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Response of growth and yield linseed (*Linum usitatissimum* L.) as influenced in cropping system, irrigation and phosphorous

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Abstract
A field investigation was conducted at Agronomy research farm A. S. (P.G) College, Lakhaoti, Bulandshahr during rabi seasons of 2006 and 2007. The treatments consisted of combination of four cropping systems *viz*. chickpea sole (M1), linseed sole (M2), chickpea+ linseed 2:1 ratio (M3) and pigeonpea + linseed 4:2 ratio (M4) in main plots; two irrigations *viz*. two irrigations at vegetative stages (30-40 days) and flowering stage (70-75 days) (S1) and one irrigation at flowering stage (70-75 days) (S2) in sub plots and three levels of phosphorous *viz*. control (L1), 30 kg P_2O_5/ha (L2) and 60 kg P_2O_5/ha (L3) in sub-sub plots in split plots design replicated thrice during the rabi season. The chickpea variety BG-362 and linseed variety neelam were used in the cropping systems during rabi season. The soil of the experimental site was low in organic carbon (0.47 and 0.48 kg/ha) and total nitrogen (154.0 and 155.1 kg/ha). It was low in available phosphorus (9.2 and 9.24 kg/ha) and medium in available potassium (203.0 and 203.6 kg/ha) and sandy loam in texture having alkaline reaction (pH 7.5). The weather during the both years of the experiment was by and large normal and devoid of any extreme conditions. The net return was found to be maximum under chickpea: linseed in 4:2 row ratio with two irrigations and 60 kg P_2O_5/ha. (Rs. 21,632 and Rs. 22,128) followed by sole chickpea with two irrigation and 60 kg P_2O_5/ha. Due to relatively higher gross return. The maximum B:C ratio of 1.87 and 1.91 was obtained from chickpea: linseed in 4:2 with one irrigation at flowering and 60 kg P_2O_5/ha, because of reduced cost of on irrigation and higher gross return of the system.

Keywords: Cropping System, irrigation, levels of phosphorous, lineseed

Introduction
Linseed (*Linum usitatissimum* L.) is one of the important oilseed crop of the world from very beginning of the human civilization. It belongs to the genus Linum of the family Linaceae, having 13 genera, but only *Linum usitatissimum* (with diploid chromosome 2n = 30) is the only cultivated species of genus Linum. It is believed that this crop species originated from Linum angustifolium Huds native to the Mediterranean region [1]. The name Linum was derived from Latin lin or “thread” and the species name usitatissimum meaning “most useful”. The word ‘flax’ is used when it is grown for fibre, ‘linseed’ is used when it is grown for oil purpose and ‘dual purpose flax’ when grown for both oil and fibre. It is also popularly known as Alsi, Tisi, Jawas, Aksebija in Indian languages. Linseed is currently cultivated in Russia, U.S.A., Argentina, Uruguay, India, Pakistan, China, Japan, Morocco, Australia, Ireland, Scotland, Poland, and a few other European countries. The family is cosmopolitan, and includes about 250 species in 14 genera, classified into two subfamilies: the Linoideae and Hugonioideae (often recognized as a distinct family, the Hugoniaceae). Leaves of the Linaceae are always simple; arrangement varies from alternate (most species) to opposite (in *Sclerolinon* and some *Linum*) or whorled (in some *Hesperolinon* and *Linum* species).
In the Linoideae, the largest genus is *Linum*, the flaxes, with 180–200 species including the cultivated flax, *Linum usitatissimum*. Members of the Linoideae include herbaceous annuals and perennials, as well as woody subshrubs, shrubs, and small trees (*Tirpitzia*) inhabiting temperate and tropical latitudes of Eurasia, Africa, Australia, and the Americas. The largest genus of the Hugonioideae is *Hugonia* (about 40 species); the Hugonioideae are woody vines, shrubs, and trees, and are almost entirely tropical in distribution. In addition to their growth habits and geographic distributions, the Linoideae and Hugonioideae can be differentiated by the number of fertile stamens (five in the Linoideae, 10 in the Hugonioideae) and fruit type.

lntercropping is an agronomic refinement of the old practice of crop mixture, where in the crop components, usually two are sown in separate rows, their population ratios are know and they can be harvested singly and produce recorded separately. The crop components often have. different growth period and growth habits, statistical analysis and interpretation of the total and individual products is, thus, possible and valid, for drawing conclusion of the propriety or otherwise of the system in a given region. Among various measures adopted for improving the productivity of oil seed crops, one technique may be to grow these crops with legumes. It has been observed that intercropping of oil seed with cereals, pulses and fibers is one of the best techniques to increase production. Phosphorus is the most vital nutrient, which contributes directly to both yield and quality of chickpea. It plays an important role to various physiological processes. Moreover, it is constituent of ADP, ATP, nucleic acids and nucleo proteins and several co-enzymes, which are of great importance in energy transformation and metabolic activities of the plant. Phosphorus deficiency is usually the key factor for poor yield of pulses on most of the soils. In absence of inadequate supply of phosphorus sometimes, other nutrient elements also become ineffective for plant use. A good supply of phosphorus to the plants helps in better root development and hastens maturity. Optimum levels of phosphorus increases growth, nodulation and nitrogen fixation in legumes. There is a considerable variation in its requirement, which need careful study before making any recommendation for getting economical yield.

Materials and Methods

A field investigation was conducted at Agronomy research farm A. S. (P.G) College, Lakhaoti, Bulandshahr during rabi seasons of 2006 and 2007. The treatments consisted of combination of four cropping systems *viz*. chickpea sole (M1), linseed sole (M2), chickpea+ linseed 2:1 ratio (M3) and chickpea + linseed 4:2 ratio (M4) in main plots; two irrigations *viz*. two irrigations at vegetative stages (30-40 days and flowering stage (70-75 days) (S1) and one irrigation at flowering stage (70-75 days) (S2) in sub plots and three levels of phosphorous *viz*. control (L1), 30 kg P_2O_5/ha (L2) and 60 kg P_2O_5/ha (L3) in sub-sub plots in split plots design replicated thrice during the rabi season. The chickpea variety BG-362 and linseed variety neelam were used in the cropping systems during rabi season. The soil of the experimental site was low in organic carbon (0.47 and 0.48 kg/ha) and total nitrogen (154.0 and 155.1 kg/ha). It was low in available phosphorus (9.2 and 9.24 kg/ha) and medium in available potassium (203.0 and 203.6 kg/ha) and sandy loam in texture having alkaline reaction (pH 7.5). The weather during the both years of the experiment was by and large normal and devoid of any extreme conditions. The experiment was conducted as per the standard procedures and all the pre and post harvest observations were recorded and analyzed as per the prescribed statistical procedures. The experimental data pertaining to each character were subjected to statistical analysis by using the technique of analysis of variance (ANOVA) and their significance was tested by "F" test (Cochran and Cox, 1957). Standard error of means (SEm+) and least significant difference (LSD) at 0.05 probabilities were worked out for each character studied to evaluate differences between treatment means.

Table 1: Plant height of linseed as influenced by cropping systems, irrigation and phosphorus levels

Treatments	30DAS		60DAS		90DAS		At harvest	
	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08
Cropping Systems								
Sole linseed	8.13	8.41	25.68	25.80	42.43	42.77	45.64	46.12
Chickpea + Linseed (2:1)	8.15	8.40	24.49	24.77	40.12	40.40	42.80	43.52
Chickpea + Linseed (2:1) 4:2)	8.17	8.48	25.38	25.75	41.77	42.20	44.35	44.76
SEm±	0.09	0.09	0.26	0.26	0.42	0.40	0.65	0.53
CD at 5%	NS	NS	0.82	0.82	1.31	1.26	2.06	1.68
Irrigation								
Vegetative + Flowering stage	8.17	8.43	27.75	27.99	46.53	46.95	49.24	49.73
Flowering stage	8.13	8.42	22.61	22.89	36.35	36.71	39.34	39.87
SEm±	0.07	0.07	0.21	0.21	0.34	0.33	0.53	0.44
CD at 5%	NS	NS	0.67	0.67	1.07	1.03	1.68	1.37
Phosphorus levels (kg/ha)								
Control	8.07	8.35	23.44	23.71	38.60	38.88	40.72	41.29
30 kg P_2O_5/ha	8.17	8.43	25.60	25.98	42.17	42.61	45.32	45.78
60 kg P_2O_5/ha	8.22	8.52	26.50	26.63	43.56	44.00	46.82	47.34
SEm±	0.10	0.12	0.32	0.37	0.52	0.62	0.47	0.53
CD at 5%	NS	NS	0.92	1.09	1.52	1.82	1.36	1.54

Table 2: Yield attributes of linseed as influenced by cropping systems, irrigation and phosphorus levels

Treatments	No. of capsules /plant		No. of seeds/capsule		1000 seed weight (g)		Seed weight (g/plant)	
	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08
Cropping Systems								
Sole linseed	27.97	28.25	2.72	2.77	8.33	8.35	1.90	1.96
Chickpea + Linseed (2:1)	33.24	34.00	2.89	2.97	8.37	8.39	2.36	2.43
Chickpea + Linseed (4:2)	31.60	31.91	2.81	2.85	8.33	8.36	2.27	2.32
SEm±	0.39	0.41	0.03	0.02	0.07	0.06	0.01	0.02
Irrigation								
CD at 5%	1.23	1.30	0.11	0.07	0.23	NS	NS	0.06
Vegetative + Flowering stage	32.36	32.95	2.84	2.90	8.35	8.37	2.26	2.32

Flowering stage	29.51	29.83	2.78	2.83	8.34	8.37	2.09	2.15
SEm±	0.32	0.34	0.03	0.02	0.06	0.05	0.01	0.02
CD at 5%	1.00	1.06	0.09	0.06	0.19	NS	NS	0.05
Phosphorus levels (kg/ha)								
Control	26.71	27.26	2.49	2.51	8.24	8.27	1.60	1.65
30 kg P_2O_5/ha	32.75	33.22	2.93	2.97	8.38	8.40	2.43	2.49
60 kg P_2O_5/ha	33.35	33.68	3.00	3.11	8.41	8.43	2.51	2.57
SEm±	0.39	0.39	0.04	0.04	0.10	0.12	0.03	0.03
CD at 5%	1.17	1.17	0.10	0.10	0.31	NS	NS	0.08

Table 3: Seed and stover yield and harvet index of linseed as influenced by cropping systems, irrigation and phosphorus levels

Treatments	Seed yield q/ha		Stover yield (q/ha)		Harvest index (%)	
	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08
Cropping Systems						
Sole linseed	12.76	13.06	26.20	27.01	32.71	32.55
Chickpea + Linseed (2:1)	5.75	5.67	14.70	14.29	28.11	28.41
Chickpea + Linseed (4:2)	5.35	5.44	12.53	12.72	29.91	29.94
SEm±	0.07	0.10	0.15	0.28	0.27	0.49
CD at 5%	0.22	0.32	0.47	0.87	0.86	1.56
Irrigation						
Vegetative + Flowering stage	8.47	8.59	18.70	18.78	30.53	30.76
Flowering stage	7.44	7.53	16.91	17.23	29.96	29.84
SEm±	0.06	0.08	0.12	0.23	0.22	0.40
CD at 5%	0.17	0.26	0.38	0.71	NS	NS
Phosphorus levels (kg/ha)						
Control	7.28	7.39	16.74	16.97	26.69	29.75
30 kg P_2O_5/ha	8.20	8.22	18.19	18.18	30.42	30.47
SEm±	0.12	0.11	0.25	0.21	0.41	0.33
CD at 5%	0.36	0.34	0.72	0.62	NS	NS

Table 4: Oil content and oil yield of linseed as influenced by cropping systems, irrigation and phosphorus levels

Cropping systems	Oil content (%)		Oil yield kg/ha)	
	2006-07	2007-08	2006-07	2007-08
Cropping Systems				
Sole linseed	35.45	35.60	452.32	464.84
Chickpea + Linseed (2:1)	37.03	37.20	213.06	211.13
Chickpea + Linseed (4:2)	37.90	38.02	203.02	207.09
S.Em.±	0.35	0.30	1.99	2.21
CD at 5%	1.10	0.95	6.28	6.96
Irrigation				
Vegetative + Flowering Stage	36.57	36.71	305.86	311.05
Flowering stage	37.02	37.17	273.07	277.66
S.Em.±	0.29	0.25	1.63	1.80
CD at 5%	NS	NS	5.13	5.68
Phosphorus levels (kg/ha)				
Control	36.17	36.28	260.20	265.15
30 kg P_2O_5/ha	37.05	37.18	299.91	301.45
60 kg P_2O_5/ha	37.17	37.35	308.29	316.47
S.Em.±	0.44	0.54	3.85	4.61
CD at 5%	NS	NS	11.23	13.45

Table 5: Phosphorus content and its uptake by linseed as influenced by cropping systems, irrigation and phosphorus levels

Treatments	P content in seed (%)		P content in stover (%)		P uptake in seed kg/ha		P uptake in stover kg/ha		Total P uptake kg/ha	
	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08	2006-07	2007-08
Cropping Systems										
Sole linseed	0.38	0.38	0.208	0.211	4.81	4.95	5.47	5.71	10.27	10.66
Chickpea + Linseed (2:1)	0.38	0.38	0.214	0.217	2.21	2.19	3.14	3.11	5.35	5.29
Chickpea + Linseed (4:2)	0.39	0.39	0.218	0.220	2.08	2.13	2.74	2.80	4.82	4.93
SEm±	0.001	0.001	0.002	0.001	0.020	0.030	0.033	0.029	0.051	0.047
CD at 5%	NS	NS	NS	NS	0.062	0.094	0.105	0.091	0.161	0.149
Irrigation										
Vegetative + Flowering stage	0.38	0.38	0.211	0.215	3.22	3.28	3.93	4.02	7.15	7.30
Flowering stage	0.38	0.39	0.216	0.217	2.85	2.90	3.64	3.73	6.49	6.62
SEm±	0.001	0.001	0.002	0.001	0.016	0.024	0.027	0.024	0.042	0.038
CD at 5%	NS	NS	NS	NS	0.051	0.077	0.086	0.074	0.131	0.121

Phosphorus levels (kg/ha)										
Control	0.36	0.37	0.201	0.203	2.64	2.70	3.33	3.43	5.98	6.13
30 kg P_2O_5/ha	0.39	0.39	0.217	0.221	3.18	3.20	3.91	3.99	7.09	7.20
60 kg P_2O_5/ha	0.39	0.39	0.223	0.224	3.28	3.36	4.10	4.20	7.38	7.56
SEm±	0.005	0.005	0.002	0.002	0.049	0.040	0.055	0.044	0.094	0.112
CD at 5%	NS	NS	NS	NS	0.147	0.119	0.162	0.127	0.275	0.328

The influence of cropping systems on plant height was markedly observed 60 DAS onwards in both the seasons. The maximum plant height was recorded in sole linseed while minimum in 2:1 row ratio. This might be due to the variation in row spacing, which might have caused differences in competition for light. Dry matter accumulation in linseed 30 DAS remained unaffected due to inter-cropping. It might be too early for plants to compete for growth resources. However, at later stages, linseed grown in 2:1 ratio of inter-cropping recorded higher dry matter than that of it sole stand. Single row (2:1) spacing of linseed and double (4.2) row ratio of inter-cropping might have affected the availability of growth resources to the individual plants which finally led to differences in accumulation of photosynthates. These results are in close conformity with those of Malik *et al*. (2001) [3] and Kumar *et al*. (2002) [2].

The significant variation in the yield attributes (number of capsules per plant, number of seeds per capsule and yield per plant) were recorded in cropping systems over sole linseed. Greater availability of growth resources and comparatively lesser competition from source to sink, consequently resulting in development of yield attributes. Poor development of yield attributes in 4:2 (chickpea + linseed) row ratio might be due to poor plant growth with reduced dry matter accumulation compared with 2:1 row ratio. The ratio 2:1 might have resulted in relatively greater competition effect and would have adversely affected the positioning of photosynthates in yield attributes. The growth and development of linseed is affected by plant density and geometry also plays important role. These result are in close conformity with those of kumar *et al*. (2002) [2], Panwar and Grag (2004) [5] and Ahlawat *et al*. (2005) [1].

The seed and stover yield of linseed were adversely affected in 2:1 and 4:2 planting patterns. This might be due to reduced plant density of linseed. The harvest index also was reduced in intercropping system. This may be due to partitioning of photosynthates in the seed. The linseed in 2:1 and 4:2 planting pattern gave 54.93% and 56.58% and 58.07 and 58.38% lesser yield over sole crop during 2006-07 and 2007-08. This yield advantages under these two planting pattern was due to less composition under reduced density.

Inter-cropping systems did not affect NPK content in seed and stalk. However, marked reduction in uptake of these nutrients was noted in 2:1 and 4:2 planting pattern compared with sole crop. It might be due to reduced seed and stalk yield owing to lower plant density in these planting patterns as the uptake of nutrients being the function of nutrient content in plant and total biomass/hectare.

The oil content in seed of linseed was not improved by different planting patterns in inter-cropping systems. The higher seed yield in sole crop resulted in maximum oil yield in sole crop than 2:1 and 4:2 ratio which recorded lower seed yield.

Irrigation

Crop irrigated at vegetative and flowering stages significantly improved the growth of linseed in both the years. Two (vegetative + flowering) produced taller plants and higher dry matter accumulation as compared to irrigation at sowing stage in both the years. This could be attributed to availability of more water in the root zone and favourable effect of cell formation and enlargement of plants on the other hand, supply of irrigation water induced proper plant growth and helped development of yield attributes and yield. This observation is supported by Malik *et al*. (2001) [3].

Phosphorus application

Growth attributes of linseed i.e. plant height and dry matter production were favourably improved upto 60 kg P2O5/ha except initial stage of crop during both the years. The improvement in growth by phosphorus application might be due to greater availability of phosphorus in soil and its effect on metabolism of growing plants. Similar results were reported by Parihar and Tripathi (1989) [4] and Sune *et al*. (2006) [6].

Conclusion

The higher values of yield attributes *viz*. maximum number of capsules per plant, higher number of seeds per capsule and seed yield per plant was recorded when crop irrigated at vegetative + flowering stage.

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