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# Optimization of Crop Establishment Methods and Phosphorus Fertilizer Levels on Growth and Economic Efficiency of Groundnut under Semi-Arid Region of Afghanistan

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## ABSTRACT

**An experiment was conducted at the farm of Afghanistan National Agricultural Science and Technology University (ANASTU), Kandahar Province, Afghanistan in cropping season of 2020 to investigate the Optimization of Crop Establishment methods and Phosphorus Fertilizer levels on Growth and Economic Efficiency of Groundnut under Semi-arid region of Afghanistan. The experimentation was conducted in split-plot design with 15 treatment combinations and replicated thrice. main-plot consisted of crop establishment methods, 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 of the investigation revealed that the growth parameters in terms of plant height in and leave area were highest in BBF, followed by FB and minimum was in RF. Adoption of BBF recorded significantly higher gross return (238928 AFN/ha), net return (202728 AFN/ha) and net benefit cost of ratio (5.2) were in Broad Bed and Furrow, followed in ridged and furrow and the minimum was in flat bed method. It can be concluded, cultivating of groundnut with Broad Bed and Furrow with application of 60 kg $P_2O_5$/ha was found beneficial for reaching higher productivity and profitability under semi-arid region of Afghanistan.**

***Keywords***- Broad Bed and Furrow, Economic, Establishment, Flatbed, Groundnut, Growth, Phosphorus, Ridge and furrow.

## I. INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is one of the most vital oil seed crops and food grain pulses which is well cultivated in the recently cultivated sandy soils which usually suffers from the deficiency or absence of most phosphorus fertilizer. It ranks the 13th among the food crops and yearly oil seed crops in the world. It has a good ability for cultivating the physical structure of such soils. Most nutrients in these soils are deficient due to the low organic matter content, high CaCO3 content and high soil pH. To overcome the difficulties of these soils and expand the fertility levels, soil amendments, such as clays and organic materials, as well as chemical fertilizers should be applied to these soils (*Khaleeq et al., 2023c*). The beneficial effect of macronutrients

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comes from its role in the improvement of photosynthesis and groundnut yield and quality as well as the nutrient uptake. Macronutrients promote the plants to grow well and improve transferring the photosynthetic substances from leaves to grains during the synthesis process due to their effects on enzymatic activities that are definitely reflected on the weight of grains (*Nazir et al., 2022, Khaleeq et al., 2024a*).

Phosphorus fertilizer is the second most important critical nutrient element for crop growth, quality, yield and one of the evident effect of phosphorus is shown on plant root system improvement. There is higher requirement for phosphorus in pulses in compared to non-legume crops because of its role in nodule formation and fixation of atmospheric nitrogen *Khaleeq et al., (2024b)* reported an growth in biomass of groundnut after the application of phosphorus fertilizer and attributed it to availability of soluble phosphate that improved widespread root expansion. Suitable phosphorus nutrition has been attributed to improved yield and income of groundnut farmers because of the role played by phosphorus in the physiological process of plant growth and expansion. *Samim et al., (2023*), *Khaleeq et al., (2023b*) reported that improved pods/plant, seed yield and shelling percentage of groundnut was due to early and plentiful availability of phosphorus to plants which well influenced the kernel increase and kernel size. Due to the essential role played by Phosphorus in the physiological processes of plants, application of Phosphorus to soil poor in this nutrient leads to rise groundnut yield (*Seerat et al., 2023, Hemmat et al., 2023)*. Groundnut is essential legume oilseed crop and it is also known as peanut, earth nut, monkey nut and goober. Locally it is called *Pali* and *Mumpali* in Pashto and *Badam-e-zamini* in Dari language in Afghanistan, Groundnut kernel has nearly 50% high quality edible oil, 25% digestible protein and 20% carbohydrates (*Nazir et al., 2022, Sadiq et al., 2023*; *Khaleeq et al., 2024f*). Groundnut is cultivating in tropical, sub-tropical and warm temperature regions between 40º N and 40º S latitude. The global area under groundnut cultivation is 31.57 million hectare with total produce 53.64 million tones, the average production is 1.691 ton/ha (*Dass et al., 2014*; *Farkhari et al., 2023; Khaleeq et al., 2024c; Khaleeq et al., 2024g*) However, groundnut efficiency is low because of flatbed crop growing which hampers sufficient pod expansion. Also, flat bed resulted in higher dehydration resulting in drought stress in groundnut.

Therefore, modifying crop establishments like raised bed technique tends to improve growth and production of crops by reducing energy and carbon dynamics (*Rathore et al., 2020*, *Khaleeq et al., 2023d*). Phosphorus fertilizer is required by groundnut plants for effective root expansion for nodulation. Phosphorus is essential of nucleic acid and thus aids in stimulus of root growth and nodule activity. The objectives of this research is to evaluate effect of different crop establishment methods and phosphorus doses on growth and economic efficiency of groundnut in semi-arid regions of Afghanistan.

## II. MATERIALS AND METHODS

A field experiment was conducted at the farm of ANASTU, Kandahar Province, Afghanistan (31°30'N, 65°50'E, 1010 m above mean sea-level) in cropping season of 2020 to estimate the different level of phosphorus fertilizer for groundnut in different crop establishment methods. The experiment site has a subtropical steppe/low-latitude semi-arid condition and hot climate. The maximum and minimum temperature during the experiment was 47°C and 18 °C, respectively with annual average precipitation of 190.6 mm. The experiment was conducted in a split-plot design with 15 treatment combinations each replicated thrice. The main-plots consisted of three crop establishment methods (ridge and furrow (RF), broad bed and furrow (BBF) and flatbed (FB), while the sub plots consisted of variable Phosphorus levels (0, 20, 40, 60 and 80 kg $P_2O_5$/ha). Apart from the treatments, other normal agronomic crop management practices were followed across the treatments. Growth parameters were taken by the average of five tagged plants. The recorded data were subjected to statistical analysis using ANOVA for the split-plot design.

## III. RESULT AND DISCUSSION

The plant height (cm) was recorded at different crop growth stages (30, 60, 90 DAS and also at harvest), significant impact was observed at different crop establishment methods and also Phosphorous levels. At 30 DAS, there was no effect of crop establishment on plant height, while at 60, 90 DAS and also at harvest Ridge & Furrow, Broad bed & Furrow resulted in enhanced plant height over flatbed configuration. The Phosphorous levels also have significant impact on plant height of groundnut. Compared to control, the successive dosses of Phosphorous resulted in increased plant height of groundnut (Table 1). At 30 DAS, $P_2O_5$ level of 40-80 kg/ha resulted in higher plant height of the groundnut crop. More or less similar was the trend at 60 and 90 DAS barring at 60 DAS, the $P_2O_5$ level of 20 kg/ha resulted in at par with 80 kg/ha and increase plant height over absolute control. While at harvest stage, the $P_2O_5$ level of 60 and 80 kg/ha resulted in higher plant height of 32.41 cm and 32.14 cm, respectively over the remaining Phosphorous levels. An examination of data presented in (Table1) revealed that leaf area of groundnut crop influenced by different crop establishment methods and different levels of phosphorus. Broad bed & Furrow resulted into maximum leaf area per plant (115.88, 225.91, 669.52 and 3030.78 $cm^2$) at 30, 60, 90 DAS and also at harvest. The next best was Ridge & Furrow which recorded

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significantly higher leaf area at different stages of the crop. While compare to the $P_2O_5$ levels, it was noticed that 80 kg $P_2O_5$/ha did not differ significantly than 60 kg $P_2O_5$/ha with respect to leaf area at 30 DAS. Conversely, at 60 DAS maximum value of leaf area was noted with application of 40 kg $P_2O_5$/ha which remained at par with 20 and 80 kg $P_2O_5$/ha. At 90 DAS and at harvest 40- 80 kg $P_2O_5$/ha found equally effective and resulted in maximum increase in leaf area of the groundnut crop. Significantly lowest leaf area was produced under absolute control at different growth stages. Our finding is similar with the result of *Nazir et al., (2022); Khaleeq et al., (2024g)* reported maximum plant height and leave area were recorded in phosphorus application of 60 kg $P_2O_5$/ha along with Broad bed & Furrow. *Khaleeq et al., (2023e*) who also reported Broad bed & Furrow with phosphorus application at the rate of 60 kg $P_2O_5$/ha increased plant height and leave area of groundnut at 30 DAS, 60 DAS, and 90 DAS and at harvest time. The effects economic of crop establishment and level of Phosphorous on groundnut economics has been depicted Table 2, 3. Ridge & Furrow and Broad bed & Furrow resulted in maximum gross as well as net return (232960, 196760 AFN/ha and 238928 and 202728 AFN/ha respectively compare to flatbed land. The $P_2O_5$ level of 60 kg/ha resulted in best economics in terms of net return, gross return and also B: C ratio. Indicates the economic optimum level of 60 kg/ha of $P_2O_5$ under different crop establishment. *Khaleeq et al., (2023c*) observed Broad bed & Furrow along with 60 $P_2O_5$ were the highest yield, gross and net return of groundnut. *Samim et al., (2023); Khaleeq et al., (2023a); Ahmadi et al., (2024)* demonstrated crop establishment significantly affected yield of soybean, broad bed and furrow with optimum level of phosphorus fertilizer at the rate 60 kg $P_2O_5$/ha highly significantly increased soybean yield.

**Table (1): effect of crop Establishment methods and phosphorus fertilizer doses on plant height and leaf area**

| Treatments | Plant height (cm) | | | | Leaf Area ($cm^2$) | | | |
|---|---|---|---|---|---|---|---|---|
| | 30 DAS | 60 DAS | 90 DAS | At harvest | 30 DAS | 60 DAS | 90 DAS | At harvest |
| Crop Establishment methods | | | | | | | | |
| Ridge & Furrow | 5.1 | $14.9^b$ | $25.9^a$ | $33.9^a$ | $75.1^b$ | $188.9^b$ | $482.0^b$ | $1920.7^b$ |
| Broad bed & Furrow | 5.2 | $16.2^a$ | $24.8^b$ | $33.3^a$ | $115.8^a$ | $225.9^a$ | $669.5^a$ | $3030.7^a$ |
| Flatbed | 5.0 | $16.1^a$ | $21.2^c$ | $28.5^b$ | $59.3^c$ | $180.8^b$ | $445.0^b$ | $1774.3^b$ |
| SEm± | 0.59 | 0.8 | 1.0 | 1.4 | 3.8 | 10.2 | 21.2 | 75.2 |
| CD (P=0.05) | NS | 1.5 | 2.2 | 3.0 | 8.0 | 19.5 | 52.2 | 185.2 |
| Phosphorus fertilizer Levels | | | | | | | | |
| Absolute control | $4.5^b$ | $14.0^b$ | $20.9^c$ | $28.9^c$ | $54.6^c$ | $160.2^c$ | $469.3^c$ | $1566.3^b$ |
| 20 kg $P_2O_5$ $ha^{-1}$ | $4.8^b$ | $15.8^a$ | $23.2^b$ | $29.5b^c$ | $81.2^b$ | $214.7^a$ | $507.9^b$ | $1564.9^b$ |
| 40 kg $P_2O_5$ $ha^{-1}$ | $5.3^a$ | $16.7^a$ | $25.7^{ab}$ | $31.1^{ab}$ | $87.1^b$ | $215.7^a$ | $573.7^a$ | $2471.0^{ab}$ |
| 60 kg $P_2O_5$ $ha^{-1}$ | $5.4^a$ | $16.1^a$ | $27.8^a$ | $32.4^a$ | $90.2^{ab}$ | $188.2^b$ | $552.2^{ab}$ | $2640.0^a$ |
| 80 kg $P_2O_5$ $ha^{-1}$ | $5.6^a$ | $16.2^a$ | $27.0^a$ | $32.1^a$ | $101.3^a$ | $213.8^a$ | $557.7^{ab}$ | $2967.3^a$ |
| SEm± | 0.22 | 0.71 | 1.2 | 1.5 | 5.2 | 9.85 | 24.2 | 14.2 |
| CD (P=0.05) | 0.55 | 1.56 | 2.8 | 3.2 | 11.5 | 19.5 | 55.6 | 31.2 |

**Table (2): effect of crop establishment methods and phosphorus levels on gross return, net return and Net B: C ratio**

| Treatments | Cost of cultivation (AFN/ha) | Gross return (AFN/ha) | Net return (AFN/ha) | Net B:C ratio |
|---|---|---|---|---|
| Crop Establishment methods | | | | |
| Ridge & Furrow | 36200 | $232960^a$ | $196760^a$ | $5.3^a$ |
| Broad bed & Furrow | 36200 | $238928^a$ | $202728^a$ | $5.2^a$ |
| Flatbed | 36200 | $206245^b$ | $170045^b$ | $4.7^b$ |
| SEm± | - | 11200 | 9500 | 0.20 |
| CD (P=0.05) | NS | 22800 | 18200 | 0.4 |
| Phosphorus fertilizer Levels | | | | |
| Absolute control | 32120 | $162080^d$ | $129960^d$ | $4.0^c$ |
| 20 kg $P_2O_5$ $ha^{-1}$ | 35720 | $210471^c$ | $174751^c$ | $4.8^b$ |

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| 40 kg $P_2O_5$ ha$^{-1}$ | 36720 | 253013$^{ab}$ | 216293.33$^{ab}$ | 5.8$^{a}$ |
| 60 kg $P_2O_5$ ha$^{-1}$ | 37720 | 269040$^{a}$ | 231320$^{a}$ | 6.1$^{a}$ |
| 80 kg $P_2O_5$ ha$^{-1}$ | 38720 | 235618$^{bc}$ | 196898$^{bc}$ | 4.0$^{c}$ |
| SEm± | - | 11600 | 95300 | 0.21 |
| CD (P=0.05) | NS | 23400 | 19500 | 0.45 |

**Table (3): Interaction effect of crop establishment methods and phosphorus levels on net return (AFN/ha)**

| | Absolute control | 20 kg $P_2O_5$ ha$^{-1}$ | 40 kg $P_2O_5$ ha$^{-1}$ | 60 kg $P_2O_5$ ha$^{-1}$ | 80 kg $P_2O_5$ ha$^{-1}$ | Main Plot Means |
|---|---|---|---|---|---|---|
| Ridge & Furrow | 126200 | 170013 | 242986 | 248226 | 196373 | 196760$^{A}$ |
| Broad bed & Furrow | 106013 | 166226 | 223013 | 303213 | 215173 | 202728$^{A}$ |
| Flatbed | 157666 | 188013 | 182880 | 142520 | 179146 | 170045$^{B}$ |
| Sub Plot Mean | 129960$^{D}$ | 174751$^{C}$ | 216293$^{AB}$ | 231320$^{A}$ | 196898$^{BC}$ | General Mean=189844 |
| MP - Main Plot, SP - Sub Plot | | | | | | |

## IV. CONCLUSION

The experiment entitled optimization of crop establishment methods and phosphorus fertilizer levels has shown that the combination of broad bed and furrow along with 60 kg $P_2O_5$/ha has resulted highest growth and economic efficiency. This approach has demonstrated potential for increasing crop yields while also optimizing the use of phosphorus fertilizer. Further research and field trials are needed to confirm these findings and to explore the potential benefits of this approach in different agricultural practices. However, the results suggest that Broad bed and furrow method along with 60 kg $P_2O_5$/ha has the potential to contribute to sustainable and efficient crop production.

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