GAU Res. J. 1996. 21 (2) : 24-31

Wheat Response to P Under Different Soil Treatments : III - Effect of M x F x P and M x AL x P

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ABSTRACT

A pot experiment was carried out to study the effect of phosphorus (0, 25, 50, 100 ppm) with moisture (-0.5 bar, - 1.0 bar), FYM (0, 2 per cent) and active lime (0, 5, 25 per cent of the total 30 per cent lime added in the soil) on yield attributes, yield and concentration and uptake of P, Zn and Ca by wheat cv GW-120. The interaction M x F x P was significant only in case of the earthead length and the concentration and uptake of P and Zn by the grain and straw, respectively and concentration of Ca in grain. The interaction M x AL x P significantly affected the earhead length, straw yield , concentration and uptake of P, Zn and Ca in grain and straw except concentration of P and Ca in straw. The length of earhead and P concentration in the grain and straw were almost doubled even under M2 when FYM and P3 interacted togather. Thus, the higher level of P fertilization and FYM incorporation could help overcome the adverse effects produced through the moisture stress. The wheat response to P fertilization was greatly limited by the higher moisture tension level and active lime content in the soil.

(Received on 29th Nov., 1994)

INTRODUCTION

Low soil moisture level and a corresponding water deficit in plants is a typical constraint on plant growth in alkaline Aridisols. At low soil moisture levels both the diffusion of nutrients to root surface and root extension are impaired. The uptake of P is closely related to soil moisture and root extension. In alkaline calcareous soils with low level of labile P, its deficiency is, therefore, more closely related to decreasing soil moisture level than to increasing pH (Marschner, 1986). The incorporation of FYM along with NPK or P exhibited additve effect on the growth and yield of the field crops (Maurya and Ghosh, 1972; Sandhu and Meelu, 1974), P uptake (Dahiya *et al.*, 1987) and availability of P in the soil (Chahal *et al.*, 1984). It has been also documented by many workers that adverse effect of lime on the crop growth and yield, nutrient uptake and nutrient availability in the soil (Patel and Golakiya, 1986; Sutaria and Patel, 1987; Golakiya and Patel, 1988).

MATERIALS AND METHODS

A pot experiment was carried out on a medium black calcareous vertisol during *rabi* 1986. The fourty eight treatment combinations consisted of two moisture levels viz., -0.5 bar (M1) and -1.0 bar (M2), two levels of FYM viz.,

0 (F0) and 2 (F1) per cent, three levels of active lime viz., 0 (AL0), 5 (AL1) and 25 (AL2) per cent of the total 30 per cent lime added in the soil, and four levels of phosphorus viz., 0 (P0), 25 (P1), 50 (P2) and 100 (P3) ppm as a monocalcium phosphate [$Ca(H_2PO_4)_2 .H_2O$]. These all treatments were repeated twice. A basal dose of N @ 60 ppm through urea was mixed with the soil and a split application of 60 ppm N was given at 25th days after sowing of wheat cv GW-120. Some of the soil characteristics are : sand 13.0%, silt 30.3%, clay 56.7%, p^H 7.8, EC 0.18 DSm^{-1}, $CaCO_3$ 3.3%, CEC 53.0 me 100^{-1} g soil, organic C 0.84%, Olsen's P 5.73 ppm P_2O_5, Available K 172.5 ppm K_2O, exchangeable Ca 44.5 me IOC^{-1} g soil and DTPA extrable Zn, Fe, Cu and Mn were 0.62, 6.53, 3.22 and 11.56 ppm, respectively. The polythylene lined earthen pots (12 liters capacity) were filled with 12 kg of treated soil. Healthy and bold wheat seeds were sown, which were thined to nine plants per pot a week after germination. The pots were irrigated as per moisture treatment. The observations like plant height, effective tillers, grain and straw yield and test weight were made timely. After harvesting the crop, plant samples were digested in a diacid mixture. The acid extract was used for analysis of nutrient P, Zn and Ca. Phosphorus in the acid extract was determined by Vanadomolybdo phosphoric yellow colour method, Ca by Versanate method (Jackson, 1958) and Zn by atomic absorption spectrophotometry (Shimadzu make model No. AA-640-13).

RESULTS AND DISCUSSION

Moisture x FYM x Phosphorus Interaction

Yield attributes and yield

The interaction among M x F x P was significant in case of the earhead length (Table 1). Incorporation of FYM increased the earhead length by 19 and 3 per cent under M1F1P3 and M2F1P3 over that in M1F0P3 and M2F0P3, respectively. The interaction effect on the grain and straw yield was found nonsignificant but, the incorporation of FYM increased the grain and straw yield by 62 and 49 per cent, respectively, under M1F1P3 over that under M1F0P3. However, the correcponding per cent increase in these parameters at the same level of P under M2 was to the tune of 86 and 9 per cent. The adverse effect of water stress was alleviated mainly due to FYM application as there was little difference between M1F0P3 and M2F1P3.

Nutrient content and uptake

The concentration and uptake of P by grain and straw were significanly affected due to M x F x P interaction (Table 1). The P concentration in the grain and straw were almost doubled even under moisture stress (M2), when FYM and P3 interacted togather as compared to F0P0. The increment in the P concentration is also attributed to reduced grain and straw yield under moisture stress conditions. The application of FYM alone increased the concentration and uptake of P by grain to the tune of 20 and 94 per cent, respectively, under M1F1P3 over that in M1F0P3. Similarly it was increased by 11 and 88 per cent under M2F1P3 over that under M2F0P3. The result of the present experiment was coroborate with that of Nambiar and Ghosh (1984) who concluded that addition of FYM along with 100 per cent NPK to medium black soils improved the grain yield of wheat (8%), P uptake and available P status of the soils. However, the reduction in its concentration and uptake by straw under M1F1P3 and M2F1P3 over M1F1P0 and M2F1P0 is contrary to the expectation and for that we have no explanation.

TABLE 1

Interaction effect of moisture, FYM and phosphorus on yield attributes, yield, concentration and uptake of phosphorus by wheat cv GW-120.

Treatment combinations	*Plant height (cm)*	*Effective tillers*	*Earhead lenght (cm)*	*Test weigth (g)*	*Grain yield (g pot^{-1})*	*Straw yield (g pot^{-1})*	*P concentration (mg g^{-1})*		*P uptake (mg pot^{-1})*	
							Grain	*Straw*	*Grain*	*Straw*
M1F0P0	33.9	11.0	3.11	39.6	9.86	12.78	2.58	0.87	25.4	11.1
M1F0P1	42.3	14.6	4.88	40.5	11.85	23.30	4.12	0.58	48.8	13.5
M1F0P2	47.1	18.5	6.94	40.7	15.11	34.88	4.51	0.67	68.1	23.3
M1F0P3	47.5	19.4	7.73	42.0	12.95	32.19	4.24	0.72	54.9	23.2
M1F1P0	64.7	17.3	6.12	41.3	11.79	42.11	4.70	0.89	55.4	37.5
M1F1P1	48.0	20.0	7.30	43.2	14.45	95.23	5.19	0.80	75.0	36.2
M1F1P2	55.5	21.2	8.26	43.9	18.78	45.31	5.14	0.82	97.5	37.1
M1F1P3	57.8	22.1	9.22	44.7	20.95	48.03	5.10	0.60	106.8	28.8
M2F0P0	33.3	10.1	2.97	34.7	8.70	18.59	3.83	0.93	33.3	17.3
M2F0P1	40.1	9.4	3.31	35.8	9.58	20.28	4.81	0.89	46.1	18.0
M2F0P2	44.2	14.0	5.06	36.9	10.43	22.20	5.24	0.92	54.6	20.4
M2F0P3	44.5	15.6	6.00	38.4	9.70	22.53	4.97	1.00	48.2	22.5
M2F1P0	37.2	14.8	4.14	36.5	10.39	23.67	5.35	1.16	55.6	27.4
M2F1P1	43.7	18.4	5.54	36.9	10.93	25.10	5.18	1.13	56.6	28.3
M2F1P2	47.5	19.2	6.18	38.0	15.24	22.92	5.00	1.21	77.4	27.7
M2F1P3	48.0	20.4	6.20	39.3	18.08	23.87	5.01	1.12	90.6	26.7
CD (0.05)	NS	NS	1.12	NS	NS	NS	0.12	0.01	21.8	11.5

TABLE 2

Interaction effect of moisture, FYM and phosphorus on concentration and uptake of zinc and calcium by wheat cv GW - 120.

Treatment combinations	Zn concentration ($\mu g\ g^{-1}$)		Zn uptake ($\mu g\ pot^{-1}$)		Ca concentration ($mg\ g^{-1}$)		Ca uptake ($mg\ pot^{-1}$)	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
M1F0P0	81.4	70.8	802	905	1.20	3.68	11.8	47.0
M1F0P1	82.9	64.3	982	1498	1.28	3.16	15.1	73.6
M1F0P2	78.4	52.9	1184	1845	1.09	3.14	16.5	109.5
M1F0P3	79.9	48.5	1035	1561	1.11	3.12	14.4	100.4
M1F1P0	78.6	80.5	927	3390	1.14	3.20	13.4	134.7
M1F1P1	68.0	68.5	982	3098	1.10	3.09	15.9	139.7
M1F1P2	63.5	63.5	1192	2877	1.30	3.92	24.4	177.6
M1F1P3	57.7	63.8	1209	3064	1.11	3.18	23.2	152.7
M2F0P0	76.6	70.8	666	1316	1.10	3.00	9.6	67.1
M2F0P1	69.1	56.9	662	1154	0.99	3.31	9.5	67.1
M2F0P2	59.5	52.1	620	1157	1.06	3.58	11.0	79.4
M2F0P3	59.3	38.5	575	867	0.93	3.00	9.0	67.6
M2F1P0	69.2	51.2	719	1212	1.03	3.25	10.7	76.9
M2F1P1	66.8	47.0	730	1180	0.93	3.11	10.2	78.0
M2F1P2	51.7	46.5	780	1066	0.85	3.08	12.9	70.6
M2F1P3	56.2	51.9	1016	1239	0.93	3.06	16.8	73.0
CD (0.05)	6.8	0.5	61	112	0.07	NS	NS	NS

The concentration of Zn in the grain and straw was decreased with P and moisture stress (Table 2). Incorporation of FYM could not help in improving the concentration in the plant, possibly due to dilution effect in the plant and natural organic chelation of Zn (Chen and Stevenson, 1986) in the presence of FYM. The uptake of Zn by the grain and straw was reduced to 14 and 34 per cent under M2F1P3 over that under M2F0P0, respectively. In general, irrespective of P addition, incorporation of FYM increased the Zn uptake. Only the Ca content in the grain was affected due to interaction of M x F x P (Table 2). However, the Ca concentration and its uptake by grain and straw were higher under M1 compared to that under M2 conditions. The application of P alone, in absence of FYM reduced the Ca concentration in grain and straw by 8 and 15 per cent under M1F0P3 over M1F0P0, respectively. However, its uptake was increased by 22 and 113 per cent, respectively, in the grain and straw under same treatment combinations. The application of FYM failed to mitigate the adverse effect of water stress.

Moisture x active lime x phosphorus interaction

Yield attributes and yield : This inter- action significantly affected the earhead length and straw yield (Table 3). Maximum P response on earhead length was obtained under M1AL0 (8.71 cm). Earhead length was decreased by 7 per cent under M1AL2P3 over that under M1AL1P3.

Similarly, it was decreased by just 2 per cent under M2AL2P3 over M2AL0P3. Under both the moisture levels, the earhead length was almost doubled at P3 level compared to that in P0 within any level of active lime. Irrespective of active lime, the application of P increased grain and straw yield under both the moisture stress. The grain and straw yield were increased by 61 and 56 per cent under M1AL2P3 over that under M1AL2P0, respectively. Similarly, the corresponding increase under M2 was 49 and 3 per cent. But the incorporation of active lime reduced the grain and straw yield by 9 and 7 per cent under M1AL2P3 over that in M1AL0P3 and that of under M2 was 7 and 13 per cent, respectively. In general, the negative effect of both active lime and moisture stress on the crop was mitigated by P fertilization, most probably through higher P fertility resulting in increased root growth. Sutariya and Patel (1987) and Golakiya and Patel (1988) reported adverse effect of lime on the crop growth, yield nutrient uptake and nutrient availability in the soil. The incorporation of active lime react with P and produced a range of Ca-phosphates of varying solubility (Taylor and Woods, 1981) which determines crop response to P fertilization in the calcareous soils.

Nutrient content and uptake

The concentration and uptake of P were significantly affected by M x AL x P, except P concentration in the straw (Table 3). It generally increased the grain with the levels of P but with the lower magnitude as the active lime content increased in the soil. A slight depressing effect of AL on the P concentration was comparatively more pronounced under M1. The uptake of P by the grain and straw was generally increased with the levels of P but with the lower magnitude under active lime and procisely so under M1. In general, treatment differences under M2 were not as conspicuous as those under M1, perhaps due to reduced growth and yield in the former.

TABLE 3

Interaction effect of moisture, active lime and phosphorus on yield attributes, yield concentration and uptake of phosphorus by wheat cv GW-120.

Treatment combinations	Plant height (cm)	Effective tillers	Earhead length (cm)	Test weight (g)	Grain yield (g pot^{-1})	Straw yield (g pot^{-1})	P concentration (mg g^{-1})		P uptake (mg pot^{-1})	
							Grain	Straw	Grain	Straw
M1AL0P0	66.5	14.7	4.64	40.7	11.88	30.38	3.81	1.09	45.2	33.1
M1AL0P1	45.8	18.2	6.47	41.9	14.24	34.81	4.63	0.65	65.9	22.6
M1AL0P2	52.2	20.3	7.94	42.5	18.29	40.74	5.15	0.90	94.2	36.7
M1AL0P3	53.4	20.9	8.71	44.5	17.91	42.01	4.78	0.84	85.6	35.2
M1AL1P0	31.0	14.0	4.64	40.5	10.75	26.96	3.59	0.77	38.6	20.7
M1AL1P1	45.1	17.2	6.11	42.1	13.16	34.22	5.17	0.79	68.0	27.0
M1AL1P2	51.3	20.1	7.78	42.4	17.17	40.28	4.92	0.80	84.3	32.2
M1AL1P3	52.8	20.7	8.60	41.7	16.60	39.33	4.79	0.60	79.5	23.5
M1AL2P0	40.4	13.7	4.56	40.0	10.14	24.99	3.51	0.78	35.6	19.5
M1AL2P1	44.6	16.6	5.73	41.5	12.05	33.76	4.16	0.64	50.1	21.6
M1AL2P2	50.3	19.1	7.04	42.1	15.71	38.98	4.42	0.54	69.4	21.0
M1AL2P3	51.7	20.6	8.10	43.9	16.34	38.99	4.43	0.54	72.4	21.0
M2AL0P0	36.2	11.2	3.69	36.1	10.46	21.32	4.67	1.37	48.8	29.2
M2AL0P1	42.4	14.1	4.16	36.6	11.14	24.58	5.34	1.05	59.5	25.8
M2AL0P2	46.4	17.6	5.87	37.7	14.39	24.45	5.39	0.94	77.5	22.9
M2AL0P3	47.0	18.7	6.76	39.5	14.57	25.08	5.39	1.42	78.5	35.6
M2AL1P0	35.2	11.1	3.51	35.6	9.08	20.98	4.64	0.96	42.1	20.1
M2AL1P1	41.7	13.9	3.91	36.5	9.89	22.54	5.08	0.85	50.2	19.1
M2AL1P2	45.8	16.7	5.60	37.6	12.49	20.45	5.19	1.29	64.8	26.3
M2AL1P3	45.9	18.0	6.09	38.8	13.60	22.73	5.41	0.86	73.5	19.5
M2AL2P0	34.4	15.1	3.45	35.1	9.09	21.08	4.47	0.80	40.6	16.8
M2AL2P1	41.6	13.7	3.70	36.0	9.74	20.94	4.56	1.13	44.4	23.6
M2AL2P2	45.2	15.5	5.39	37.2	11.62	22.77	4.90	0.97	56.9	32.1
M2AL2P3	45.8	17.7	6.05	38.2	13.51	21.78	5.15	0.90	69.5	19.4
CD (0.05)	NS	NS	2.14	NS	NS	3.64	1.15	NS	13.6	8.2

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TABLE 4

Interaction effect of moisture, active lime and phosphorus on the concentration and uptake of zinc and calcium by wheat cv GW-120.

Treatment Combination	Zn concentration (mg g $^{-1}$)		Zn uptake (mg pot $^{-1}$)		Ca concentration (mg q $^{-1}$)		Ca uptake (mg pot $^{-1}$)	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
M1AL0P0	76.2	80.3	905	2439	4.26	3.54	15.0	107.5
M1AL0P1	78.7	81.0	1120	2819	1.44	3.16	20.5	110.4
M1AL0P2	71.5	70.4	1307	2868	1.21	2.87	22.1	117.1
M1AL0P3	68.2	69.3	1221	2911	1.16	2.86	20.8	120.0
M1AL1P0	82.7	77.0	889	2075	1.11	3.63	11.9	97.0
M1AL1P1	70.8	65.1	931	2238	0.97	3.07	12.7	105.1
M1AL1P2	72.7	49.7	1246	2002	1.07	3.04	18.3	127.4
M1AL1P3	71.0	59.0	1178	2330	1.05	3.18	18.1	125.0
M1AL2P0	81.3	69.5	824	1737	1.14	3.15	11.5	79.0
M1AL2P1	76.8	53.1	925	1792	1.16	3.15	14.0	106.3
M1AL2P2	68.5	54.0	1076	2105	1.30	3.18	20.4	123.4
M1AL2P3	67.2	70.2	1098	1567	1.00	3.41	17.6	132.9
M2AL0P0	78.1	55.9	817	1192	0.94	3.36	9.8	71.2
M2AL0P1	73.7	50.3	921	1236	0.98	3.62	10.9	90.4
M2AL0P2	57.4	40.3	826	9853	1.00	3.46	15.6	84.6
M2AL0P3	55.5	35.0	902	8782	1.01	3.14	14.7	78.7
M2AL1P0	67.0	63.2	608	1326	1.26	2.82	11.4	59.1
M2AL1P1	65.2	51.1	645	1152	0.96	3.21	9.5	72.3
M2AL1P2	51.9	56.2	648	1149	0.98	3.41	12.2	73.8
M2AL1P3	57.9	50.2	787	1141	0.93	3.48	12.6	79.1
M2AL2P0	73.5	64.0	668	1349	0.94	2.85	9.0	60.1
M2AL2P1	64.9	55.4	632	1160	0.93	2.96	9.0	61.9
M2AL2P2	57.4	91.5	667	2083	0.79	2.95	9.1	67.2
M2AL2P3	59.8	50.4	808	1098	0.84	3.25	11.3	70.8
CD (0.05)	10.8	10.5	159	162	0.07	NS	1.4	3.5

The concentration and uptake of Zn by the grain and straw were significantly affected by M x AL x P (Table 4). The concentration of Zn in the grain and straw was reduced with P levels under M1 and M2, its differences became wider with increasing contents of active lime in the soil, particularly under M2. This may be due to the higher concentration of P under M2, because of the reduced growth. Since the Zn uptake by the grain and straw increased with the levels of P due to higher yields in response to P fertilization. Contrary to this, the Zn uptake by grain and straw was curtailed by 10 and 46 per cent under M1AL2P3 over M1AL0P3, respectively. Possibly due to adverse effect of active lime when combined with P application which curtailed the growth and yield of field crops (Golakiya and Patel, 1988).

The concentration and uptake of Ca by the grain and straw were significantly affected by M x AL x P except Ca concentration in straw (Table 4). The Ca concentration was diminished with the P levels. However, its considerable reduction (6 – 26%) in the grain along the active lime content remained a moot point and this complexicity was further intensified by no such effect of active lime on the Ca concentration in the straw. On the contrary, the Ca uptake was increase with increasing P levels, but it was curtailed with increasing content of active lime in the soil, particularly under M2. The Ca uptake by grain and straw was reduced by 23 and 10 per cent under M2AL2P3 over that under M2AL0P3, respectively.

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