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PHYSIOLOGICAL INVESTIGATIONS ON INTERACTIVE EFFECT OF P AND K ON GROWTH AND YIELD OF CHICKPEA

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SUMMARY

A field experiment was conducted to study the individual and combined effect of phosphorus and potassium on morphophysiological traits and yield of chickpea (*Cicer arietinum* L.) cv. Pusa 417. The observations were recorded on branch number, shoot dry weight, root dry weight and nodule number/ plant, nitrogenase activity of nodules, leaf area index, crop growth rate and net assimilation rate. At maturity pod number, 100 seed weight, seed yield and seed yield merit were recorded. A combination of 40 kg P_2O_5 and 20 kg K_2O/ha produced maximum yield. The low input of P_2O_5 was compensated by high input of K_2O and vice versa. At lower phosphorus levels (0 or 20 kg P_2O_5/ha) the requirement of potassium was high (40 kg K_2O/ha). However, at higher level of phosphorus (40 or 60 kg P_2O_5/ha) the application of only 20 kg K_2O/ ha proved effective. Seed yield and seed yield merit were enhanced by 82 and 85% by 40 kg P_2O_5 x 20 kg K_2O over control.

***Key words*: *Cicer arietinum*, nitrogenase activity, phosphorus, potassium.**

INTRODUCTION

Legumes have no parallel in the green world as a source of biological fixed nitrogen. They have a vital place in the cropping pattern and form a major constituent of food. However, these crops have remained neglected even in the era of the so called 'Green Revolution' that laid emphasis on cereals to cope up with the fast multiplying population. Therefore, neither genetic stock nor agronomic practices of grain legumes could be improved satisfactorily. This has resulted in the perpetual problem of wide spread protein malnutrition. The nutritional package is, therefore, to be worked out to overcome the obstacle in the realization of their genetic potential. These crops require relatively higher amount of phosphorus. Apart from upgrading per capita productivity of grain legumes, it is highly desirable to explore the possibilities of achieving economy of phosphatic fertilizers without sacrificing yields. Since legumes are also known to respond to potassium (Yahiya 1995), it is necessary to work out a judicious application of phosphorus and potassium on growth and yield of chickpea. Chickpea accounts for nearly 34 per cent of the area and 46 per cent of the production of all green legumes grown in India (Yahiya 1996).

MATERIALS AND METHODS

A field experiment was conducted at the Agriculture Farm, Aligarh Muslim University, Aligarh, India to study the individual and interactive effects of 0, 20, 40 and 60 kg/ha each of phosphorus (P_2O_5) and potassium (K_2O) applied basally. Seeds of chickpea (*Cicer arietinum* L.) cv. Pusa 417 were inoculated with *Rhizobium* and were sown in 10 m^2 plots at a rate of 60 kg/ha. Each treatment with three replicates was arranged in a factorial randomized block design. The distance between plants and between rows was maintained at 15cm and 37 cm, respectively. The crop was irrigated twice during the entire growth period. The soil of the field was sandy loam (% sand: 73.45; % silt: 7.98; %clay: 18.57), conductivity: 0.48 mhos/cm, available N: 180.62, P: 15.67 and available K: 250.35 kg/ha.

Plant samples were collected from each plot at 30, 60, 90 and 120d after sowing. They were washed gently with tap water. Plant characteristics determined at these stages were branch number/plant, dry weight/plant, nodule number/plant, root dry weight/plant, leaf area index (LAI) and nitrogenase activity of root nodules. Crop growth rate (CGR) and net assimilation are (NAR) were calculated for the periods, 30-60, 60-90 and 90-120d intervals. At harvest (150d) pod number, 100 seed weight, seed yield, harvest index and seed yield merit were recorded.

Plants were taken out from the soil and separated into root and shoot to determine root and shoot characteristics. The dry mass was determined after drying to a constant weight at 80°C for one week. Leaf area was determined gravimetrically. The leaf area of 10% of the total leaves in each plot was determined by outlining on a graph paper and the dry weight of these leaves was recorded. The leaf area per plant was computed using the leaf dry weight per plant and dry weight of those leaves for which the area was estimated (Watson 1958).

The formulae of Watson (1958), Watson (1952) and Milthorpe and Moorby (1979) were used to calculate LAI, CGR and NAR respectively at different intervals. Nitrogenase activity of root nodules was determined following the method of Hardy *et al.* (1968). 500mg of carefully detached nodules were taken into 30 ml glass bottles, with a rubber septum as a stopper to allow it to be pierced by a syringe. Three ml gas was withdrawn from the sample container with a syringe and replaced with same amount of high purity acetylene. The tubes were kept at 25°C for 30 minutes. A 0.5ml sample of the gas from each tube was analysed for evolved ethylene on a gas chromatograph fitted with integrator (Nucon 5700, New Delhi, India) and flame ionization detector.

At harvest pod number was counted, sun dried and threshed. Random samples of seeds were taken to note 100 seed weight. Seed yield was recorded on whole plot basis. Seed yield merit was calculated as product of seed yield and harvest index (Imsande 1992). Analysis of variance was performed and F value was calculated to record the significance.

RESULTS AND DISCUSSION

Mean sum square values for individual and interactive effect of P and K for growth traits at different sampling times are given in Table 1. A perusal of the data on morph-physiological and seed traits revealed that individual application of phosphorus (40kg P_2O_5/ha) and potassium (40kg K_2O/ha) proved the best. Phosphorus and potassium interact and it was observed that at lower phosphorus levels (0 or 20 kg P_2O_5/ha) the requirement of potassium was high (40 kg K_2O/ha). However, at higher levels of phosphorus (40-60 kg P_2O_5/ha) the application of only 20kg K_2O/ha proved sufficient (Table 2 and 3). Effect of potassium application on nodule number (at initial stage) and nitrogenase activity of nodules was not significant. Maximal nitrogenase activity was noted at 60d (Fig. 1). Nitrogenase activity at other times is not shown. The higher amount of available potassium in soil (250.35 kg/K ha) was sufficient for nodulation and nitrogenase activity and because of this, these parameters did not respond to applied potassium.

Application of nutrients enhanced branch number and LAI through its well established role in increasing cell size and leaf expansion (Marschner 1986). The increase in leaf area due to nutrient has been reported by Rao and Subramanian (1990) in cowpea and by Reddy *et al.* (1991) in ground nut. The increased LAI resulted in accumulation of photosynthates and enhanced shoot dry matter accumulation. It was also observed that crop attained maximum LAI at 120d. However, the maximum NAR and CGR were recorded during 60-90d interval (Table 2). It seems that though the crop attained maximum LAI at 120d, but the optimum leaf area for the most efficient utilization of photosynthetically active radiation was only during 60-90d interval. Thereafter shading of lower leaves started resulting in the decrease in NAR and CGR values at later growth intervals. Earlier, Samiullah *et al.* (1992) reported a beneficial effect of phosphorus on NAR in lentil. Chickpea dry mass accumulation due to phosphorus has also been reported by other workers including Rao *et al.* (1986) and Khokar and Warasi (1987).

The favourable response of root traits (nodule number and root dry mass) including nitrogenease activity of root nodules (Fig. 1) reported in the present study to applied phosphorus and potassium was because of sufficient

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Table 1. Mean sum square (MSS) values for branch number/plant, dry weight/plant, nodule number/plant, leaf area index and root dry weight/plant of chickpea (*Cicer arietinum* L.) cv. Pusa 417 at 30, 60, 90 and 120 after sowing.

Source of variation	df	Days after sowing			
		30	60	90	120
Branch number/plant					
Phosphorus (P)	3	2.335**	8.417**	66.712**	120.182**
Potassium (K)	3	3.114**	8.935**	67.478**	113.965**
PXK	9	0.778**	2.849**	9.202**	12.432**
Error	30	0.0519	0.1295	0.7668	2.0721
Dry weight/plant (g)					
Phosphorus (P)	3	1.138**	4.532**	26.041**	2.129**
Potassium (K)	3	0.517**	5.827**	9.014**	1.398**
PXK	9	0.579**	2.549**	14.523**	21.299**
Error	30	0.0207	0.1295	0.5008	0.6656
Nodule number/plant					
Phosphorus (P)	3	50.115**	60.395**	70.903**	63.306**
Potassium (K)	3	NS	30.84**	71.551**	26.51**
PXK	9	2.236**	19.66**	67.342**	30.996**
Error	30	0.7710	1.2850	3.2376	0.9534
Leaf area index					
Phosphorus (P)	3	5.899**	5.324**	17.844**	6.301**
Potassium (K)	3	3.655**	2.797**	7.917**	12.267**
PXK	9	4.794**	2.425**	17.357**	5.001**
Error	30	0.1128	0.1128	0.3045	0.1969
Root dry weight/plant (g)					
Phosphorus (P)	3	1.274**	2.628**	1.628**	2.116**
Potassium (K)	3	2.124**	1.789**	1.426**	1.824**
PXK	9	1.283**	2.121**	1.323**	1.246**
Error	30	0.8288 $\times 10^{-3}$	2.4188 $\times 10^{-3}$	4.3528 $\times 10^{-3}$	4.8406 $\times 10^{-3}$

(df, degree of freedom; **, significant at 5%; NS, not significant)

production and supply of photosynthates from source to these parts. The nodule number increased progressively upto 90d and then decreased. This is due to the fact that initially the competition for photosynthates was confined to root, nodules and aerial vegetative organs, but when flowering and fruit setting started (90d onwards), they provided strong demanding sink for the utilization of photosynthates. This created a shortage of photosynthates supply to the nodules as a result of which nodule degeneration started.

Yield attributing parameters pod number, 100 seed weight, seed yield and seed yield merit were maximally affected by interactive effect of 40 kg P_2O_5/ha and 20kg K_2O/ha. Harvest index, which reflects the photosynthetic partitioning efficiency of crop plants was enhanced by phosphorus and potassium application. Seed yield merit (a product of seed yield and harvest index) was also maximally affected by the same treatment. Seed yield and seed yield merit were enhanced by 82 and 85% by this treatment.

Table 2. Effect of four basal levels each of phosphorus and potassium on crop growth rate (CGR) and net assimilation rate (NAR) of chickpea (*Cicer arietinum*) cv. Pusa 417.

Potassium	Phosphorus (kg P_2O_5/ha)														
(kg K_2O/ha)	30-60 DAS					60-90 DAS					90-120 DAS				
	0	20	40	60	Mean	0	20	40	60	Mean	0	20	40	60	Mean
						Crop growth rate (g/m²/day)									
0	1.96	2.29	2.21	2.26	2.18	2.95	4.26	5.16	5.27	4.41	3.68	4.92	5.53	5.64	4.94
20	2.23	2.49	2.66	2.62	2.50	3.35	4.64	6.20	6.12	5.08	4.19	5.35	6.65	6.56	5.69
40	2.45	2.63	2.62	2.62	2.58	3.68	4.89	6.12	6.12	5.20	4.60	5.65	6.56	6.55	5.84
60	2.45	2.67	2.62	2.59	2.58	3.67	4.96	6.11	6.06	5.20	4.59	5.73	6.54	6.49	5.84
Mean	2.27	2.52	2.53	2.52		3.41	4.69	5.89	5.89		4.27	5.41	6.32	6.31	
LSD at 5%	P=0.087		K=0.087	PxK=NS		P=0.083		K=0.083		PxK=0.167	P=0.120	K=0.120		PxK=0.240	
						Net assimilation rate (mg/m²/day)									
0	2.41	2.51	2.24	2.25	2.35	2.26	2.74	2.89	2.90	2.70	1.94	2.12	1.98	2.01	2.01
20	2.55	2.59	2.50	2.46	2.53	2.25	2.72	3.18	3.13	2.82	1.77	2.04	2.15	2.12	2.02
40	2.65	2.62	2.44	2.45	2.54	1.99	2.72	3.11	3.11	2.73	1.70	1.96	2.11	2.10	1.97
60	2.63	2.62	2.45	2.43	2.53	2.19	2.73	3.12	3.08	2.78	1.70	1.98	2.11	2.09	1.97
Mean	2.56	2.59	2.41	2.40		2.17	2.73	3.08	3.06		1.78	2.03	2.09	2.08	
LSD at 5%	P=0.085		K=0.085	PxK=NS		P=0.099		K=0.099		PxK=NS	P=0.088	K=NS		PxK=NS	

DAS: Days after sowing

Table 3. Effect of four basal levels each of phosphorus and potassium on yield parameters, seed yield and seed yield merit of chickpea (*Cicer arietinum*) cv. Pusa 417.

Potassium	Phosphorus (kg P_2O_5/ha)				
kg K_20/ha	0	20	40	60	Mean
			Pod number/plant		
0	34.70	48.50	56.13	56.23	48.89
20	43.30	53.80	64.03	64.07	56.30
40	47.60	57.67	64.73	65.30	58.82
60	48.10	58.33	64.40	64.57	58.85
Mean	43.42	54.57	62.32	62.54	
LSD at 5%	P=1.90	K=1.90	PxK=3.80		
			100 seed weight (g)		
0	10.08	10.49	11.73	11.72	11.01
20	10.14	11.26	12.66	12.67	11.68
40	10.98	11.72	12.67	12.68	12.01
60	10.94	11.71	12.79	12.81	12.06
Mean	10.53	11.29	12.46	12.47	
LSD at 5%	P=0.13	K=0.13	PxK=0.26		
			Seed yield (q/ha)		
0	14.33	19.11	21.84	21.89	19.29
20	16.29	20.99	26.08	26.35	22.43
40	18.05	22.32	26.32	26.42	23.27
60	18.21	22.56	26.35	26.29	23.35
Mean	16.72	21.24	25.15	25.24	
LSD at 5%	P=0.50	K=0.50	PxK=1.00		
			Harvest index (%)		
0	39.02	39.02	39.59	38.86	39.12
20	39.01	39.19	39.77	40.28	39.56
40	40.39	40.62	41.17	40.24	40.60
60	39.68	39.51	40.32	42.85	40.59
Mean	39.52	39.58	40.21	40.56	
LSD at 5%	P=0.37	K=.037	PxK=NS		
			Seed yield merit		
0	559.16	745.67	864.65	850.64	755.03
20	635.47	822.59	1037.20	1061.38	889.16
40	729.04	906.64	1083.59	1063.14	945.60
60	722.57	891.35	1062.43	1126.53	950.72
Mean	661.56	841.56	1011.97	1025.42	
LSD at 5%	P=58.6	K=58.6	PxK=117.2		

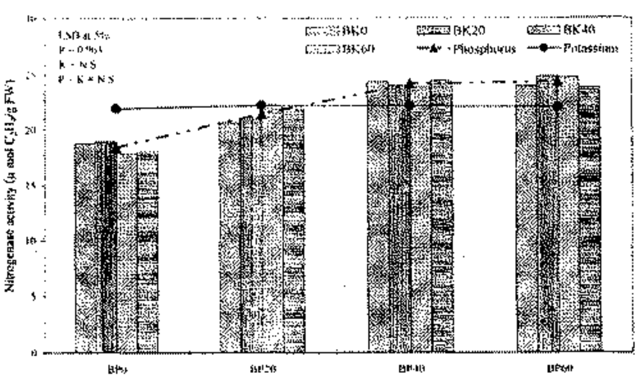

Fig. 1. Effect of four basal levels each of phosphorus and potassium on nitrogenase activity of rootnodules of chickpea (*Cicer arietinum* L.) cv. Pusa 417 at 60d of growth.

It may be concluded that effectiveness of basally applied phosphorus was further enhanced with the application of potassium. Further, requirements of phosphorus may be curtailed by increased input of potassium. Since the soil potassium status was high in the present study, the interaction of 40kg P_2O_5, and 20kg K_2O proved the best.

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