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Original Research

RESPONSE OF DIFFERENT PHOSPHORUS LEVELS AND APPLICATION METHODS ON THE GROWTH YIELD AND QUALITY OF LINSEED CROP

MUHAMMAD HF*, AHMAD A, TAHIR M

Department of Agronomy, University of Agriculture, Faisalabad Pakistan
Corresponding Author: awanuaf2010@gmail.com

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Abstract: *The effects of five phosphorus levels and two fertilizer application methods on the growth, yield and quality of linseed were evaluated at the Agronomic Research Area, University of Agriculture, Faisalabad. Linseed variety "Chandni" was grown under triplicate RCBD factorial design following two application methods of fertilizer, including side drilling and broadcast, with different doses of P2O5, i.e. 20, 40, 60, 80 and 100 kg ha-1,using DAP as a source in sub plots, with net plot size of 5 m × 1.8 m. The data was recorded for different traits and statistically analyzed which showed highly significant results with respect to side drilling method; while, parameters including time to start germination and time taken to 50% germination showed non-significant effect in regard of phosphorus application methods. Broadcasting method of application has showed statistically significant results for mean emergence time, plant population, plant height, number of branches per plant, number of seeds per capsule, seed yield and biological yield as well. Among different phosphorus levels, phosphorus applied @ 60 kgha-1 significantly affected maximum to start germination, mean emergence time, plant height, number of capsule per plant, number of seeds per capsule, biological yield and seed protein content; while, plant population, 1000-seed weight, seed oil content were significantly affected by the phosphorus applied @ 40 kgha-1. Among the interaction effect between application method and different phosphorus levels, phosphorus applied @ 60 kgha-1 through the method of side drilling significantly affected the time to start germination, mean emergence time, plant height, biological yield and seed protein content. It was concluded from our study that the application method of side drilling and level of phosphorus when applied @ 60 kgha-1 significantly affected on growth, yield and quality of linseed.*

Keywords: Growth, yield, broadcast, side drilling, phosphorous levels, application methods

Introduction

Linseed (*Linum usitatissimum* L.) is grown as a winter annual crop which belongs to family Lineaceae. It is the sixth largest oilseed crop around the world and mostly grown in West Asia and Mediterranean regions. It maintains a unique importance among oil seed as well as fiber crops and stands on significant position for centuries regarding production (Genser and Morris, 2003). It is considered to be an important cultivated crop due to high nutritional potential like protein content, water soluble fiber fraction (Warrand *et al*., 2005), lignin content (Hyvarinen *et al*., 2006), enzymes (El-Nagdy *et al*., 2010), mucilage, linamarin (a cyanogenic glycoside) and specifically for its oil contents now a days (Oomah, 2001). The dietary fiber content is about 28% in linseed crop (Foster *et al*., 2009) along with 33-47% oil and 20-25% protein content. Seed contains esters of linolenic acid, oleic acid and stearic acid with 30-40% fatty acid content (El-Nagdy *et al*., 2010). The 1:3 ratio of omega-3 to omega-6 fatty acids found only in linseed as compared with the rest of the oil seed crops (Bhatia *et al*., 2006). Among the major roles that the agricultural crop production mostly provide to the humans include lipids, carbohydrates, proteins in the form of amino acids, 13 vitamins and 17 mineral elements. But linoleic acid, linolenic acids and lipids are such types of substances that cannot be produced by the humans and must be obtained in their dietary sources. Along with flax production to the oil seed extraction and fiber content, that has been used in poultry and animal feed production, varnishes & paints, cosmetics and compact wood production known as particle board (Bakry *et al*., 2012). Phosphorus plays a significant role in the photosynthesis process (Cho et al., 2012), conservation of energy (Schluepmann et al., 2012) and metabolism of carbon (Abel et al., 2002). Experimental studies have shown that phosphorus has a significant effect on the growth and development of plants along with an increase in grain yield of oilseed crops (Gao et al., 2006; Grant et al., 2010). Balanced dose of fertilizers increases the yield of fiber and quality of flax (Yang and lu, 2003; Liu et al., 2013).

Materials and Methods

The present study was carried out at the Agronomic Research Area, University of Agriculture, Faisalabad

(31.25˚N, 73.09 ˚E) during winter 2015. The soil was a sandy clay loam in texture. Soil samples were taken up to a depth of 30 cm for physiochemical analysis before sowing of crops, which showed.

Table 1: Chemical analysis of soil

	Soil Depth (cm)	
Parameters	15	30
pH	7.59	7.8
EC ds/m	1.05	0.70
CO3 me/L	1.2	-
HCO3 me/L	3.48	4.52
Cl- me/L	5.72	10.5
Ca+Mg me/L	7.32	5.6
N %	0.075	0.087
Mechanical Analysis		
Sand %	61	57
Silt %	19	20
Clay %	20	23
Textural class	Loam	

The experiment was laid out in a randomized complete block design with factorial arrangements having net plot size 5 m × 1.8 m with three replications. **Factor A:** (Application methods of Phosphorus), M_1: Broadcast, M_2: Side Drilling, **Factor B:** (Phosphorus levels) kg ha^{-1}, P1: 20, P2: 40, P3: 60, P4: 80, P5:100

Results and discussions

Plant population m^{-2} at harvest

Plant population is an important yield contributing parameters. A good stand establishment ensures better yield of crop. From Table 3 it was found that both the factors have significantly increased the plant population of linseed crop. And their interaction was also found to be significant. Maximum plant population (32.00) was found where linseed was grown under fertilization of phosphorous @ 100 kg ha^{-1} by side drilling. Increase in plant population m^{-2} might be due to maximum phosphorous level and side drilling of phosphorous, as it might have increased the uptake and P absorption through roots that ultimately increased the plant population per m^2.

Table 2. Analysis of variance for diffident studied traits of linseed

SOV	DF	Plant population m^{-2} at harvest	Plant height (cm)	Number of capsules per plant	Number of seed per capsule	Seed yield kg. ha^{-1}
Replication	2	0.0337	0.0074	10.4	0.00016	6.9
Method	1	34.6688**	2.845**	16585.8**	2.5172**	7124**
Phosphorous levels	4	5.0138**	51.7908**	355.5**	2.9142**	6511.5**
Method × phosphorous	4	16.9238**	98.3728**	1828.2**	7.6363**	18819.4**
Error	18	0.0322	0.0007	12.3	0.00183	23.2**

**= Highly Significant

Table 3. Individual comparison of treatment means of Plant Population m^{-2} At Harvest

Factor B	**Treatments – Factor A (Application methods)**		
Phosphorus levels	**M_1 (Broadcasting)**	**M_2 (Side drilling)**	**Means**
P_1 @ 20 (kg ha^{-1})	30.2 c	30.0 c	**30.100 A**
P_2 @ 40 (kg ha^{-1})	28.2 e	31.5 b	**29.850 B**
P_3 @ 60 (kg ha^{-1})	29.1 d	26.7 g	**27.900 D**
P_4 @ 80 (kg ha^{-1})	26.0 h	31.8 ab	**28.925 C**
P_5 @ 100 (kg ha^{-1})	27.7 f	32.0 a	**29.850 B**
Means	**28.250 B**	**30.400 A**	

LSD 0.05 for method = 0.137 LSD for phosphorous = 0.217 LSD for Interaction = 0.3078

Plant height (cm)

Plant height shows the vegetative growth of crop, if a crop is well nourished then its growth increases resulting in increase of plant height. From Table 4 it was reported that both factors application method and phosphorous levels and their interaction had significantly increased the plant height of linseed. Highest plant height (85.2 cm) was found where side drilling of phosphorous was performed by using P @ 60 kg ha^{-1}. Increase in plant height might be due to phosphorous fertilization as P is important part of many enzymes that increases the growth of plant (Oomah, 2001; El-Nagdy et al., 2010; Cho et al., 2012; Liu et al., 2013; Gao et al., 2006).

Table 4. Individual comparison of treatment means for Plant Height (cm)

Factor B	Treatments Factor A (Application methods)		
Phosphorus levels	**M_1 (Broadcasting)**	**M_2 (Side drilling)**	**Means**
P_1 @ 20 (kg ha^{-1})	73.4 h	70.7 j	**72.065 E**
P_2 @ 40 (kg ha^{-1})	62.3 b	75.1 g	**78.735 B**
P_3 @ 60 (kg ha^{-1})	72.3 i	85.2 a	**78.785 A**
P_4 @ 80 (kg ha^{-1})	75.7 e	76.0 d	**75.895 D**
P_5 @ 100 (kg ha^{-1})	81.8 c	75.5 f	**78.700 C**
Means	**77.144 A**	**76.528 B**	

LSD 0.05 for method = 0.020 LSD for phosphorous = 0.032 LSD for Interaction = 0.046

Number of capsules per plant

Increase in capsule increases the yield of crop. From Table 5 it was cleared that both the factors and their interaction has enhanced the number of capsules per plant. Maximum number of capsules per plant (310.00) was found where side drilling of phosphorous was done @ 20 kg ha[1]. Increment in number of capsules might be due to a greater number of branches per plant, application of phosphorous and especially the application method. Side drilling might have better effect on number of capsules of plant (El-Nagdy et al., 2010; Liu et al., 2013; Gao et al., 2006).

Table 5. Individual comparison of treatment means of number of Capsules per Plant

Factor B	Treatments Factor A (Application methods)		
Phosphorus levels	**M_1 (Broadcasting)**	**M_2 (Side drilling)**	**Means**
P_1 @ 20 (kg ha^{-1})	211.50 g	310.00 a	**260.75 B**
P_2 @ 40 (kg ha^{-1})	247.30 f	304.33 ab	**275.81 A**
P_3 @ 60 (kg ha^{-1})	266.67 d	286.83 c	**276.75 A**
P_4 @ 80 (kg ha^{-1})	258.67 e	268.33 d	**263.50 B**
P_5 @ 100 (kg ha^{-1})	250.67 f	300.45 b	**275.56 A**
Means	**246.96 B**	**293.99 A**	

LSD 0.05 for method = 2.68 LSD for phosphorous = 4.25 LSD for Interaction = 6.01

Number of seed per capsule

Increase in number of seed per capsule increases the final yield of crop. It is an important factor which is directly affected by fertilization and its application methods. From Table 6 it was evident that maximum number of seeds per capsule (9.59) was found in treatment where side drilling of phosphorous was done and P was applied @ 20 kg ha^{-1}. And minimum number of seed per capsule (5.90) was found where side drilling of phosphorous @ 40 kg ha^{-1} was done (El-Nagdy et al., 2010; Cho et al., 2012; Liu et al., 2013).

Table 6. Individual comparison of treatment means of number of Seed Per Capsule

Factor B	Treatments Factor A (Application methods)		
Phosphorus levels	**M_1 (Broadcasting)**	**M_2 (Side drilling)**	**Means**
P_1 @ 20 (kg ha^{-1})	594.20 g	738.60 b	**666.40 C**
P_2 @ 40 (kg ha^{-1})	642.27 f	788.30 a	**715.28 A**
P_3 @ 60 (kg ha^{-1})	687.40 d	704.70 c	**696.05 B**
P_4 @ 80 (kg ha^{-1})	676.40 e	581.47 h	**628.93 D**
P_5 @ 100 (kg ha^{-1})	695.40 d	636.70 f	**666.05 C**
Means	**689.95 A**	**659.13 B**	

LSD 0.05 for method = 0.032 LSD for phosphorous = 0.051 LSD for Interaction=0.073

Seed yield (kg ha^{-1})

Seed yield of crop is important and economical part. It indicates the overall potential of crop. It was confirmed from Table 7 that both the factors and their interaction had significantly increased the seed yield of linseed. Maximum seed yield (788.30 kg ha^{-1}) was found where side drilling of phosphorous dose @ 40 kg ha^{-1} was done. Increase in seed yield might be due to proper phosphorous level and proper application method (Cho et al., 2012; Gao et al., 2006).

Table 7. Individual comparison of treatment means of Seed Yield Kg. ha^{-1}

Factor B	Treatments Factor A (Application methods)		
Phosphorus levels	**M_1 (Broadcasting)**	**M_2 (Side drilling)**	**Means**
P_1 @ 20 (kg ha^{-1})	6.50 h	9.59 a	**8.04 AB**
P_2 @ 40 (kg ha^{-1})	7.05 f	5.90 j	**6.47 D**
P_3 @ 60 (kg ha^{-1})	8.15 d	8.00 e	**8.07 A**
P_4 @ 80 (kg ha^{-1})	8..60 c	6.00 i	**7.30 C**
P_5 @ 100 (kg ha^{-1})	9.05 b	6.96 g	**8.00 B**
Means	**7.87 A**	**7.29 B**	

LSD 0.05 for method = 3.696 LSD for phosphorous = 5.843 LSD for Interaction = 8.264

Conclusions

Among different plant parameters including; time taken to 50% germination, number of capsules per plant, number of seeds per plant, 1000-seed weight, seed yield, harvest index, seed oil content, seed protein content showed highly significant results with respect to side drilling method of application. While among different P levels, phosphorus applied @ 60 kg. ha^{-1} significantly affected maximum plant attributes like time to start germination, mean emergence time, plant height, number of capsule per plant, number of seeds per capsule, biological yield and seed protein content; while, parameters like plant population, 1000-seed weight, seed oil content were significantly affected by the phosphorus applied @ 40 kgha^{-1}. Plant parameters including number of branches and seed yield were highly affected by the phosphorus applied @ 40 kgha^{-1}. Plant parameter including harvest index were being significantly affected through the phosphorus application @ 1000 kgha^{-1}. Among the interaction effect between application method and different phosphorus levels, phosphorus applied @ 60 kgha^{-1} through the method of side drilling significantly affected the maximum number of plant attributes including time to start germination, mean emergence time, plant height, biological yield and seed protein content. Overall, best results were observed by application method of side drilling and level of phosphorus when applied @ 60 kgha^{-1} significantly affected on the growth, yield and quality of linseed. So, present study suggested that growth, yield and quality of linseed can be maintained by the proper use of phosphorus fertilizer and by adopting an appropriate application method preferably side drilling method.

Conflict of interest

The authors declared absence of any type of conflict of interest for manuscript publication.

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