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Response to phosphorus applied in rainy-season crop and nitrogen applied to wheat (*Triticum aestivum*) under sorghum (*Sorghum bicolor*)/cowpea (*Vigna unguiculata*)–wheat cropping system

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ABSTRACT

The results of 2 years field experiment showed that fodder yield nitrogen and phosphorus uptake in the rainy-season crops increased favourably up to 30 kg P_2O_5/ha while grain yield responded up to 60 kg P_2O_5/ha. Wheat (*Triticum aestivum* L. emend. Fiori & Paol.) preceded by sorghum [*Soghum bicolor* (L.) Moench] + cowpea [*Vigna unguiculata* (L.) Walp.] fodder (F), followed by cowpea grain straw incorporation (SI) performed better than grown after sorghum (F). Both these cropping systems contributed 26.38 and 28.62 kg N/ha, respectively, resulting in an increase in wheat yield than sorghum (F)–wheat system. Residual effect of phosphorus (applied to rainy-season crops @ 30 and 60 kg P_2O_5/ha) increased grain yield of succeeding wheat by 7.53 and 10.13%, respectively, over no phosphorus and also favourably influenced N and P uptake. Grain yield of wheat increased by 26.96 and 32.71% higher at 75 and 150 kg N/ha, respectively over the control, while N and P uptake responded only up to 75 kg N/ha.

Key words : Sorghum, Cowpea, Straw incorporation, Cropping system

As intensive cropping patterns have resulted in depletion of soil nutrients, their requirement by plants increased, correspondingly use of chemical fertilizers also increased without due consideration of organic sources like inclusion of legumes in cropping systems either as sole or as an intercrop, which help in improving nitrogen status of soil and yield of base as well as succeeding crop and also cover the risk of failure of crops during aberrant weather conditions (Balyan, 1990).

Phosphorus helps increase returns, uptake and being a slow release fertilizer also favourably influences the succeeding crop (Balyan 1997).

MATERIALS AND METHODS

A field experiment was conducted with an additive series during the rainy and winter seasons of 1995–96 and 1996–97 at the research farm of the IARI, New Delhi. To

study the different cropping systems and phosphate management during the rainy season and their after-effect on productivity and nitrogen economy in succeeding wheat under irrigated conditions. The treatments consisting of 3 cropping systems, viz. sorghum fodder (F), sorghum (F) + cowpea (F) and cowpea grain straw incorporation (SI), and 3 levels of phosphorus (0, 30 and 60 kg P_2O_5/ha) as main plots, replicated thrice in randomized block design during rainy season. In winter season, the rainy-season plots were considered as main plot and further split into 3 subplots where 3 nitrogen levels (0,75 and 150 kg N/ha) were applied to wheat. The varieties used were sorghum fodder ('Pusa Chari'), cowpea fodder ('EC 4216'), cowpea grain ('C 152') and wheat ('HD 2285'). Recommended seed rate for fodder sorghum (40–50), cowpea (30–40) and cowpea grain (25–30 kg/ha) was sown. Sorghum and cowpea were removed from the field for green fodder 60 days after sowing, in case of cowpea grain. Pods were pick up at the maturity and straw was incorporated into the field. The soil was sandy loam, with pH 7.8, poor in organic carbon and available P deficient in total N and rich in available K.

RESULTS AND DISCUSSION

Rainy-season crops

Significantly higher green-fodder yield of sorghum was obtained in sole sorghum than sorghum + cowpea intercropping systems (Table 1). Application of P_2O_5 @ 30 and 60 kg/ha, being at par gave higher fodder yield than control.

Total green fodder : Different cropping systems did not show any marked influence on total green fodder yield in either of the years (Table 1).

An application of 30 kg P_2O_5/ha markedly increased the total green fodder yield over the control. However, further increase in P level up to 60 kg P_2O_5/ha failed to bring any marked difference to its preceded level (Table 1). The results confirm the findings of Vashishtha and Dwivedi (1997). Grain yield of cowpea significantly increased with an application of 60 kg P_2O_5/ha over the control while 0 and 30, 30 and 60 kg P_2O_5/ha did not show any marked difference between themselves (Table 2).

Uptake : Total N uptake in intercropping system was significantly higher than sole sorghum (Table 1). Total N uptake was significantly higher with an application of 60 kg P_2O_5/ha compared with the control. However, 30 and 60 kg/ha did not significantly differ between themselves in either year (Table 1).

Both of the sole sorghum (F) and sorghum + cowpea (F) intercropping systems did not significantly differ between themselves for total P uptake in any year of study. Total P uptake increased significantly higher at the level of 60 kg P_2O_5/ha over the control. However, the difference between 30 and 60 kg P_2O_5/ha was marginal (Table 1). Both the levels of 30 and 60 kg P_2O_5/ha being at par recorded significantly higher total N uptake by grain cowpea over no phosphorus in both years (Table 2).

Total P uptake by grain cowpea increased significantly with increasing level of P up to 30 kg/ha over the control. However, further increase in phosphorus level

Table 1. Green fodder yield (q/ha), nitrogen and phosphorus uptake (kg/ha) in sorghum and cowpea as influenced by different treatments

Treatment	Green fodder (q/ha)			Uptake (kg/ha)					
	Sorghum	Cowpea	Total	Sorghum		Cowpea		Total	
				N	P	N	P	N	P
				1995–96					
Cropping system									
Sorghum (F)	371.64		371.69	131.75	33.54			131.75	33.54
Sorghum+cowpea (F)	300.39	95.41	395.71	109.33	27.56	39.53	5.38	148.86	32.94
CD (P = 0.05)	30.45		NS	9.15	2.68			7.73	NS
P_2O_5 (kg/ha)									
0	303.62	88.32	353.76	110.47	25.47	33.94	4.51	144.41	29.98
30	342.34	96.33	390.52	124.43	31.72	39.88	5.43	164.31	37.15
60	356.11	101.30	406.76	126.73	34.46	44.78	6.22	171.51	40.68
CD (P = 0.05)	36.79	6.49	36.74	11.22	3.28				
				1996-97					
Cropping system									
Sorghum (F)	362.33		362.33	128.28	30.25			128.28	30.25
Sorghum+cowpea (F)	294.96	93.97	388.93	105.41	25.82	38.95	5.20	144.36	31.02
CD (P=0.05)	25.67		NS	8.09	2.31			6.86	NS
P_2O_5 (kg/ha)									
0	300.22	86.52	343.48	104.29	23.05	33.43	4.27	137.72	27.32
30	335.64	94.72	383.00	122.68	28.69	38.95	5.14	161.63	33.83
60	350.08	100.67	400.42	124.33	32.36	44.48	6.21	168.81	38.57
CD (P=0.05)	31.44	6.34	38.86	9.91	2.83			8.87	6.03

Table 2. Grain, straw yield and growth parameters of wheat as influenced by different treatments

Treatment	Green yield (q/ha)		Straw yield (q/ha)		Plant height (cm) 120 DAS		Leaf-area index 80 DAS		Dry matter (g/plant) 120 DAS		No. of tillers/ plant 120 DAS	
	1995–96	1996–97	1995–96	1996–97	1995–96	1996–97	1995–96	1996–97	1995–96	1996–97	1995–96	1996–97
Cropping system												
Sorghum (F)	37.00	34.45	54.77	52.00	61.52	58.32	3.22	3.07	4.52	4.37	1.83	1.73
Sorghum+cowpea (F)	47.16	44.31	64.02	60.14	69.25	63.64	3.61	3.45	5.05	4.91	2.07	1.94
Cowpea grain (SI)	45.58	42.43	61.81	58.04	68.31	63.64	3.59	3.43	4.85	4.75	1.98	1.89
CD (P=0.05)	2.66	2.61	3.98	3.40	3.49	2.83	0.22	0.21	0.24	0.28	0.11	0.12
P_2O_5 (kg/ha)												
0	40.82	38.33	56.30	53.09	64.05	60.16	3.31	3.26	4.75	4.59	1.82	1.74
30	43.93	41.18	61.00	57.53	67.36	62.20	3.49	3.33	4.87	4.70	1.98	1.89
60	44.99	42.17	63.19	59.56	67.66	62.93	3.52	3.36	4.90	4.74	2.03	1.94
CD (P=0.05)	2.66	2.61	3.98	3.40	NS	NS	NS	NS	NS	NS	0.11	0.12
N (kg/ha) to wheat												
0	36.00	33.89	51.30	48.33	58.17	54.30	3.00	2.86	4.09	3.95	1.60	1.53
75	45.80	42.92	64.14	59.77	69.05	64.96	3.62	3.47	5.13	4.94	2.08	1.99
150	47.89	44.86	66.16	62.08	71.85	66.04	3.79	3.62	5.30	5.13	2.15	2.05
CD (P=0.05)	2.47	2.26	3.38	2.85	3.21	2.85	0.20	0.17	0.20	0.23	0.10	0.11

up to 60 kg/ha did not affect the P uptake favourably over its preceding level (Table 3). This increase could be attributed to beneficial effect of phosphorus on fodder, grain and straw yields and also N and P uptake. Rajput and Singh (1996) also obtained similar results.

Wheat

Previous rainy-season crops, i.e. sorghum + cowpea (F) and cowpea grain (SI), being at par augmented the grain and straw yields of succeeding wheat significantly higher than in sorghum (F)–wheat cropping sequence (Table 2). The increase in wheat yield might be attributed to the effect of legume like cowpea which might have provided an additional N to succeeding wheat through biological N fixation and mineralization of root biomass. The results corroborated with those of Balyan (1997).

Both the levels of residual P (30 and 60 kg P_2O_5/ha) being at par resulted in significantly higher grain and straw yields of succeeding wheat over the control (Table 2). The results are in confirmation with those of Lal *et al.* (1997).

Higher grain and straw yields of wheat were found with 150, followed by 75 kg N/ha and these levels being at par remained significantly superior to the control (Table 2). Bhagat *et al.* (1995) made similar observations.

Growth parameters : Significantly higher values of all the growth parameters of wheat (plant height, leaf-area index, dry-matter accumulation and tillers/plant) were recorded in legume-based cropping systems than sorghum (F)–wheat sequence (Table 3). This might be attributed to biological fixation of N and addition of organic matter in the soil through legume incorporation.

Growth parameters of wheat did not influence due to residual phosphorus; however, tillers/plant being at par at 30 and 60 kg P_2O_5/ha applied to previous rainy-season crops remained significantly superior to the control.

Direct applied N to wheat @ 75 and 150 kg/ha being at par encouraged favourably higher growth parameters plant height, leaf-area index, dry-matter accumulation and tiller/plant over the control (Table 3). The results conform the results of Morgan (1988).

Uptake : The N uptake values in wheat (grain, straw and total uptake) being at par found significantly superior when wheat preceded by sorghum + cowpea (F) and cowpea grain (SI) than wheat grown after sole crop of sorghum (F) (Table 3). This

Table 3. Grain yield, N and P uptake in cowpea as influenced by phosphorus levels

Treatment P_2O_5 (kg/ha)	Grain yield (q/ha)		Straw yield (q/ha)		Total N uptake (kg/ha)		Total P Uptake (kg/ha)	
	1995	1996	1995	1996	1995	1996	1995	1996
0	11.00	10.70	51.70	50.18	115.83	111.76	20.65	19.43
30	13.50	12.90	63.72	60.63	146.20	137.17	27.11	24.96
60	14.00	13.61	66.22	64.19	155.59	149.06	29.40	26.94
CD (P=0.05)	2.94	2.44	4.26	3.92	14.31	13.54	3.04	2.69

Table 4. Nitrogen, phosphorus and total uptake of wheat as influenced by different treatments

Treatment	N uptake (kg/ha)						P uptake (kg/ha)					
	Grain		Straw		Total		Grain		Straw		Total	
	1995–96	1996–97	1995–96	1996–97	1995–96	1996–97	1995–96	1996–97	1995–96	1996–97	1995–96	1996–97
Cropping system												
Sorghum (F)	60.38	54.80	22.09	20.47	82.47	75.27	8.33	7.43	3.12	2.89	11.45	10.32
Sorghum+cowpea (F)	90.69	83.22	30.68	28.00	121.37	111.22	10.75	9.77	3.77	3.48	14.52	13.25
Cowpea grain (SI)	87.04	80.04	29.19	26.85	116.23	106.89	10.51	9.54	3.60	3.30	14.11	12.84
CD (P=0.05)	6.60	6.03	2.68	2.59	7.83	6.78	0.68	0.64	0.30	0.26	1.08	0.97
P_2O_5 (kg/ha)												
0	72.92	66.78	25.02	22.16	97.94	88.94	9.17	8.31	3.23	2.98	12.40	11.29
30	80.86	74.13	27.50	25.28	108.36	99.41	10.02	9.04	3.57	3.28	13.59	12.32
60	84.32	77.05	29.43	26.88	113.75	103.93	10.40	9.39	3.69	3.40	14.09	12.79
CD (P=0.05)	6.60	6.03	2.68	2.59	7.83	6.78	0.68	0.64	0.30	0.26	1.08	0.97
N (kg/ha) to wheat												
0	62.20	57.33	20.69	19.09	82.89	76.42	8.18	7.40	2.93	2.70	11.11	10.10
75	85.45	79.16	29.36	27.09	114.81	106.25	10.44	9.40	3.68	3.40	14.12	12.80
150	90.44	82.57	31.81	29.16	122.25	111.73	10.98	9.95	3.88	3.57	14.86	13.52
CD (P=0.05)	5.57	5.08	2.52	2.40	6.47	5.98	0.60	0.56	0.23	0.18	0.84	0.79

may be ascribed to higher yields which accounted for higher uptake of N. The improvement in yields and uptake after these crops was due to N fixed in the soil by the legumes. Similar findings was observed by Patel (1980).

Residual effect of phosphorus augmented significantly higher N uptake in grain, straw and total uptake by wheat at an application of 30 kg P_2O_5/ha over the control. However. Further increase in P level up to 60 kg P_2O_5/ha did not differ markedly to its preceded levels.

Both the N levels, i.e. 75 and 150 kg/ha, being at par recorded significantly higher N values removed by wheat grain. Straw and total uptake except the total N uptake increased significantly with each increase in N levels up to 150 kg/ha over its preceded level in 1995–96 only (Table 4). These findings are in close proximity with those of Naphade *et al.* (1995).

Preceding crops, i.e. sorghum + cowpea (F) and cowpea grain (SI), resulted in significantly higher P uptake in grain, Straw and total P uptake by succeeding wheat over wheat grown after sorghum (F). However, both of sorghum + cowpea (F) and cowpea grain (SI) did not differ statistically between themselves (Table 4).

The P uptake by wheat grain straw and total uptake increased significantly with increasing levels of residual P up to 30 kg P_2O_5/ ha over no phosphorus. However, further increase in P level up to 60 kg P_2O_5/ ha did not influence P uptake markedly (Table 4). These results are in agreement with those of Lal *et al.* (1997).

The P removed by wheat grain, straw and total uptake increased significantly with increase in N level up to 75 kg/ha over the control. However, further increase in N up to 150 kg/ha did not affect the P uptake over its preceded level (Table 4).

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