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Research Communication

Optimization of phosphorus levels for enhancing groundnut productivity under different land configuration in semi-arid ecologies of Afghanistan

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ABSTRACT

The present investigation entitled "Optimization of phosphorus levels for groundnut under different land configuration in Afghanistan" was carried out at Afghanistan National Agricultural Science and Technology University (ANASTU), Kandahar Province, Afghanistan during spring season of 2020. The experiment was conducted in a split-plot design with 15 treatment combinations and three replications. The main-plot consised of land configurations, viz. ridge and furrow (RF), broad bed and furrow (BBF) and flatbed (FB), while the sub-plots comprised of phosphorus levels, viz. absolute control, 20, 40, 60 and 80 kg P_2O_5/ ha. The results revealed that the plant growth in terms of dry matter accumulation (above ground and below ground) and number of branches/plant were maximum in BBF, followed by FB and minimum in RF. Adoption of BBF also recorded significantly higher pod yield (2,987 kg/ha) and harvest index (31.0). With respect to P levels, application of 60 kg P_2O_5/ha produced significantly higher pod yield (3,363 kg/ha), biological yield (13,157 kg/ha) than other P_2O_5 levels. Therefore, growing of groundnut on BBF with application of 60 kg P_2O_5/ ha was found beneficial for achieving higher production and productivity under Afghanistan conditions.

Key words: Broad bed and furrow, Flat-bed, Pod yield, Ridge and furrow, Root dry matter

Groundnut (*Arachis hypogaea* L.) is an economically-important oilseed, feed, and food crop, which is widely cultivated in tropical and sub-tropical regions of the world (Ajay *et al*., 2023). It is an annual crop primarily grown for its protein rich kernel and edible oil. Planting geometry has a plentiful effect on the groundnut growth and productivity as it decides the plant architecture and its ability to use adequate resources. Groundnuts can be planted using a number of methods which include planting on flat ground (FG), earthing up after plant on flat ground, planting on raised bed and planting on ridges (Rathore *et al.,* 2014, Meena *et al*., 2022). However, groundnut productivity is low due to flatbed cultivation which hampers adequate pod development. Also, flat beds resulted in higher evaporation resulting in drought stress in groundnut. Therefore, modifying land configurations like raised bed technique tends to enhance growth and productivity of crops by reducing energy and carbon dynamics (Rathore *et al*., 2020). Phosphorus (P) is needed by groundnut plants for efficient root development for nodulation. P is a constituent of nucleic acid and thus aids in stimulation of root growth and nodule activity. Kamara *et al*. (2011) reported an increase in biomass of groundnut after the application of P fertilizer and attributed it to the availability of soluble phosphate that enhanced extensive root development. Adequate phosphorus nutrition has been attributed to enhanced yield and income of groundnut farmers because of the role played by phosphorus in the physiological process of plant growth and development. Hence, the proper optimization of P doses in different land configuration techniques is having a vital importance in deciding the productivity of groundnut. Therefore, the current study was carried out to investigate the effects of land configurations and P fertilizers on the performance of groundnut.

A field experiment was carried out at the ANASTU farm, Kandahar Province, Afghanistan (31°30'N, 65°50'E, 1010 m above mean sea-level) during spring season of 2020 to evaluate the different level of phosphorus for groundnut in different land configuration techniques. The

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experimental site has a subtropical steppe/low-latitude semi-arid hot climate. The maximum and minimum temperature during the experiment was 43°C and 15 °C, respectively with annual average precipitation of 190.6 mm. The experiment was laid out in a split-plot design with 15 treatment combinations each replicated thrice. The main-plots consisted of three land configuration techniques [ridge and furrow (RF), broad bed and furrow (BBF) and flatbed (FB)], while the sub plots consisted of variable P levels (0, 20, 40, 60 and 80 kg P_2O_5/ha). Apart from the treatments, other standard agronomic crop management practices were followed across the treatments. Growth parameters were taken by taking the average of five tagged plants. The recorded data were subjected to statistical analysis using ANOVA for the split-plot design.

The results showed that adoption of different land configuration and optimization of phosphorus significantly influenced on growth attributes of groundnut (Table 1). The adoption of BBF exhibited maximum branches/plant which remained significantly higher over other methods, and the minimum branches/plant were produced under FB at all crop growth stages (30, 60, 90 DAS and harvest). With respect to P levels, the application of 40-80 kg P_2O_5/ha performed equally and produced maximum branches/plant as compared to 20 kg P_2O_5/ha and absolute control at 30 DAS. At 60 DAS, 40 kg P_2O_5/ha noted significantly more branches/plant followed by 80 kg P_2O_5/ha. At 60 DAS and at harvest, the application of 80 kg P_2O_5/ha recorded significantly higher branches/plant, being at par with 60 and 40 kg P_2O_5/ha. However, the dry matter accumulation was higher at 60 kg P_2O_5/ha, which remained at par with 80 kg P_2O_5/ha. Nazir *et al*. (2022) reported that the P levels failed to affect number of main branches/plant significantly, but the application of 60 kg P_2O_5/ha produced slightly higher main branches/plant, mainly because of synchronous P supply and demand by the crop. Choudhary *et al*. (2011) carried out a field study on loam sand and reported that application of 20 kg N+40 kg P_2O_5/ha to cowpea produced significantly higher dry matter/meter row length, branches/plant, plant height, total chlorophyll content and number and weight of root nodules per plant over lower doses of N and P.

Dry matter accumulation (DMA) was also influenced significantly at 60, 90 DAS and also at harvest stage. No significant effect of land configurations was recorded on DMA at 30 DAS, but at 60 DAS, the higher DMA was recorded under BBF (Table 1). At 90 DAS, RF was recorded with significantly higher DMA (12.5 g/plant) whereas at harvest, the higher DMA (45.2 and 42.3 g/plant, respectively) was recorded under RF and BBF and the minimum was noticed under FB (29.5 g/plant). At 60 DAS, 40 kg P_2O_5 resulted in maximum dry matter (7.11 g/plant), whereas the minimum was recorded under control (4.17 g/plant). A similar trend of results was also recorded at harvest as noted at 90 DAS. Nazir *et al*., (2022) reported that the application of 60 kg P_2O_5/ha resulted in significantly higher plant height, leaf area index at 90 DAS and plant dry matter accumulation as compared to control. Whereas, at 90 DAS, higher (0.78 g) and lower (0.62 g) root dry matter accumulations were recorded with the application of 80 kg P_2O_5/ha and control plots, respectively. Choudhary *et al*. (2011) reported that P is needed by plants for efficient root development for nodulation and also phosphorus is a constituent of nucleic acid and thus aids in stimulation of root growth and nodule activity.

Among yield attributes, pods weight/plant increased under BBF (31.51 g), but it remained at par (Pd”0.05) with RF (30.36 g). Likewise, pods/plant (23.32) and 100 seed weight (77.89 g) were recorded higher with adoption of BBF over other land configurations (Table 2). The trend in

Table 1. Effect of land configuration and phosphorus levels on growth attributes of groundnut

Treatment	Branches/plant				Plant dry matter accumulation (g/plant)				Root dry matter accumulation (g/plant)		
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	At harvest
Land configuration											
RF	3.8^{b}	5.8^{b}	6.8^{b}	8.0^{c}	0.6	5.4^{b}	12.5^{a}	45.2^{a}	0.23^{a}	0.53^{b}	0.74^{a}
BBF	4.0^{a}	6.1^{a}	7.8^{a}	10.0^{a}	0.7	6.4^{a}	10.0^{b}	42.3^{a}	0.21^{a}	0.62^{a}	0.73^{a}
FB	3.7^{b}	5.6^{b}	7.7^{a}	8.5^{b}	0.7	5.1^{b}	8.0^{c}	29.5^{b}	0.18^{a}	0.34c	0.66^{b}
Phosphorus levels (kg P_2O_5/ha)											
Control	3.5^{b}	4.9^{d}	6.9^{c}	6.7^{c}	0.6	4.1^{c}	7.8^{c}	33.1^{c}	0.06^{d}	0.31^{b}	0.62^{c}
20	3.6^{b}	5.4^{cd}	7.2^{bc}	8.3^{b}	0.7	4.7^{c}	8.0^{c}	31.8^{c}	0.09^{c}	0.34^{b}	0.64^{c}
40	4.0^{a}	6.6^{a}	7.6^{ab}	9.5^{a}	0.8	7.1^{a}	9.6^{b}	35.8^{b}	0.14^{a}	0.44^{a}	0.73^{ab}
60	4.0^{a}	5.8^{bc}	7.8^{a}	9.5^{a}	0.6	5.5^{bc}	10.9^{a}	39.9^{a}	0.11^{b}	0.52^{a}	0.68^{b}
80	4.0^{a}	6.4^{ab}	7.8^{a}	10.1^{a}	0.6	6.8^{ab}	10.4^{a}	43.5^{a}	0.11^{b}	0.42^{a}	0.78^{a}

*RF: Ridge & furrow; BBF: Broad bed & furrow; FB: flat bed, similar letter within the column depicts non-significance at 5% probability level

Table 2. Effect of land configuration and optimization of phosphorus levels on yield and yield attributes of groundnut

Treatment	Pod weight/ plant (g)	Pod length (cm)	Kernel/ pod	Pods/ plant	100 -seed weight (g)	Pod yield (kg/ha)	Biological yield (kg/ha)	Harvest index	Shelling (%)
Land configuration									
RF	28.5^{b}	3.5^{a}	1.7^{a}	19.2^{b}	66.7^{c}	$2{,}912^{a}$	$9{,}009^{b}$	33^{a}	66.4
BBF	31.5^{a}	3.5^{a}	1.8^{a}	23.3^{a}	77.8^{a}	$2{,}987^{a}$	$9{,}673^{b}$	31^{a}	67.8
FB	30.3^{ab}	3.5^{a}	1.7^{a}	21.0^{b}	71.9^{b}	$2{,}578^{b}$	$11{,}344^{a}$	24^{b}	65.4
Phosphorus levels (kg P_2O_5/ha)									
Control	28.1^{b}	2.8^{d}	1.6^{c}	18.7^{c}	65.3^{b}	$2{,}026^{d}$	$7{,}198^{e}$	29^{b}	$65.3b^{c}$
20	27.9^{b}	3.4^{c}	1.7^{bc}	18.1^{c}	73.0^{a}	$2{,}631^{c}$	$8{,}950^{d}$	29^{ab}	$65.6ab^{c}$
40	29.8^{b}	3.6^{b}	1.8^{ab}	22.2^{b}	72.5^{a}	$3{,}163^{ab}$	$9{,}776^{c}$	33^{a}	69.2^{ab}
60	34.4^{a}	3.9^{a}	1.9^{a}	25.6^{a}	73.9^{a}	$3{,}363^{a}$	$13{,}157^{a}$	26^{b}	71.5^{a}
80	30.2^{b}	3.9^{a}	1.7^{bc}	21.1^{b}	76.1^{a}	$2{,}945^{bc}$	$10{,}965^{b}$	29^{b}	61.0^{c}

*RF, Ridge & furrow; BBF, Broad bed & furrow; FB, flat bed, similar letter within the column depicts non-significance at 5% probability level

groundnut pod and biological yield was also noted similar to yield attributes. The shelling percentage ranged 61.0 to 71.5%, with maximum being in BBF with 60 kgP_2O_5/ha and decreased with further increase in P_2O_5 levels (Table 2). The reasons for this decline with increase in P level might be due to antagonistic effects of P with other nutrients in the soil (Rathore *et al*., 2014). Significantly higher values yield (11,344 kg/ha) and seed yield/plant (0.21 kg) were noted under BBF than other land configurations. Adoption of BBF and RF also recorded significantly higher pod yield (2987 and 2912 kg/ha, respectively) and harvest index (31.0 and 33.0, respectively) and both remained statistically at par with each other. The extent of yield increment with BBF and RF over FB was 15.87 and 12.96%, respectively. The BBF provided a loose soil mass with adequate soil moisture which heightened the crop growth attributes. These conditions favorably influenced the easy peg penetration, pod development and thereby the shelling percentage, thus enabling the plants to express their potential to large extent (Heba *et al*., 2021).

Likewise, application of 60 kg P_2O_5/ha produced maximum pod weight/plant (34.46 g) and pods/plant (25.6) and proved significantly superior over other treatments. Increased pod length was noted in 60-80 kg P_2O_5/ha over other of phosphorus levels. Conversely, maximum kernel/pod was noted with 60 and 40 kg P_2O_5/ha which found significantly similar with each other. Application of 60 kg P_2O_5/ha produced significantly higher pod yield (3363 kg/ha), biological yield (13,157 kg/ha) and being at par with 40 kg P_2O_5/ha except biological yield which recorded significantly different from other levels of Phosphorus levels. The remarkable increase in pod yield with corresponding value of 65.99% was noted with the application of 60 kg P_2O_5/ha over control. With respect to 100 seed weight maximum value was recorded with 80 kg P_2O_5/ha and remained significantly static with other levels of phosphorus except control which found with significantly lowest 100 seed weight. Similarly, Nazir *et al.* (2022) reported that application of 60 kg P_2O_5/ha significantly increased yield attributes as well as pods yield, kernel yield, haulm yield and biological yield.

From the current study, it may be concluded that the adoption of BBF along with 60 kg/ha P_2O_5 will be beneficial for increasing the growth and productivity of groundnut in Afghanistan and similar other agro-ecologies.

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