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Management of Acid Sulphate Soil of Coastal Sunderbans Region: Observations under On-farm Trial

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The acid sulphate soils are found at some places in Sundarbans region of West Bengal. These soils are highly acidic, deficient in P and, high in Fe and Al content with very poor crop yield. In the present investigation the effect of P-fertilizer, lime and green manure on the productivity of rice and effect of P-fertilizer and residual effect of lime on sunflower was studied under farmer's field condition with an objective to develop strategies for the efficient management of these soils. Under the on-farm study 3 doses of P [0, 40 (recommended dose) & 80 (double of recommended dose) P_2O_5 kg ha^{-1}], 3 doses of lime (0, half & full of lime requirement determined by KCl extraction method) with or without green manure were evaluated under RBD laid out field experiment with 3 replications. Locally available oyster shells (milled) were applied as cheap source of lime during dry season. Significant increase in the plant growth parameters like plant height and root density was recorded at double the recommended dose of P followed by the recommended dose compared to no P-fertilizer treatment. The increase in grain and straw yield of rice and grain yield of sunflower was also followed the same trend. The improvement in growth and yield of rice due to application of lime and residual effect of lime on yield of sunflower at P-fertilizers treatments with full lime requirement dose was at par with half lime requirement dose. The effect of the application of green manure was found to be significant at all the treatments of P fertilizer and lime. Lime application resulted in increase in pH of soil and decease in KCL extractable Al and, DTPA extractable Fe and Mn of the soil. The available P content of the soil has been increased due to application of P-fertilizer as well as lime.

*(**Key words:** Acid sulphate soil, P-fertilizer, Lime, Green manure, Rice, Sunflower, Yield and growth parameters, Coastal soil)*

Highly acidic (acid sulphate soil) soils are found in some places in the coastal region of Sundarbans (Bandyopadhyay 1988, 1989, Bandyopadhyay *et al.*, 2003, Bandyopadhyay and Maji, 1995). Acidity of these soils is due to oxidation of pyrites and other sulphidic materials which has, sometime in the past, accumulated in the soils. The acid sulphate soils of Sunderbans are saline with toxic content of Fe and Al, and very low level of available P (Bandyopadhyay and Maji, 1995). Soil acidity impairs root growth of crops, reduces water and nutrient uptake, and subsequently decreases the yield. Due to adverse effect of acid sulphate soil farmers fail to grow crops on these soil particularly during dry season and the lands usually remain fallow after *kharif* rice. Application of lime and higher doses of P could increase the yields of crops grown in the acid suphate soils in Sunderbans region (Bandyopadhyay and Maji, 1999). However, farmers hardly apply those primarily due to cost factor. The beneficial effect of green manuring on the improvement crop yield on salt affected soils especially saline and alkaline soils has been reported by many workers (Bandyopadhyay *et al.*, 2008, Bandyopadhyay and Rao, 2001, Singaravel and Balasundaram, 1999). In the present experiment under on-farm condition attempts were made to improve the productivity of the acid sulphate soils through the use of low cost technology.

MATERIALS AND METHODS

A field trial was conducted during 2005 and 2006 in farmer's field at village Kheria in the District of South 24 Parganas, West Bengal, India. The site typically represents area affected by both acidity (acid sulphate soils) and salinity in the coastal Sunderbans region of India (latitude: 22°05′ – 22°30′N, longitude: 88°30′N – 88°55′E). The climate is sub-humid with aquic soil moisture and hyperthermic soil temperature regimes. The average annual rainfall is 1759 mm, out of which about 80% occurs during monsoon (June-October) and only very limited rain during rest of the period of year.

The pH of the experimental soil was low (4.2) with high soil salinity (ECe 21.5 dS m^{-1}), high extractable Al (111.9 ppm), high available Fe (172.5 ppm), high available K (489.0 kg ha^{-1}), medium org. C (0.62%), medium available N (372.5 kg ha^{-1}) and very low available P (4.28 kg ha^{-1}). Three doses of P-fertilizer [0, 40 (recommended dose) & 80 (double of recommended dose) P_2O_5 kg ha^{-1}] and 3 doses of

lime (0, half & full dose of lime requirement determined by KCl extraction method) with or without green manure were evaluated under RBD laid out field experiment with 3 replications. Rice (c.v. SR26B) and sunflower (c.v. PAC36) were taken as test crops during *kharif* (2005) and *rabi*/summer (2006) seasons, respectively. Green manuring crop *Sesbania* was grown *in situ* and it was incorporated in the soil during land preparation for transplanting of *kharif* rice. *Sesbania* and rice were grown as rainfed crops (in *kharif*) while sunflower (in *rabi*/summer) was grown under irrigated condition. Recommended dose on N as urea was applied to rice and sunflower. Phosphorous was applied as single super phosphate to both the crops. Lime was applied during dry season (February, 2005) before seeding of *Sesbania*. Milled oyster shell, a locally available material was used as a cheap source of lime. No lime was applied to sunflower crop and the residual effect of lime which was applied in dry season of previous year was studied on sunflower. The CaO content in the oyster shells was 64.46 wt%, which is comparable to that of commercial lime. Lime requirement of the soil was determined by KCl extraction method (Lin and Coleman, 1960). About 1.33 t ha^{-1} and 1.66 t ha^{-1} of oyster shells were applied as half and full of the recommended doses respectively.

Soil samples collected from the surface of the soil up to 15 cm depth. EC, pH, organic carbon, KCl extractable Al, and available N, P, K, Fe (DTPA) and Mn (DTPA) were determined following standard methods given by Black (1965). Al, Fe and Mn were determined by Atomic Absorption Spectrophotometer (ECIL, model-4141).

RESULTS AND DISCUSSION

There was a high significant increase in the plant height, root density, grain and straw yield of rice at double recommended dose (80 kg P_2O_5 ha^{-1}) followed by recommended dose of P (40 kg P_2O_5 ha^{-1}) compared to no P-fertilizer treatment (Table 1). Compared to control highly significant increase in grain yield of sunflower was also recorded at double of the recommended dose of P followed by recommended dose of P. The average increase in grain yield of rice was 72.84% and 123.46% at 40 kg and 80 kg P_2O_5 ha^{-1}, respectively over no P-fertilizer treatment. The improvement in the yield of sunflower was 30.20 % and 78.68 % at recommended and double of the recommended doses of P, respectively over control

Table 1. *Growth parameters, grain and straw yield of rice, and grain yield of sunflower grown on acid sulphate soil*

Treatments		Rice				Sunflower
		Growth at 60 DAT		Yield at harvest		
P_2O_5 & GM	Lime	Plant height (cm)	Root density (kg m^{-3})	Grain (t ha^{-1})	Straw (t ha^{-1})	Grain (t ha^{-1})
40 kg P_2O_5 ha^{-1} +GM	L_0	103	10.93	3.21	5.67	1.35
	$L_{1/2}$	108	11.61	3.69	6.83	1.78
	L_1	109	12.04	3.80	7.31	1.84
40 kg P_2O_5 ha^{-1}	L_0	97	9.24	2.80	5.28	1.23
	$L_{1/2}$	103	9.87	3.14	6.04	1.70
	L_1	104	10.30	3.15	6.18	1.75
80 kg P_2O_5 ha^{-1} +GM	L_0	110	11.84	4.01	7.43	1.67
	$L_{1/2}$	115	12.80	4.33	7.87	2.13
	L_1	117	12.38	4.36	7.79	2.17
80 kg P_2O_5 ha^{-1}	L_0	105	10.83	3.62	6.96	1.59
	$L_{1/2}$	110	11.40	3.97	7.49	2.05
	L_1	109	11.79	3.93	7.42	2.08
Control (No P_2O_5, lime and GM)		61	7.95	1.62	3.18	0.89
CD at P = 0.05		4.91	0.46	0.29	0.16	0.05

GM: green manure, L_0 : No lime application, $L_{1/2}$: Half dose of lime requirement (1.33 t ha^{-1}), L_1 : Full of lime requirement (2.66 t ha^{-1})

where no P fertilizer was applied. Increase in the growth parameters and yield of rice and sunflower were primarily due to higher P availability as soil was extremely poor in available P with high P fixation capacity. Bandyopadhyay & Maji (1999) also reported significant improvement in the yield of rice due to application of higher doses of P to acid sulphate soil of Sunderbans. The effect of application of green manure was found significant at all the treatments for both rice and sunflower crops. The green manure in combination of recommended and double recommended doses of P-fertilizer enhanced grain yield of rice by 98.15% and 147.53%, respectively and that of sunflower by 51.69% and 87.64%, respectively compared to control treatment where no green manure and phosphate was applied.

The effect of lime on growth parameters and yield (both grain and straw) of rice and its residual effect on yield of sunflower which was grown during dry season after harvest of *kharif* rice was found significant. The significant improvement in grain yield of rice (*kharif*) due to application of lime to acid sulphate soil was also reported by Bandyopadhyay and Maji (1999). In the present experiment, the improvement in growth parameters and yield of rice and yield of sunflower at full lime requirement dose was at per with half of lime requirement dose with all phosphate treatments and, with or without green manure. Maximum plant height, root density, grain and straw yield of rice and grain yield of sunflower was recorded when lime was applied at half or full lime requirement dose along with double recommended doses of P (80 kg P_2O_5 ha^{-1}) and green manure. In these treatments the improvement in grain yield for rice and sunflower was 169.14% and 143.82% respectively, compared to control treatment.

The physico-chemical properties of the surface soil up to a depth of 15 cm after harvest of the sunflower crop are presented in Table 2. The lime application resulted in increase in pH of soil. The soil pH increased from 4.2 at control treatment to 5.2-5.4 at half dose of lime and 6.0-6.1 at full dose of lime in combination with P and with or without green manure. The available P content of the soil increased due to application of P-fertilizer as well as lime and green manure. The available P content increased to maximum of 15.12 kg ha^{-1} at double recommended dose of P along with application of full lime dose and green manure compared to control (3.68 kg ha^{-1}). Available N content of soil also increased due to application of green manure along with lime and P fertilizer. The effect of application of lime was found to reduce the extractable Al, and available Fe and Mn content of soil. The effect was more with full lime dose compared to half lime dose.

Table 2. *Soil properties at the surface soil (0-15 cm soil depth) after harvest of sunflower crop*

Treatments P_2O_5 & GM	Lime	Soil properties							
		ECe (dS m^{-1})	pH	Av. P	Av. N (kg ha^{-1})	Av. K_2O (kg ha^{-1})	Extra c.SAl (ppm)	Av. Fe (ppm)	Av. Mn (ppm)
40 kg P_2O_5 ha^{-1} +GM	L_0	6.5	4.3	8.2	290.5	401.4	109.5	203.6	47.0
	$L_{1/2}$	6.2	5.4	8.4	300.7	424.5	80.7	185.8	33.6
	Ll	6.6	6.1	9.4	315.5	432.2	55.2	160.3	31.0
40 kg P_2O_5 ha^{-1}	L_0	6.3	4.3	8.0	237.8	405.1	107.3	219.3	39.8
	$L_{1/2}$	6.5	5.2	8.3	256.7	417.6	79.9	181.2	31.9
	L_1	6.9	5.8	8.6	269.5	424.3	56.3	157.3	31.2
80 kg P_2O_5 ha^{-1} +GM	L_0	6.4	4.6	15.0	305.3	411.5	103.9	208.9	42.5
	$L_{1/2}$	6.1	5.2	15.2	325.1	438.8	77.4	181.0	31.3
	L_1	6.7	6.0	15.7	356.7	448.4	57.9	158.3	30.7
80 kg P_2O_5 ha^{-1}	L_0	6.0	4.1	14.7	255.9	405.7	107.3	204.2	45.3
	$L_{1/2}$	6.1	5.3	15.3	264.4	426.4	84.0	184.3	33.7
	L_1	6.7	6.1	15.7	292.9	430.6	63.6	165.8	30.6
Control (No P_2O_5, lime and GM)		6.23	6.2	4.2	3.7	202.9	387.8	113.4	203.6

GM: green manure, L_0 : No lime application, $L_{1/2}$: Half dose of lime requirement (1.33 t ha^{-1}), L_1 : Full of lime requirement (2.66 t ha^{-1})

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