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Integrated phosphorus management in maize (*Zea mays*)–sunflower (*Helianthus annuus*)–cowpea (*Vigna unguiculata*) fodder cropping system

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ABSTRACT

A field experiment was conducted during 1997–98 and 1998–99 at Tamil Nadu Agricultural University, Coimbatore, to study the effect of phosphorous sources and levels in a maize (*Zea mays* L.)–sunflower (*Helianthus annuus* L.)–cowpea [*Vigna unguiculata* (L.) Walp.] fodder cropping system. Single superphosphate with 75% recommended level of P_2O_5 increased the plant height, dry-matter production and productivity of maize and sunflower crops. Single superphosphate application+microbial inoculants with 75% recommended level of P_2O_5 increased the growth and yield of cowpea fodder. The P_2O_5 application for all the 3 crops in the system increased the productivity.

Key words : Phosphorus, Cropping system, Microbial Inoculants

In the western zone of Tamil Nadu, maize–sunflower–cowpea fodder is a widely practised cropping system. It is estimated that the intensive cropping system annually removes about 150 kg P_2O_5 ha, which is persumably twice as much as added through fertilizer (Goswami and Kamath, 1984). In actual practice, the farmers apply fertilizers for individual crops of a system rather than considering the system as a whole. Research works carried out throughout India revealed that residual effects of fertilizers are observed with respect to phosphorous fertilizers. Hence the present investigation was carried out to find out a suitable source and level of P for the maize–sunflower–cowpea fodder cropping system.

MATERIALS AND METHODS

The field experiment was conducted during 1997–98 and 1998–99 at Tamil Nadu Agricultural University, Coimbatore, in black soil of pH 8.1. The first crop of maize was raised in split-plot design, the second and third crops, *viz.* sunflower and cowpea fodder, were raised in split-split design with 3 replications. The first crop maize consisted of phosphorous sources as main plots, viz. Mussoorie rock phosphate

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(MRP) + microbial inoculants (F_1), MRP alone (F_2), single superphosphate (SSP) + microbial inoculants (F_3), SSP Alone (F_4), with phosphorus levels in the subplots, viz. 50% recommended level of P_2O_5 (P_1), 75% recommended level of P_2O_5 (P_2), and 100% recommended level of P_2O_5 (P_3). The second crop sunflower and the third crop cowpea fodder consisted of the main and subplot treatments of maize. For the sunflower crop, the sub-subplot treatments were application of P_2O_5 for maize crop alone, i.e. skipping P_2O_5 for sunflower (S_1), and application of P_2O_5 for both the crops, viz. maize and sunflower, i.e. no skipping (S_2). Whereas for the cowpea fodder crop the sub-subplot treatments were application of P_2O_5 for maize crop alone, i.e. skipping P_2O_5 for sunflower and cowpea fodder (S_1), application of P_2O_5 for maize and sunflower, i.e. skipping P_2O_5 for cowpea fodder alone (S_2), and application of P_2O_5 for all the 3 crops in the system, viz. maize, sunflower and cowpea fodder, i.e. no skipping (S_3). The N and K were applied at recommended levels for all the 3 crops in the system. The microbial inoculants consisted of phosphobacteria 200 g, *Trichoderma viride* 100 g and *Pseudomonas florescens* 100 g. This mixture was applied for 1,134 m^2. The variety of maize, sunflower and cowpea fodder used was 'CO 1', 'CO 4' and 'CO 5' respectively. Maize crop was raised during September, sunflower during January and cowpea fodder during April. The recommended level of P_2O_5 for maize, sunflower and cowpea fodder was 62.5, 20 and 40 kg/ha. The duration of maize sunflower and cowpea fodder was 110, 90 and 60 days respectively.

RESULTS AND DISCUSSION

Maize

The phosphorus sources significantly influenced the growth and yield of maize. Single superphosphate with microbial inoculants increased the plant height, dry-matter production, and stover yield. But it was on par with the single superphosphate when applied alone (Table 1). The single superphosphate with microbial inoculants increased the grain yield over single superphosphate during 1997–98 and however during 1998–99 the yield obtained by single superphosphate with microbial inoculants and single superphosphate were on par. The stover yield increased with single superphosphate + microbial inoculants and was comparable with that with single superphosphate. The growth parameters and the yield were lower in the Mussoorie rockphosphate treatments when compared to single superphosphate treatments. Rachewad *et al.* (1991) reported that P as single superphosphate was more effective than P as Mussoorie rockphosphate.

The phosphorus levels significantly influenced the growth and yield of maize. The significant increase in plant height and yield was noticed up to 75% of the recommended level P_2O_5. The dry-matter production significantly increased at 100% recommended level of P_2O_5. Similar findings were reported by Vig *et al.* (1989). The stover yield exhibited a significant increase with 100% recommended level of P_2O_5 during 1997–98, whereas it was comparable with 75% recommended level of P_2O_5 during 1998–99.

Table 1. Plant height, dry-matter production and yield of maize as influenced by phosphorus-management practices

Treatment	Plant height cm			Dry-matter production (kg/ha) at 60 days			Grain yield (kg/ha)			Stover yield (kg/ha)		
	1997–98	1998–99	Mean	1997–98	1998–99	Mean	1997–98	1998–99	Mean	1997–98	1998–99	Mean
Phosphorus source												
F_1	180	147	164	6,917	6,795	6,856	4,571	4,476	4,524	6,648	6,234	6,441
F_2	174	143	158	6,429	6,392	6,411	4,282	4,037	4,160	6,520	5,910	6,215
F_3	192	161	176	8,500	5,458	8,479	5,608	4,867	5,238	7,615	6,794	7,205
F_4	187	161	174	8,194	8,042	8,118	5,254	4,820	5,037	7,513	6,620	7,067
CD (P=0.05)	9.91	4.58	7.10	529.42	425.90	482.26	255.66	214.21	242.8	456.52	186.55	192.8
Phosphorus levels												
P_1	175	146	160	7,167	6,980	7,074	4,742	4,279	4,511	6,779	6,016	6,398
P_2	185	156	171	7,509	7,422	7,466	5,033	4,617	4,825	7,107	6,488	6,798
P_3	189	158	174	7,854	7,863	7,859	5,146	4,753	4,950	7,336	6,664	7,000
CD (P=0.05)	6.90	3.51	4.25	330.62	352.33	378.45	161.55	171.78	147.4	156.46	235.88	212.6

Details of treatments are given in text

Table 2. Plant height, dry-matter production, stem girth and seed yield of sunflower as influenced by phosphorus-management practices

Treatment	Plant height at harvest (cm)			Dry-matter production at 60 days (kg/ha)			Stem girth (cm)			Seed yield (kg/ha)		
	1997–98	1998–99	Mean	1997–98	1998–99	Mean	1997–98	1998–99	Mean	1997–98	1998–99	Mean
Phosphorus source												
F_1	141	139	140.32	2,570	2,829	2,700	2.22	2.19	2.21	1,027	1,056	1,042
F_2	141	137	139.04	2,286	2,712	2,499	2.21	2.18	2.20	979	1,021	1,000
F_3	156	147	151.06	3,255	3,344	3,300	2.45	2.50	2.48	1,111	1,153	1,132
F_4	154	145	149.91	3,036	3,244	3,140	2.44	2.47	2.46	1,097	1,109	1,103
CD (P=0.05)	6.07	6.64	5.24	148.08	94.71	126.8	0.11	0.09	0.01	40.13	49.81	36.72
Phosphorus level												
P_1	144	138	140.96	2,262	2,748	2,505	2.30	2.30	2.30	1,011	1,037	1,024
P_2	150	143	146.34	2,989	3,109	3,049	2.34	2.33	2.34	1,066	1,111	1,089
P_3	150	145	147.85	3,110	3,239	3,175	2.35	2.36	2.36	1,080	1,115	1,098
CD (P=0.05)	3.81	4.83	3.24	99.23	76.33	107.1	NS	NS	NS	19.67	47.44	20.78
Skipping phosphorus												
S_3	146	141	143.38	2,693	2,960	2,827	2.32	2.32	2.32	1,005	1,038	1,022
S_2	150	144	146.79	2,881	3,104	2,993	2.34	2.36	2.35	1,100	1,131	1,116
CD (P=0.05)	3.19	NS	3.06	77.98	83.39	92.8	NS	NS	NS	23.07	26.32	21.01

Treatment details are given in text

Sunflower

The plant height, dry-matter production, stem girth and seed yield were significantly influenced by the phosphorus sources. The plant height increased with single superphosphate + microbial inoculants and was comparable with single superphosphate. Significant increase in plant height, stem girth and seed yield were noticed between the single superphosphate and mussoorie rockphosphate applied treatments. The single superphosphate with microbial inoculants significantly increased the dry-matter production over the single superphosphate treatment.

The significant increase in plant height and seed yield was observed up to 75% recommended level of P_2O_5 (Table 2). The dry-matter production increased significantly at 100% recommended level of P_2O_5. Similar increase in dry-matter production was noticed by Ateeque *et al.* (1993). The stem girth did not exhibit any significant difference.

Application of P_2O_5 to maize and sunflower significantly increased the plant height during 1997–98 and during 1998–99 significant differences were not noticed between skipping of P_2O_5 and no skipping for sunflower. The skipping of P_2O_5 and no skipping had no significant effect on the stem girth. The dry-matter production and seed yield significantly increased when P_2O_5 was applied for both maize and sunflower crops.

Cowpea fodder

The plant height, dry-matter production and green-fodder yield were significantly

Table 3. Growth and yield of cowpea fodder as influenced by phosphorus-management practices

Treatment	Plant height at 60 days (cm)			Dry-matter production (kg/ha) at 45 days			Green fodder yield (tonnes/ha)		
	1997–98	1998–99	Mean	1997–98	1998–99	Mean	1997–98	1998–99	Mean
Phosphorus source									
F_1	42	56	49	1,648	1,658	1,653	13.51	16.66	15.09
F_2	41	54	48	1,488	1,334	1,411	13.22	15.63	14.43
F_3	48	64	56	1,998	2,309	2,154	17.79	21.36	19.58
F_4	47	62	54	1,883	1,972	1,928	16.70	19.20	17.95
CD (P=0.05)	0.36	0.25	0.52	51.7	104.9	83.5	0.90	1.49	1.60
Phosphorus level									
P_1	43	56	49	1,612	1,694	1,653	11.47	15.18	13.33
P_2	45	60	53	1,785	1,848	1,848	16.81	19.38	18.10
P_3	46	61	53	1,865	1,888	1,888	17.63	20.00	18.82
CD (P=0.05)	0.17	1.36	0.64	52.8	56.6	44.9	1.05	0.68	0.72
Skipping phosphorus									
S_1	43	56	49	1,656	1,682	1,669	12.30	15.23	13.77
S_2	44	60	52	1,751	1,841	1,796	16.25	19.44	17.85
S_3	47	61	54	1,856	1,932	1,894	17.37	19.96	18.67
CD (P=0.05)	0.19	1.81	1.20	50.67	49.93	63.4	0.60	0.74	0.79

Treatment details are given in text

higher at single superphosphate with microbial inoculants. With respect to the phosphorus levels, 100% recommended level significantly increased the plant height during 1997–98. However 100% and 75% of the recommended level were comparable during 1998–99 (Table 3). The dry-matter production increased at 100% recommended level of P_2O_5. Similar findings were reported by Venugopalan and Prasad (1992). The green-fodder yield increased up to 75% recommended level of P_2O_5.

It may be concluded that for maize and sunflower crops. Single superphosphate with 75% recommended level of P_2O_5 and for cowpea fodder crop. Single superphosphate + microbial inoculants with 75% recommended level of P_2O_5 increased the growth and yield. The P_2O_5 application for all the 3 crops in the system would be beneficial for increased productivity of the system.

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