highest LER of 1.35, which is due to significant additional yield realised in this system from the intercrop.

Net returns (Rs/ha): The different treatments significantly influenced the net returns. Except in groundnut intercropped with ragi or cowpea, the net returns from other intercropping systems were higher than that from groundnut in pure stands (Rs.6,586/ha). Drastic reduction in groundnut + ragi and groundnut + cowpea could be attributed to significant lower groundnut yield and poor intercrop yield recorded in these systems. Groundnut + red gram proved to be the most remunerative system (Rs.7,813/ha).

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STUDIES ON RESIDUAL, DIRECT AND CUMULATIVE EFFECT OF PHOSPHORUS SOURCES ON THE AVAILABILITY, CONTENT AND UPTAKE OF PHOSPHORUS AND YIELD OF MAIZE

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ABSTRACT

Field experiment conducted at Coimbatore with maize in a typic ustropept soil revealed that application of phosphatic fertilizers irrespective of source, level and effects increased the available P. Among the sources, DAP and SSP were superior over RP and its combinations. The various sources and levels and the effects did not produce any significance in the P content of grain and stalk of maize. Significant difference among the sources for P uptake in grain was observed under cumulative effect whereas it was the direct effect for stalk uptake. The DAP and SSP proved significantly superior over RP and its combinations in the grain yield under direct and cumulative effects. However, the same trend was observed for residual and direct effects in the stalk yield.

Fertilizer P is a costly input and its utilization by individual crops is poor due to fixation and immobility in the soil. A single crop uses about 20 per cent of the applied P and the rest remains as residue and converted to various reaction products of varying solubility which is utilized by the

Table 1. Available P (ppm) in soil of maize.

Treatment	Knee high stage				Tasseling stage				Harvest state			
	RE	DE	CE	Pool	RE	DE	CE	Pool	RE	DE	CE	Pool
a) Source												
SSP	13.4	19.7	21.9	18.3	13.0	19.8	19.4	17.4	11.0	17.3	18.0	15.6
RP	13.6	14.3	18.7	16.3	11.5	15.1	15.0	13.8	10.7	14.1	13.9	12.1
2/3 RP + 1/3 SSP	14.2	18.4	19.3	17.3	12.8	17.9	17.4	16.0	11.8	16.4	15.5	14.6
RP + PB	14.4	17.3	19.1	16.9	12.0	16.4	16.7	15.0	10.5	16.0	15.3	14.1
DAP	14.9	21.3	23.0	19.8	15.1	22.4	21.1	19.6	13.9	19.8	19.6	17.8
Control	4.6	4.5	4.1	4.4	4.6	4.6	4.3	4.5	4.1	4.5	4.5	4.3
b) Level												
30 kg P_2O_5/ha	11.3	14.9	17.0	14.4	10.9	15.0	14.8	13.3	9.1	14.2	13.7	12.3
60 kg P_2O_5/ha	13.8	18.8	20.4	17.7	12.7	18.5	17.7	16.3	10.9	17.1	16.1	14.7
90 kg P_2O_5/ha	17.2	21.1	23.8	21.0	15.9	21.5	21.2	19.5	14.7	19.8	19.9	17.9
Source : SED	0.8	0.8	0.7	0.4	0.9	0.8	1.6	0.5	0.6	0.8	1.0	0.5
CD	NS	1.7	1.5	0.9	1.9	1.7	2.1	1.0	1.3	1.7	2.1	1.0
Level : SED	0.6	0.6	0.6	0.3	0.7	0.6	0.8	0.4	0.5	0.6	0.8	0.3
CD	1.3	1.3	1.2	0.7	1.5	1.3	1.6	0.8	1.1	1.3	1.6	0.7
S x L : SED	1.5	1.4	1.3	0.8	1.6	1.4	1.8	0.9	1.1	1.3	1.8	0.8
CD	NS	3.0	2.7	1.6	NS	NS	NS	1.8	NS	NS	NS	1.7

RE : Residual effect; DE : Direct effect; CE : Cumulative effect

Table 2. Content of P (per cent) of maize.

Treatment	Grain				Stalk			
	RE	DE	CE	Pool	RE	DE	CE	Pool
a) Source								
SSP	0.34	0.33	0.31	0.33	0.13	0.12	0.09	0.11
RP	0.37	0.33	0.26	0.32	0.15	0.10	0.12	0.12
2/3 RP + 1/3 SSP	0.48	0.36	0.31	0.35	0.13	0.14	0.11	0.13
RP + PB	0.32	0.34	0.28	0.31	0.13	0.13	0.12	0.12
DAP	0.37	0.32	0.34	0.34	0.14	0.13	0.10	0.12
Control	0.36	0.34	0.29	0.33	0.12	0.11	0.10	0.11
b) Level								
30 kg P_2O_5/ha	0.35	0.33	0.29	0.32	0.12	0.13	0.11	0.12
60 kg P_2O_5/ha	0.34	0.34	0.38	0.32	0.14	0.12	0.11	0.12
90 kg P_2O_5/ha	0.37	0.34	0.32	0.34	0.13	0.12	0.11	0.12
Source : SED	0.03	0.03	0.03	0.02	0.01	0.02	0.01	0.01
CD	NS	NS	NS	NS	NS	NS	NS	NS
Level : SED	0.03	0.03	0.03	0.04	0.01	0.01	0.01	0.01
CD	NS	NS	NS	NS	NS	NS	NS	NS
S x L : SED	0.05	0.06	0.06	0.03	0.04	0.02	0.03	0.04
CD	NS	NS	NS	NS	NS	NS	NS	NS

RE : Residual effect; DE : Direct effect; CE : Cumulative effect

succeeding crop. Hence, this experiment was undertaken to study the direct, residual and cumulative effect of different phosphatic fertilizers on various parameters in maize grown after fingermillet.

MATERIALS AND METHODS

A field experiment was carried out at Tamil Nadu Agricultural University, Coimbatore to evaluate the residual, direct and cumulative effect of different sources of P in the maize grown after fingermillet. The experiment was laid out in FRBD with three replications. The nutrient status of clay loam soil (typic ustropept) was low, low and high for N, P and K respectively with a pH of 8.02. The experiment involved 16 treatments with five sources of P viz., single superphosphate (SSP), rock phosphate (RP), 2/3 rock phosphate + 1/3 single superphosphate (RP + SSP), rock phosphate + Phosphobacterium (RP + PB) (*Bacillus megaterium*) and Diammonium phosphate (DAP) and three levels of P viz. 30, 60 and 90 kg P_2O_5/ha along with an absolute control. Phosphatic fertilizers were applied to the previous crop of fingermillet only, to study the residual effect in the succeeding maize crop, to maize only to study the direct effect and both to the previous crop of fingermillet and to the present crop of maize to study the cumulative effect. The N as urea was added uniformly to all the treatments in maize and no K was added since the soil contained high amounts of available K. Stagewise soil samples and plant samples at harvest stage were collected for analysis.

RESULTS AND DISCUSSION

Available phosphorus

The data on available P for different stages in soil of maize crop are given in Table 1. The available P was increased with the addition of P at all stages of maize growth and also in all the effects viz., residual, direct and cumulative. In all the effects, the DAP and SSP were superior over RP and its combinations RP + SSP and RP + PB. It is in confirmity with the findings of Biswas *et al.* (1985). In general, increasing levels of P resulted in enhanced available P at all the stages and effects studied.

P content of grain and stalk

The mean P content of grain (Table 2) was influenced by the interaction effect involving

Table 3. Uptake of P (kg/ha) of maize.

Treatment	Grain				Stalk			
	RE	DE	CE	Pool	RE	DE	CE	Pool
a) Source								
SSP	12.5	12.9	12.5	12.6	12.4	12.5	8.2	11.1
RP	13.6	12.2	10.3	12.1	12.6	8.9	10.2	10.6
2/3 RP + 1/3 SSP	14.4	14.1	13.0	13.1	11.7	14.2	9.4	11.8
RP + PB	12.1	12.4	11.0	11.8	11.8	12.1	9.9	11.3
DAP	14.0	13.8	14.6	14.1	14.0	14.1	8.3	12.2
Control	13.7	11.8	10.0	11.8	10.2	9.3	8.7	9.4
b) Level								
30 kg P_2O_5/ha	12.7	12.0	11.2	12.0	11.2	12.0	9.0	10.8
60 kg P_2O_5/ha	12.9	13.2	12.2	12.8	12.8	12.3	9.6	11.6
90 kg P_2O_5/ha	14.4	14.1	13.3	13.9	13.5	12.9	9.1	11.8
Source : SED	1.2	1.3	1.3	1.2	1.1	1.5	1.0	0.7
CD	NS	NS	2.7	2.5	NS	3.0	NS	NS
Level : SED	0.9	1.0	1.0	0.5	0.8	4.1	0.7	0.5
CD	NS	NS	NS	1.1	NS	NS	NS	NS
S x L : SED	2.1	2.3	3.3	1.3	1.9	2.6	1.7	1.2
CD	NS	NS	NS	NS	NS	NS	NS	NS

RE : Residual effect; DE : Direct effect; CE : Cumulative effect

sources and levels. At the lower does of 30 kg P_2O_5/ha employed, the P content was not influenced by the sources. With further increase in the P dose to 60 kg P_2O_5/ha, the RP + SSP combination was associated with greater P content, while at 90 kg P_2O_5/ha, the DAP treatment was associated with greater P content and higher yield. The result is closely associated with the findings of Singh *et al.* (1986). The P content of stalk (Table 2) for the sources and levels did not produce any difference in all the effects studied. In spite of the changes in P fertilization practice, the stalk P content of maize was not altered. This implied that even the insoluble sources which could not muster much influence on the previous crop of fingermillet could prove beneficial for the succeeding maize crop by ensuring same concentration with that of direct and cumulative additions of P to the maize crop. This observation is in accordance with the findings of Marwaha *et al.* (1981).

Uptake of P by grain and stalk

The P uptake of maize grain remained (Table 3) similar among the sources and levels of P under residual and direct effects. However, the cumulative effect and the pooled analysis showed the water soluble P sources (DAP and SSP) and RP + SSP and also higher level favoured greater uptake of P by the grain. The increased uptake due to increased levels and water soulble sources of P was also observed by Sharma and Saxena (1985) and Mengel (1986). It is reasonable to indicate that the plants tend to translocate sufficient amount of the nutrients into the grain irrespective of the differential soil environment.

It was observed that the different P sources could account for significant variation in the stalk P uptake (Table 3) only under direct effect, where the sources DAP, SSP and RP + SSP proved better than RP + PB and RP alone. Enhanced stalk P uptake for the application of water soluble form of P sources was also observed by Sharma and Saxena (1985). Ensuring sufficient available P in the medium was conducive for translocation of the photosynthates more efficiently from the stalk for the storage organs and this has occurred in the present case.

Yield of grain

Under residual effect, the P addition proved beneficial while the sources made no difference. The doses beyond 30 kg P_2O_5/ha enhanced the

Table 4. Yield (kg/ha) of maize.

Treatment	Grain				Stalk			
	RE	DE	CE	Pool	RE	DE	CE	Pool
a) Source								
SSP	3685	3963	3943	3864	9450	10144	8350	9315
RP	3785	3747	3974	3809	8527	8820	8302	8552
2/3 RP + 1/3 SSP	3804	3873	4069	3915	8902	9587	8258	8916
RP + PB	3717	3827	3905	3816	8954	9131	8105	8703
DAP	3833	4167	4342	4114	10319	10947	8129	9798
Control	3471	3487	3487	3482	8337	8419	8089	8282
b) Level								
30 kg P_2O_5/ha	3618	3741	3914	3757	8846	9223	8198	8756
60 kg P_2O_5/ha	3780	3937	4038	3918	9195	9769	8341	9182
90 kg P_2O_5/ha	3848	4069	4188	4035	9650	10190	8148	9329
Source : SED	57.0	48.4	91.7	39.7	191.1	295.7	160.7	129.0
CD	NS	99.0	187.2	78.3	390.4	604.0	NS	256.2
Level : SED	44.1	37.5	71.0	30.5	148.0	229.1	124.5	99.9
CD	98.2	76.7	145.0	60.7	302.4	467.8	NS	198.5
S x L : SED	98.8	83.9	158.8	68.3	331.1	512.3	278.4	223.5
CD	NS	NS	NS	NS	676.3	NS	NS	443.9

RE : Residual effect; DE : Direct effect; CE : Cumulative effect

yield significantly (Table 4). This is in confirmity with the findings of Nimje and Jagdish Seth (1987). In direct effect, the sources as well as the levels brought about differences in the grain yield. Addition of P proved beneficial. Among the sources DAP and SSP proved superior to the other forms. Its successive level of P could bring about a successive and significant improvement in the yield. Similar results were also observed by Singh *et al.*(1986). Undder cumulative effect, the DAP recorded the highest among the sources and the 90 kg P_2O_5/ha associated with the highest grain yield among levels. Ved Singh and Mehta (1982) also observed similar response. The yields due to levels revealed the order 90 > 60 > 30 kg P_2O_5/ha and the effects cumulative > direct > residual.

Yield of stalk

Under residual effect, the P added treatments were associated with greater stalk yield over control (Table 4). The sources and levels were also associated with significant effect, the DAP and SSP were more efficient than the other sources. A significant improvement in the stalk yield was also observed with progressively increasing P doses. The same trend was also observed for direct effect which is also in confirmity with the findings of Rai *et al.* (1982). None of the factors reached the level of statistical significance, under the cumulative effect on the yield of stalk.

Addition of P fertilizers to the preceding fingermillet crop continued to have a marginal residual effect on the succeeding maize crop. The high doses of P showed a marginal residual value by enhancing both grain and stalk yields. In the second case, which involved P application to the maize crop (direct effect) resulted in well defined beneficial effect both for the sources and the levels in respect of grain and stalk yield. P application to the preceding crop and the maize crop certainly made difference with direct application providing more beneficial than indirect application through preceding fingermillet crop.

A striking cumulative effect could be seen when the practice of application of P fertilizers to both the crops is adopted. Application of water soluble sources viz. DAP and SSP became additive and a marked improvement both in grain and stalk yield could be observed. Application of even the insoluble sources such as RP alone and in combination with PB as also the mixed sources of RP + SSP could enhance the yield on par with SSP. Thus the application of water insoluble sources to every crop could account for grain and straw yield improvement on par with SSP. However, between the DAP and SSP, the DAP was better than SSP and proved significantly superior to all other sources of P both in respect of grain and straw yield.

REFERENCES

BISWAS, B.C., SATISH MAHESWARI and YADAV, D.S. 1985. Relative efficiency of different types of fertilizers. **Fert.News.30(11):15-23.**

MARWAHA, B.C., KANWAR, B.S. and TRIPATHI, B.R. 1981. Direct and residual effectiveness of Mussorie rock phosphate in wheat-maize rotation. **Indian J. Agric. Sci.51**:870-874.

MENGEL, K. 1986. Turn over in soil and yield response of phosphate rock containing fertilizers. **J.Plant Nutr.Soil Sci.149**(6):674-591.

NIMJE, P.M. and JAGDISH SETH. 1987. Effect of phosphorus and farm yard manure on soybean and their residual effect on succeeding winter maize.**Indian J.Agric.Sci.** 57:404-409.

RAI, R.K., SINHA, M.N. and MAHATIM SINGH. 1982. Studies on direct and residual effect of phosphorus on growth and yield of maize and wheat in sequence.**Indian J.Agron.27**:354-362.

SHARMA J.P. and SAXENA, S.N. 1985. Utilisation of phosphorus by maize as influenced by various sources of organic matter and applied phosphorus.**J.Indian Soc.Soil Sci.**33:561-567.

SINGH, G.P., BHARGAVA, P.N. and RAJENDER KAUR. 1986. Comparative performance of phosphal and SSP in different agro-ecological situations. **Fert.News. 31**(3):33-38.

VED SINGH and MEHTA, M.C. 1982. Manurial requirement of maize-wheat rotation. **Indian J.Argon. 27**:127-136.

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SOLUBLE CATIONS AND ANIONS IN RELATION TO SOIL pHs AND ECe IN TYPIC NATRAQUALF

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ABSTRACT

On an average, soluble CO_3^{2-} + HCO^{3-} and Na^+ constituted 74.2 per cent and 96.8 per cent of total soluble anions and cations respectively and were highly and positively correlated with each other (r = 0.958**), showing the dominance of Na2CO3 in these soils. The amount of various anions and cations followed the sequence as CO_3^{2-} + HCO^{3-} > Cl > SO_4^{2-} and Na^+> Ca^{2+} + Mg^{2+} > K+ respectively. Soil ECe increased by an unit with every 11.6 m.e.L^{-1} increase in soluble cations. Soluable CO_3^{2-} + HCO^{3-} and Na^+ significantly correlated with ECe of soils (r = 0.954** and 0.979**) and pHs (r = 0.535** and 0.518**) respectively, explaining the major role of these ions in regulating the pHs and ECe of salt affected soils.

Electrical conductivity and pH are the two soil parameters for suitably classifying the salt affected soils as saline and sodic from management point of view. Chemically two types of saline - alkali soils are met with, one in which the salinity is due to the presence of soluble salts having chlorides and sulphates and other in which the dominant salts are carbonates and bicarbonates. The present investigation has therefore been undertaken to study the type of cations and anions contributing towards the variation in pH and ECe of some salt affected soils collected under natural environment.

MATERIALS AND METHODS

Thirty soil samples (Family Typic Natraqualfs) ranging in pHs from 7.3 to 10.8 were finally selected out of 600 samples for the study. Soil pHs, ECe, water soluble anions viz., $CO3^{2-}$ + HCO^{3-}, Cl^-, and cations viz., Na^+, Ca^{2+} + Mg^{2+} and K^+ were determined as per methods described by Richards (1954). Soluble $SO4^{2-}$ content was estimated turbidimetrically according to method described by Jackson (1973). To assess the contribution of various cations and anions towards variation in pHs and ECe, regression and multiple correlation analyses were carried out.

RESULTS AND DISCUSSION

The data of analyses are presented in tables 1 to 3. Soil ECe increased from 1.56 to 70.52 dSm^{-1} with increase in water soluble CO32- + HCO3- and Na^+ from 8.00 to 522.00 m.e.L^{-1} and from 6.08 to 800.00 m.e.L^{-1} respectively. There was a significant relationship between ECe and soluble anions or cations. Usually, ECe is increased by 1 dSm^{-1} per 10 m.e.L^{-1} increase in soluble cations (Richards, 1954). But in these soils, an increase in ECe by 1 dSm^{-1} per 11.6 m.e.L^{-1} increase in