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To Evaluate the Effect of Oxalic Acid Industry Waste Treated Rock Phosphate with Native and Applied Phosphorus on Growth, Phosphorus Use Efficiency and Yield of Soybean

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A field experiment was taken on soybean with the treament of increasing levels of phosphorus added through single superphosphate (SSP), rock phosphate (RP) and rock phosphate treated with oxalic acid industry waste (RP + OAIW) at J.N. Krishi Vishwavidyalaya Research Farm. The results showed that applicationo of 40 kg P_2O_5 ha^{-1} (RP) mixed with OAIW proved to be superior and beneficial in increasing the grain yield as compared to control and over rest of the treatments.

The maximum net return (Rs 9170.00 ha^{-1}) over control and cost benefit ratio (1 : 2.88) was achieved in the application of 40 kg P_2O_5 ha^{-1} (RP) + OAIW (T_4). No harmful effect of OAIW was observed on plant growth as well as on soil health during the entire life cycle of crop.

INTRODUCTION

In India the waste generated per annum is about 5000 million tonnes. The quality of the waste varies with the type of industry and the type of raw materials used. Most of the industries in India presently dispose their untreated waste on land and natural streams. About 65 to 70 per cent waste does not get any treatment.[1] Due to lack of treatment and improper mode of disposal, wastes, when disposed of on land or natural streams, cause physical, chemical and biological disorders. Organic residue as a source of plant nutrients recycling in agriculture becomes an increasingly important aspect of environmentally sound sustainable agriculture.[2,3] One of such organic wastes is oxalic acid industry waste, where oxalic acid is obtained by treating the bark of Saja (*Terminalia termentosa*) tree with concentrated sulphuric acid. After extracting the oxalic acid from reacting materials, remaining waste material contains 13% sulphur, 12.5% free acidity and other nutrients in trace amount. Oxalic acid industry waste can be successfully used for partial acidulation of rock phospate. The present study describes the effect of oxalic acid industry waste treated rock phosphate on crop yield and phosphorus use efficiency as compared with levels of single superphosphate application alone.

EXPERIMENTAL

A field experiment was conducted with soybean var. 75–46 in Kharif 1994 at J.N. Krishi Vishwavidyalaya Research Farm, Jabalpur. An experiment was carried out on typical chromustert clay soil which was low in available N (182 kg ha^{-1}), available P (11.62 kg ha^{-1}), available S (6.28 kg ha^{-1}) and high in available K (371 kg ha^{-1}). Soil was neutral in reaction (7.2 pH) and electrical conductivity was 0.28 dS m^{-1}. The experiment was statistically designed in randomised block design and all the treatments were replicated three times in plots (5 m × 2.5 m). Single superphosphate (SSP) was applied @ 0 (T_0), 40 (T_1) and 80 (T_2) kg P_2O_5 ha^{-1} and rock phosphate (RP) @ 40 (T_3), 80 (T_4) and 120 (T_5) kg P_2O_5 ha^{-1} treated with 5 metric tonnes of oxalic acid industry waste (OAIW) and alone 5 metric tonnes OAIW (T_6) was also added without RP. Basal doses of 20 kg N (urea) and 30 kg K_2O ha^{-1} (MOP) were given at the time of sowing. Soybean was sown @ 100 kg ha^{-1} in lines at row to row distance of 50 cm and plant to plant distance of 10 cm. The crop was harvested at maturity and grain yield was recorded after drying (14% moisture). Representative soil and plant samples were drawn from each plot.

Soil and plant samples were processed for post-harvest chemical analysis. Soil samples were analysed for pH and electrical conductivity was measured in the ratio of 1 : 2.5 soil water suspension and the available N, P, K and S were estimated by using the conventional methods. Plant samples were wet digested by diacids mixture of nitric acid-perchloric acid in the ratio of 5 : 2. The digested material was used for the determination of phosphorus and sulphur in plant tissue following the standard procedures. The relative yield phosphorus use efficiency, physiological efficiency, fertilizer phosphorus recovery (FPR) and apparent recovery of fertilizer (ARF) was computed according to the procedures described.[4]

RESULTS AND DISCUSSION

The results (Table 1) showed that the grain yield of soybean significantly increased with increasing levels of phosphorus applied through either SSP or RP treated with OAIW and marginal grain yield varied between 0.05 and 7.25 quintal ha^{-1}. Significant differences were also observed among the treatment levels of T_2 and T_3 over control. The highest marginal grain yield (7.25 quintal ha^{-1}) and per cent response (56.34%) were obtained at the treatment where 40 kg P_2O_5 ha^{-1} (RP) was applied after mixing with 5 metric tonnes OAIW (T_5). This treatment was significantly superior to the treatment which received different rates of SSP from that recommended. This treatment indicates the better efficiency of RP when applied at higher doses along with OAIW. Excellent performance (18.12%) response of RP was obtained under OAIW treated condition as compared with SSP in increasing the grain yield of soybean.[5] Every increment in phosphorus dose through SSP increased the grain yield, but when phosphorus was applied through RP + OAIW, further increase in doses decreased the grain yield up to the highest level (T_5) and response was limited only up to T_3 level. The progressive response of SSP was associated with low phosphorus availability in experimental

TABLE-1
EFFECT OF TREATMENT ON GRAIN YIELD AND PHOSPHORUS USE EFFICIENCY

Treat-ments	Grain yield increasing over control (q ha^{-1})	Per cent increase in grain yield over control	Response (kg grain/ kg P_2O_5) AYE	Relative yield efficiency (RYE) (%)	Grain straw ratio	P : S ratio in plant tissue	Phosphorus use efficiency			Physio-logical efficiency (%)	FPR (%)	ARE (%)
							Fert. source	Soil source	Fert + soil source			
T_0	—	—	—	—	1 : 1.38	8.45 : 1	—	14.23	14.23	—	—	—
T_1	0.93	6.45	2.325	93.93	1 : 2.08	8.10 : 1	15.70	35.57	51.27	14.80	45.57	0.1570
T_2	2.13	14.79	2.662	87.11	1 : 1.92	7.14 : 1	9.31	17.79	27.10	28.59	33.63	0.0930
T_3	7.25	50.34	18.120	66.51	1 : 2.10	6.37 : 1	21.02	35.58	56.60	86.20	72.84	0.2100
T_4	1.06	7.36	1.325	93.14	1 : 1.97	8.54 : 1	9.28	17.79	27.07	14.26	34.72	0.0920
T_5	0.05	0.34	0.041	93.65	1 : 2.17	7.02 : 1	5.69	11.84	17.55	0.73	22.80	0.0592
T_6	0.25	1.73	1.557	98.29	1 : 2.01	7.06 : 1	29.12	55.98	85.10	5.88	150.70	0.2910
$S^{Em}\pm$	0.061	—	—	—	—	—	—	—	—	—	—	—
CD 5%	1.258	—	—	—	—	—	—	—	—	—	—	—

q — quintal

soils. The relative yield efficiency and grain : straw ratio ranged from 66.51 to 99.65% and 1 : 1.38 to 1 : 2.17 and addition of 120 kg P_2O_5 ha^{-1} (RP) + OAIW gave the highest value *i.e.* 99.65% and 1 : 2.17 respectively. The phosphorus : sulphur ratio in plant tisue ranges from 6.37 to 8.54 : 1 and the highest magnitude was noted when 80 kg P_2O_5 ha^{-1} (RP) and OAIW were added to the soil. This effect may be due to the fact that OAIW contained 12% S, 0.15% P and 12.5% free acidity which helps in solubilizing the insoluble phosphorus present in native and fertilizer RP.[6] Hence, increased availability of phosphorus and sulphur in the soil is self-explanatory and indicates the positive relationship between them.

It is evident from the data that in phosphorus utilization efficiency, soil sources are contributing more than fertilizer sources. The trend of phosphorus utilization efficiency was maximum at lower doses, whereas further increase in the doses reduced the efficiency. The phosphorus use efficiency in fertilizer and soil source ranges from 5.69 to 29.12% and 11.84 to 55.98% respectively. The highest total phosphorus recovery (fert. + soil sources i.e. 85.10%) was found when only 5 metric tonnes of OAIW (T_6) were incorporated in the soil. This study emphasises the need for application of relatively lower levels of RP mixed with OAIW as compared with SSP for the most efficient phosphorus utilization. The RP treated with OAIW may be due to the fact that acidulation increases the amount of water-soluble phosphorus in the soil. The physiological efficiency ranged from 0.73 to 86.20% and the highest value (86.2%) was noticed when 40 kg P_2O_5 ha^{-1} (RP) was applied after treatment with OAIW (T_3). The fertilizer phosphorus efficiency (FPR) and apparent recovery of fertilizer (ARF) ranged from 22.8 to 150.7% and 0.059 to 0.291% and maximum value was registered when only 5 metric tonnes OAIW (T_6) was given to the soil. Hence, the efficiency values were erratic and lower at higher application. This could be explained as follows. The mathematical formula used for calculating efficiency assumes that the increased yield in fertilized plots is due to increased concentration/availability of nutrients in the soil. But in reality the increase in yield is due to both, increased concentration of nutrients as well as root volume which provides access to higher soil volume for nutrient absorption.[7]

TABLE-2
EFFECT OF TREATMENT ON C : P AND P : S RATIOS ON SOIL AND ECONOMICS OF CROP

Treatment	C : P ratio	P : S ratio	Net return (Rs ha^{-1})	Net return over control	Cost-benefit ratio
T_0	38 : 1	1.41 : 1	2000	—	1 : 1.33
T_1	65 : 1	1.23 : 1	6114	4114	1 : 2.04
T_2	84 : 1	1.45 : 1	6924	4924	1 : 2.20
T_3	51 : 1	1.25 : 1	11170	9170	1 : 2.88
T_4	70 : 1	1.15 : 1	6168	4168	1 : 2.06
T_5	65 : 1	1.18 : 1	5310	3310	1 : 1.92
T_6	80 : 1	0.47 : 1	5470	3470	1 : 1.95

The application of RP treated OAIW has a tremendous influence on maintaining the higher fertility status of soil. The carbon : phosphorus and phosphorus : sulphur ratio of experimental field ranged from 38 : 1 to 84 : 1 and 0.47 : 1 to 1.45 : 1 respectively. Incorporation of 40 kg P_2O_5 ha^{-1} (RP) + OAIW gave the highest carbon : phosphorus (84 : 1) and phosphorus : sulphur (1.45 : 1) ratios in the soil. The minimum value in unmanured treatment may be explained in the light of the fact that their removal by the crop. There is ample evidence to show that three-fourths of the applied phosphorus is not utilized by the crop which leaves a positive balance of phosphorus in the soil.[8] The mxsimum net return over control *i.e.*, Rs 9170 ha^{-1} was gained at the treatment where 40 kg ha^{-1} P_2O_5 (RP) mixed with OAIW was applied and the same treatment also poses the maximum cost-benefit ratio *i.e.*, 1 : 2.88. Thus from the foregoing discussion it is evident that rock phosphate treated with oxalic acid industry waste is better suited for a substitute and cheap source of phosphatic fertilizer for crop production.

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