower doses of phosphorus. Kamara *et al.* (2011) propounded that increasing the levels of phosphorus up to 40 kg ha^{-1} significantly increased pod yield in groundnut compared to other lower doses. Nwokwu (2011) observed a significant increase in kernel yield of groundnut when 60 kg of P_2O_5 ha^{-1} was used, which was significantly higher than control by 39.0 percent.

John (2010) averred that application of 40 kg P_2O_5 ha^{-1} significantly increased pod yield, haulm yield and kernel yield of groundnut over control. Salve *et al.* (2010) conducted a field experiment at MPKV, Rahuri and averred that application of 75 kg P_2O_5 ha^{-1} in groundnut produce highest matured pods/plant (18.34), dry pod yield (34.74 q/ha), haulm yield (43.75 q/ha), oil content (51.50 %), oil yield (13.18 q/ha), protein yield (6.65 q/ha), which were statistically at par with 50 kg P_2O_5 ha^{-1} and significantly higher over 25 kg P_2O_5

ha^{-1}. Naab *et al* (2009) observed that the application of 30 kg P_2O_5 ha^{-1} resulted in a significant increase in pod and kernel yield of groundnut as compared to 0 kg P_2O_5 ha^{-1} but it was statistically equivalent to 90 kg P_2O_5 and 60 kg P_2O_5 ha^{-1}.

Kumar *et al.* (2008) averred that application of 60 kg P_2O_5 ha^{-1} significantly increased pod yield of groundnut compared to 0, 20 and 40 kg P_2O_5 ha^{-1}. Rajanikant *et al.* (2008) conducted a field experiment at Hyderabad and purported that application of 40 kg P_2O_5 ha^{-1} significantly increased pod yield and shelling out percentage in groundnut as compare to control. Basu *et al.* (2007) conducted a field experiment at Kharagpur and found that RDF (20 kg N + 40 kg P_2O_5 + 40 kg K_2O ha^{-1}) significantly increased the pod yield (1465 kg/ha) in groundnut over other treatment combinations. Kausale *et al.* (2009) investigated that increasing the level of phosphorus up to 30 kg ha^{-1} in groundnut significantly increased pod yield (2754 kg ha^{-1}) over other lower doses of phosphorus. Ranjit *et al.* (2007) conducted a field experiment and professed that use of 112.5 kg P_2O_5 ha^{-1} in groundnut produced higher haulm and pod yield of groundnut 4600 kg ha^{-1} and 3500 kg ha^{-1}, respectively.

Gobarah *et al.* (2006) avouched that increasing the levels of phosphorus from 30 to 60 kg/ha significantly increased number of pods plant^{-1}, 100-kernel weight, kernel yield, protein and oil content in groundnut. Karmakar *et al.* (2005) conducted an experiment at West Bengal in groundnut and asserted that 30 kg N + 60 kg P_2O_5 + 20 kg K_2O ha^{-1} produced higher haulm yield (4643 kg/ha) and pod yield (2715 kg/ha) compared to other treatment combinations. Panwar and Singh (2003) reviewed that by application of 60 kg P_2O_5 ha^{-1} significantly increased pod yield (28.40 q ha^{-1}) and harvest index (36.5 %) of groundnut as compared to control. Kachot *et al.* (2001) examined that application of 25 kg P_2O_5 ha^{-1} significantly increase shelling out percentage, oil content and protein content in groundnut over control.

Kumaran (2001) reviewed that application of RDF (34 kg N + 17 kg P_2O_5 + 54 kg K_2O/ha) + FYM as basal @ 12.5 t/ha + 17 kg P_2O_5/ha at 30 DAS in groundnut produced higher number of pods (14.95 plant^{-1}) and seed index (30.23 g) which was significantly higher over application of only RDF by 22.8 and 9.5 per cent, respectively. Majumdar *et al.* (2001) conducted a field experiment and stated that application of 75 kg P_2O_5 ha^{-1} significantly increased haulm (4670 kg ha^{-1}) and pod yield (3000 kg ha^{-1}) of groundnut whereas, oil and protein content was significantly higher over control by 8.3 and 9.7 per cent, respectively. Rao and Shaktawat (2001) carried out an experiment at Udaipur, Rajasthan in groundnut and opined that application of 60 kg P_2O_5 ha^{-1} produced higher pod yield (18.54 q ha^{-1}), biological yield (50.93 q ha^{-1}), oil content (49.2 %), protein content (24.3 %), which were significantly higher over 40 kg and 20 kg P_2O_5 ha^{-1} by 3.6, 3.9, 2.5, 3.0 and 13.6, 9.3, 5.3, 5.1 per cent, respectively.

Nutrient content and uptake

Kamal *et al.* (2023) conducted a field experiment at CCS HAU, Hisar, Haryana, and inferred that application of 60 kg P_2O_5 ha^{-1} progressively increased N uptake (180.5 kg ha^{-1}), P uptake (29.4 kg ha^{-1}), K uptake (96.4 kg ha^{-1}) and S uptake (23.3 kg ha^{-1}) in groundnut, which were significantly higher over 50 kg P_2O_5 ha^{-1}, 40 kg P_2O_5 ha^{-1} and control. Musa *et al.* (2017) conducted a field experiment at Nigeria in groundnut and reproduced that increasing the levels of phosphorus up to 24 kg ha^{-1} progressively increased nitrogen (12.5 kg ha^{-1}) and phosphorus (4.6 kg ha^{-1}) uptake in haulm, which were significantly higher over control by 50.4 and 38.4 per cent, respectively.

Choudhary and Yadav (2017) conducted a field experiment at Anand, Gujarat in groundnut and averred that application of 50 kg P_2O_5 ha^{-1} progressively increased phosphorus content in kernel (0.48 %) and phosphorus uptake by kernel (13.25 kg ha^{-1}), which were significantly higher over control by 14.3 and 16.1 per cent, respectively. Chirwa *et al.* (2017) conducted a field experiment at Tanzania and concluded that application of 20 kg N + 30 kg

P ha^{-1} in groundnut significantly increased uptake of N, P and Ca compared to other treatment combination and control. Yadav *et al.* (2015) averred that increasing the level of phosphorus up to 27 kg ha^{-1} in groundnut progressively increased uptake of N (120.5 kg ha^{-1}), P_2O_5 (17.7 kg ha^{-1}) and K (71.5 kg ha^{-1}), which were significantly higher over control by 43.1, 48.6 and 42.7 per cent, respectively.

Singh *et al.* (2014) conducted an experiment at Morena (MP) and avouched that application of 20 kg N + 40 kg P_2O_5 ha^{-1} progressively increased phosphorus uptake in kernel (9.23 kg ha^{-1}) and stover (8.62 kg ha^{-1}), which were significantly higher over control by 100.2 and 119.3 per cent, respectively. Salve *et al.* (2010) conducted a field experiment at MPKV, Rahuri and inferred that application of 75 kg P_2O_5 ha^{-1} progressively increased N uptake (202.21 kg ha^{-1}), P uptake (28.53 kg ha^{-1}) and K uptake (92.51 kg ha^{-1}) in groundnut, which were significantly higher over 50 kg P_2O_5 ha^{-1} and 25 kg P_2O_5 ha^{-1}. Ranjit *et al.* (2007) found that applying 112.5 kg P_2O_5 ha^{-1} in groundnut significantly increased uptake of N, P, K, and Ca compared to lesser phosphorus doses. Mirvat *et al.* (2006) averred that increasing the phosphorus dose from 30 to 60 kg P_2O_5 faddan^{-1} significantly increase protein and NPK content in kernel of groundnut considerably over control. Deka *et al.* (2001) adduced that applying 50 kg P_2O_5 ha^{-1} significantly increased N, P and K uptake in groundnut over control, while 75 and 100 kg P_2O_5 ha^{-1} had similar results.

Economics

Hinduja *et al.* (2020) adduced that maximum net return (₹ 1,38,787/ha) and benefit cost ratio (1.82) in groundnut were obtained with phosphorus dose 70 kg/ha + sulphur dose 40 kg/ha, which were significantly higher than rest of the treatments. Vali *et al.* (2020) found that application of 50 kg P_2O_5 ha^{-1} + 30 kg Zn ha^{-1} fetched highest net returns (₹ 1,39,103/ha) and benefit cost ratio (1.8) in groundnut, which were significantly higher over 30 kg P_2O_5 ha^{-1} + 0 kg Zn ha^{-1} by 37.1 and 29.5 per cent, respectively.

Kumar *et al.* (2019) conducted a field experiment at Odisha in groundnut and averred that application of 100 kg P_2O_5 ha^{-1} fetched highest gross return (₹ 97,152/ha), net return (₹ 58,858/ha) and benefit cost ratio (1.53), which were significantly higher over control by 43.8, 94.5 and 88.8 per cent, respectively. Sagvekar *et al.* (2017) testified that using 30 kg N ha^{-1}+ 75 kg P_2O_5 ha^{-1} resulted in a greater net return (₹ 58,826 ha^{-1}) and benefit cost ratio (1.78), which were significantly higher over other treatment combinations in groundnut. Yadav *et al.* (2015) reported that increasing the level of phosphorus up to 27 kg ha^{-1} progressively increased net returns (₹ 65,450/ha) and benefit cost ratio (2.54) in groundnut, which were significantly higher over control by 14.1 and 11.9 per cent, respectively.

Singh *et al.* (2014) examined that application of 20 kg N + 40 kg P_2O_5 ha^{-1} fetched highest net returns (₹ 30,123/ha) and benefit cost ratio (2.99) in groundnut, which were significantly higher over control by 73.9 and 20.0 per cent, respectively. Vishwakarma *et al.* (2012) reported that highest gross return (₹ 29,000 ha^{-1}) and benefit cost ratio (2.23) obtained with application of 30 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} + 40 kg K_2O ha^{-1}, while lowest gross return (₹ 12,060 ha^{-1}) and benefit cost ratio (1.21) obtained with control in groundnut.

Patra and Bandyopadhyay (2010) found that 150 percent phosphorus through phosphocompost grade-I had the highest net return (₹ 28590.47), while 100 percent phosphorus through phosphocompost grade-I had the highest B:C ratio (1.68) and they were far more cost-effective than sole application of chemical fertilizer and also combined sources of P application in groundnut.

Conclusion

It is concluded that phosphorus plays an important role to increase the yield of groundnut. The optimum dose of phosphorus significantly enhanced oil content, protein content, pod yield, haulm yield and prolonged crop maturity besides significant improvement in the performance of various growth parameters and dry matter production in groundnut.

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