Original Research Article

Conjointapplication of lime, organics, inorganic fertilizers, and bio-fertilizers influences groundnut productivity, available and microbial biomass phosphorus in acidic soil of Tripura

ABSTRACT

A field experiment was carried out on acidic soil of Khowai district of Tripura during 2017 and 2018 to evaluate the impact of the application of various combinations of lime, farmyard manure (FYM), poultry manure (PM), and rhizobium with the recommended doses of NPK on groundnut (*Arachis hypogaea* L.) productivity,available phosphorus (P) and microbial biomass phosphorus (MBP) content ofexperimental soil. The experiment was conducted followinga randomized block design (RBD) with 13 treatments, each of which was replicated thrice. Both initial and post-harvest soil samples were collected and analyzedto estimate the available P and MBP content. Available phosphorus and microbial phosphorus content (pooled) were increased in post-harvest soil over control in other treatment combinations studied. Results indicated that use of the recommended dose (RD) of NPK @ 20:60:40 kg ha^{-1}accompanied by lime @ 1/5th Lime Requirement (LR), PM @ 5 t ha^{-1}in addition to seed treatment with *Rhizobium* @ 20 g kg^{-1} of seed significantly increased available phosphorus and microbial phosphorus contentin the soil which has resulted in increased seed yield of groundnut compared to the RD of NPK alone in addition to other treatments combinations. Thus, the conjoint application of RD of NPK @ 20:60:40 kg ha^{-1}and lime @ 1/5th LR, PM @ 5 t ha^{-1}, and seed treatment with *Rhizobium* @ 20 g kg^{-1} of seed should be recommended to cultivators in achieving higher groundnut productivity with better return in acidic Tripura soil with increasing the available phosphorus status along with microbial biomass phosphorus of post-harvest soil.

Keywords: Groundnut, yield, lime, organic manure, fertilizers, biofertilizers, soil phosphorus

Introduction

The State Tripura characterized by varied physiography and climate is endowed with a variety of land uses and agricultural systems.The state indicates a rise in the area and production of oilseeds and pulses throughout the years. Presently, the yield of major crops in Tripura is generally low. The acid soils occur in 100% geographic area of Tripura. The highly leached soils are generally poor in fertility and water holding capacity. A substantial area with pH value of less than 5.5 is more problematic with severe deficiencies of phosphorus. Microbial decomposition and transformation of different nutrients are also retarded under acid soil conditions.To produce a better crop yield on acid soils, farmers are recommended to apply alkaline materials such as lime (primarily calcium carbonate) to increase the pH of soil and thus eliminate Al toxicity, and to apply P fertilizer to increase the bioavailability P in soil. But farmers found the complete reclamation with lime to the desired level is very expensive. Crops respond differently to lime, in general, doses of lime in particular, therefore, amelioration of soil acidity with a minimum amount of lime with a balanced application of all deficient nutrients including micronutrients is required to be popularized amongst the farmers. Applying organic manures in conjunction with lime has been shown by several authors (Bakayoko et al., 2009; Liang et al., 2011) to greatly improve soil quality since it increases the amount of organic matter in the soil. Given the declining productivity level, increasingly greater emphasis is now given to integrated nutrient management (INM) system, which plays a significant part in sustaining soil health (Melluand Moris, 1984).Under this background, present investigation was undertaken to investigate the impact of concurrent usage of lime,organics,inorganic fertilizers and biofertilizers in enhancing groundnut productivity and also to improve the available phosphorus and microbial biomass phosphorus content in the acidic soil soil of Tripura.

Material and Methods

The study was carried out at the Chebri Village of Khowai district of Tripura having 23.8974^0 North Latitude, 91.6372^0 East Longitude, and with an elevation of 23m (75ft) from mean sea level (MSL) during the two consecutive Rabi Seasons of the year 2017-18 and 2018-19. The study was conducted using a Randomized Block Design (RBD) with 13 treatment combinations each of which was replicated thrice. There were altogether 39 numbers of plots each having plot size of 2.7x1.8 m^2. Soil sampling was done from several randomly selected sites up to a depth of 0-15 cm before the layout of the field and were mixed together to draw a composite sample and were analyzed for different physico-chemical properties following the standard procedure.The following treatment combinations were undertaken: T_1: Control (only recommended dose of NPK (20:60:40 kg/ha) (RDF); T_2: Liming @1/10th LR (limestone) + RDF; T_3: Liming @1/5th LR (limestone) + RDF; T_4:Liming @1/10th LR (limestone) + RDF + FYM @ 5t/ha [T_2 + FYM]; T_5: Liming @1/5th LR (limestone) + RDF + FYM @ 5t/ha [T_3 + FYM]; T_6 : Liming @1/10th LR (limestone) + RDF + PM @ 5t/ha [T_2 + PM]; T_7: Liming @1/5th LR (limestone) + RDF + PM @ 5t/ha [T_3 + PM]; T_8 : Liming @1/10th LR (limestone) + RDF + Rhizobium (seed treatment @ 20g/kg seed) [T_2 + Rhizobium]; T_9 : Liming @1/5th LR (limestone) + RDF + Rhizobium (seed treatment @ 20g/kg seed) [T_3 + Rhizobium]; T_{10} : Liming @1/10th LR (limestone) + RDF + FYM @ 5t/ha + Rhizobium (seed treatment @ 20g/kg seed) [T_4 + Rhizobium]; T_{11} : Liming @1/5th LR (limestone) + RDF + FYM @ 5t/ha + Rhizobium (seed treatment @ 20g/kg seed) [T_5 + Rhizobium]; T_{12} : Liming @1/10th LR (limestone)+ RDF + PM @ 5t/ha + Rhizobium (seed treatment @ 20g/kg seed) [T_6 + Rhizobium]; T_{13} : Liming @1/5th LR (limestone) + RDF + PM @ 5t/ha + Rhizobium (seed treatment @ 20g/kg seed) [T_7 + Rhizobium]. Liming material ($CaCO_3$) was usedbased on Lime Requirement (LR) 15 days prior to the sowing. Prior to seeding, organic manures were used according to treatments. Bio-fertilizers were applied as seed treatment before sowing. Row-to-row and plant-to-plant spacing of 45 cm and 15 cm were maintained. Seed yield of groundnut per hectare.

RESULTSANDDISCUSSION:

The seed yield (t ha^{-1}) of groundnut as impacted by lime, organics, inorganic fertilizers, and biofertilizer was recorded and is indicated in Table 1.Seed yield differed significantly between the treatments. The maximum amount of seed output was noted in T_{13}, where 1/5th of LR and 5 t ha^{-1} of poultry manure (PM), recommended dose of fertilizer (RDF), and biofertilizer were applied. Application of RDF along with 1/10th of LR with 5 t ha^{-1}of FYM and biofertilizer for seed treatment (T_{10}) has increased the seed productivity over control by 33.54%. In contrast, RDF and 1/10th of LR with 5 t ha^{-1}of poultry manure and biofertilizer for seed treatment (T_{12}) has increased the seed productivity over control by 44.10%. Adding the recommended dose of fertilizer and 1/10th of LR (T_2) has increased the seed yield over control by 16.77%.It was noted that the addition of 5 tons of FYM/ha along with 1/5th of LR with RDF (T_5) has increased the seed productivity by 14.76 % over T_3, where only 1/5th of LR with RDF was applied. Similarly, adding 5 t ha^{-1}of poultry manure/ha and 1/5th of LR with RDF (T_7) has increased the seed yield by 18.98% over T_3. However, T_{13} has been found to increase seed yield by 5.67% over T_7. Similarly, T_{11} has increased seed yield by 5.88% over T_5. However, T_{11} has an additional seed yield increase of 18.03% T_9. Similarly, T_{13} is found to have an additional seed yield increase of 22.13% T_9. Adding 5 t ha^{-1} of FYM with the recommended dose of fertilizer and $1/10^{th}$ of LR (T_4) has increased the seed yield by 10.63% over T_2. In contrast, adding 5 t $ha^{-1}$of PM and the RD of fertilizer with $1/10^{th}$ of LR (T_6) has increased the seed yield by 19.14% over T_2. At the same time, the addition of 5 t $ha^{-1}$of FYM with RDF and $1/10^{th}$ of LR and rhizobium as a seed treatment (T_{10}) has an additional seed yield increase of 9.13% over T_8. However, 5 t $ha^{-1}$of PM with RDF and $1/10^{th}$ of LR and rhizobium for seed treatment (T_{12}) has an additional seed yield increase of 17.76% over the use of rhizobium as seed treatment with RDF along with $1/10^{th}$ of LR (T_8). The lowest seed yield of groundnut has been observed in the control plot.

The results suggest that the conjoint use of lime, organics, fertilizers and biofertilizer has improved the soil conditions for optimum uptake of nutrients and plant growth which ultimately resulted in an increased seed yield over control plot where only chemical fertilizers were applied. The increase in seed yield upon liming and INM was also observed by several researchers (Mathukia*et al.*, 2015; Reddy *et al.*, 2005). Dosani *et al. (*2003) also observed that applying lime in-furrow at one-tenth, one-half, and equal to the lime requirement to groundnut increased soil pH, exchangeable calcium, and reduced different forms of acidity, exchangeable aluminum and iron, and thereby increased seed yield of different genotypes of groundnut in Alfisols of Konkan. Singh *et al.* (2011) also opined that the addition of Lime + FYM + 50% NPK increased seed yield over other nutrient levels in groundnut. Jat and Ahlawat (2010) noted that the use of 5 t ha^{-1} FYM markedly improved yield, yield attributed to groundnut over no FYM.

The microbial biomass phosphorus (MBP) of post-harvest soil as influenced by use of the different combinations of lime, organics, inorganic fertilizers, and biofertilizer were recorded and presented in Table 2. It was recorded that the initial value of MBPinthe experimental soil was 21.54 µg g^{-1}. In all the treatments, rise in MBP contentin post-harvest soil due to applying different combinations of lime, organics, inorganic fertilizers, and biofertilizer in the experimental fields during the two-year study period. The MBPof the post-harvest soil differed significantly between the treatments. As per pooled data, the highest MBP was noted in T_{12}, where $1/10^{th}$ of LR along with 5 t ha^{-1} of poultry manure (PM), recommended dose of fertilizer (RDF), and biofertilizer was applied. The results confirm that the integrated use of lime, organics, inorganic fertilizers, and biofertilizer has improved the status of MBP in the post-harvest soil. The current study's conclusions were in line with those of Stenberg *et al.* (2000) who emphasized that liming didn't really work on soil structure variables but significantly increased the microbial activity and MBP to some extent. The soil biomass P content can be increased by adding C (Thien and Myers, 1992) or lime (Condron and Goh, 1990).

The available P_2O_5 content [kg ha^{-1}] of post-harvest soil influenced by lime, organics, inorganic fertilizers, and biofertilizer were recorded and are presented in Table 3. It was recorded that the initial available P_2O_5 of experimental soil was 10.65 kg ha^{-1}. In all the treatments except control (T_1), rise in available P_2O_5 content due to applying different combinations of lime, organics, inorganic fertilizers, and biofertilizer in the experimental fields was noted. Available P_2O_5 content differed significantly between the treatments of post-harvest soil. As per pooled data the highest available P_2O_5 content was noted in T_{13}, where 1/5th of LR and 5 t ha^{-1} of poultry manure (PM), recommended dose of fertilizer (RDF), and biofertilizer were applied. The treatment, T_{13} has increased the available $P_2O_5$of post-harvest soil over control by 75.21%. The application of RDF and 1/10th of LR (T_2) has increased the post-harvest soil's available P_2O_5 over control by 14.19%. However, T_{11} i.e., application of RDF along with 1/5th of LR, 5 t ha^{-1} of FYM, and biofertilizer for seed treatment, has increased the post-harvest available P_2O_5 content over control by 66.15%. Application of RDF along with 1/10th of LR, 5 t ha^{-1} of poultry manure, and biofertilizer for seed treatment (T_{12}) has increased the post-harvest soil's available P_2O_5 over control by 54.94%. The results confirm that the integrated use of lime, organics, inorganic fertilizers, and biofertilizer has improved the availability of P_2O_5 in the post-harvest soil. Increased P availability due to liming possibly because of the dissolution of complex Fe and Al phosphates making phosphate available in mono-calcium phosphate (Dixit and Sharma, 2003; Singh *et al.*, 2011). The finding of the present investigation was in good agreement with Sultana *et al. (*2009), who observed that liming can increase P, Ca, and Mg availability in soil.

The current study's findings were in line with those of Kumar *et al.* (2012) who reported that applying lime can enhance the availability nutrient in acid soil (pH around 4.6), reduce Al toxicity, and improve many other soil fertility attributes. Kisinyo*et al. (*2012) opined that applying lime significantly affected the available P, which was increased by 70.2% over unlimed plots. Juo and Uzu (1977) observed that optimum P availability decreased between pH 5 and above. Haynes (1992) investigated the impact of liming on the availability of phosphate in acidic soils.

Conclusion:

Significant improvement in groundnut productivity, available P_2O_5 and microbial biomass phosphorus (MBP) content of post-harvest experimental soil of Tripura was noted with the combined use of a recommended dose (RD) of NPK @ 20:60:40 kg ha^{-1}, lime @1/5thLime Requirement (LR), poultry manure (PM) @ 5 t ha^{-1}, and seed treatment withRhizobium @ 20 g kg^{-1} of seed compared to control (only RD of NPK) along with other treatments combinations. Thus, the use of RD of NPK @ 20:60:40 kg ha^{-1} conjointly with lime (@ 1/5thLR), PM (@ 5 t ha^{-1}), and treating the seeds with Rhizobium @ 20 g kg^{-1} of seed might be recommended to the growers in achieving higher groundnut productivity with better return in acidsoil of Tripura.

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Table1.Effectofintegrateduseoflime,organics,inorganicfertilizersandbiofertilizersonseedyieldof groundnut

Treatment	Seed yield (t/ha)

	2017	2018	Pooled
T1:RDF	1.60	1.62	1.61
T2:RDF+1/10 LR	1.87	1.88	1.88
T3:RDF+1/5LR	2.35	2.38	2.37
T4:RDF+1/10 LR+FYM	2.06	2.09	2.08
T5:RDF+1/5LR+FYM	2.70	2.73	2.72
T6:RDF +1/10 LR+PM	2.23	2.25	2.24
T7:RDF+1/5LR+PM	2.80	2.83	2.82
T8:RDF +1/10LR +Rhiz	1.96	1.98	1.97
T9:RDF+1/5LR+ Rhiz	2.42	2.45	2.44
T10:RDF+1/10 LR +FYM+Rhiz	2.14	2.16	2.15
T11:RDF+1/5LR +FYM+Rhiz	2.85	2.90	2.88
T12:RDF+1/10LR +PM +Rhiz	2.30	2.33	2.32
T13:RDF+1/5LR +PM + Rhiz	2.96	2.99	2.98
Sem	*0.12*	*0.14*	*0.14*
CDat 5%	*0.36*	*0.41*	*0.40*
CV(%)	*9.09*	*10.27*	*10.22*

(RDF=N:P:K@20:60:40kg/ha;LR=Limerequirement@3.2t/ha;FYM=Farmyardmanure @5t/ha;Rhiz=Seedtreatment with Rhizobium@20g/kg seed)

Table: 2 Effect of integrated use of lime, organics, inorganic fertilizers, and biofertilizer on microbial biomass phosphorus (MBP) of post-harvest soil

Treatment	Microbial biomass phosphorus	% increase

	(MBP) [µg g^{-1}]			over control
Initial Value	**21.54**			
Post Harvest Soil	**2017**	**2018**	**Pooled**	
T_1: RDF	27.67	27.71	27.69	
T_2: RDF + 1/10 LR	28.90	29.01	28.95	4.55
T_3: RDF + 1/5 LR	29.80	29.82	29.81	7.66
T_4: RDF + 1/10 LR + FYM	30.76	30.80	30.78	11.16
T_5: RDF + 1/5 LR + FYM	31.54	31.58	31.56	13.98
T_6: RDF + 1/10 LR + PM	32.02	32.06	32.04	15.71
T_7: RDF + 1/5 LR + PM	32.27	32.30	32.29	16.61
T_8: RDF + 1/10 LR + Rhiz	31.89	31.93	31.91	15.24
T_9: RDF + 1/5 LR + Rhiz	32.20	32.24	32.22	16.36
T_{10}: RDF + 1/10 LR + FYM + Rhiz	31.91	31.94	31.93	15.31
T_{11}: RDF + 1/5 LR + FYM + Rhiz	32.12	32.16	32.14	16.07
T_{12}: RDF + 1/10 LR + PM + Rhiz	32.45	32.49	32.47	17.26
T_{13}: RDF + 1/5 LR + PM + Rhiz	32.32	32.34	32.33	16.76
Sem	0.26	0.25	0.25	
CD (0.05)	0.75	0.74	0.74	
CV (%)	1.43	1.40	1.41	

(RDF = N:P:K @ 20:60:40 kg ha^{-1}; LR = Lime requirement @ 3.2 t ha^{-1}; FYM= Farm yard manure @ 5 t ha^{-1}; Rhiz= Seed treatment with Rhizobium @ 20 g kg^{-1} seed)

Table 3. Effect of integrated use of lime, organics, inorganic fertilizers, and biofertilizer on available P_2O_5content of post-harvest soil

Treatment	**Available P_2O_5content [kg ha^{-1}]**			**% increase over control**
Initial value	**10.65**			
Post-harvest soil	**2017**	**2018**	**Pooled**	
T_1: RDF	9.60	9.85	9.72	
T_2: RDF + 1/10 LR	10.87	11.33	11.10	14.20
T_3: RDF + 1/5 LR	11.68	12.07	11.87	22.12
T_4: RDF + 1/10 LR + FYM	12.43	12.80	12.61	29.73
T_5: RDF + 1/5 LR + FYM	13.05	13.27	13.16	35.39
T_6: RDF + 1/10 LR + PM	14.20	14.43	14.32	47.33
T_7: RDF + 1/5 LR + PM	15.28	15.51	15.39	58.33
T_8: RDF + 1/10 LR + Rhiz	11.82	12.23	12.03	23.77
T_9: RDF + 1/5 LR + Rhiz	14.10	14.80	14.45	48.66
T_{10}: RDF + 1/10 LR + FYM + Rhiz	14.46	14.69	14.58	50.00
T_{11}: RDF + 1/5 LR + FYM + Rhiz	15.97	16.33	16.15	66.15
T_{12}: RDF + 1/10 LR + PM + Rhiz	14.80	15.32	15.06	54.94
T_{13}: RDF + 1/5 LR + PM + Rhiz	16.75	17.30	17.03	75.21
Sem	0.28	0.37	0.23	
CD (0.05)	0.81	1.08	0.67	
CV (%)	3.59	4.61	2.89	

RDF = N:P:K @ 20:60:40 kg ha^{-1}; LR = Lime requirement @ 3.2 t ha^{-1}; FYM= Farm yard manure @ 5 t ha^{-1}; Rhiz= Seed treatment with Rhizobium @ 20 g kg^{-1} seed)