REHABILITATION OF SOILS THROUGH ENVIRONMENTAL FRIENDLY TECHONOLOGIES : ROLE OF SESBANIA AND FARM YARD MANURE

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Abstract

Environmental problems due to land degradation in the developing countries have been a concern for the last decades. The rehabilitation of problem lands has been through chemical means and engineering approaches. Present studies were undertaken to examine the role of environmental friendly practices i.e. fitting the plant life in the existing soil conditions to address the salinity issue. The effects of Agroforestry (Sesbania) and farm yard manure (FYM) on rice (Oryza sativa) were investigated in a field study on a saline-sodic soil of Pakistan. Results revealed that both paddy and straw yields were significantly improved by the application of sesbania and FYM. Green manuring with sesbania improved the paddy and straw yield by 15.4 and 14.5 % respectively. Productive tillers were increased by the application of FYM but differences were not significant between 10 and 20 t/ha of FYM application. The increases in paddy yield due to application of 5, 10 and 20 t/ha of FYM were 6.8%, 24.4% and 37.6% respectively over control. Nitrogen and P utilization by rice were also significantly improved with the application of green manure. Nitrogen uptake by rice (grain+straw) was increased by 17.8 % and that of phosphorus by 21.9 % with the green manuring.

Key words: rice nutrition, yield, organic amendment, FYM requirement, saline-sodic soil.

INTRODUCTION

The pressing need for more food coupled with scarcity of good arable land in Pakistan necessitates expanding farming to marginal lands that lie barren because of bad soil conditions. Mineral stresses that depress crop yields result from soil toxicities and nutrient deficiencies or both. These stresses are more likely to occur in salt-affected and waterlogged soils.

Worldwide saline soils cover over 380 million hectares. The magnitude 6.3 million hectares of salt-affected soils in Pakistan is alarming. The arid climatic conditions involving scanty rainfall and high evapotranspiration in the country have led to this unfavorable salt distribution and accumulation in the crop rooting zone (Bajwa et al., 1991).

Sixty percent of the salt-affected soils in Pakistan and 80% in Punjab province are saline-sodic. Because reclamation of salt-affected soils is expensive and time consuming, losses in soil productivity may be reduced by improved crop nutrition and management practices - especially the selection of crops well adapted to adverse conditions (Ilyas, et al. 1997, Quadir, et al. 2001).

Rice can be grown successfully under these conditions because of its medium tolerance to salinity, its high water requirement and its adaptability to moderate waterlogged conditions. The standing water of rice paddies dilutes the salts, increases the availability of Fe, Mn, P and S and eliminates water stress. Sesbania species have been used for reclamation of saline soils and saline-sodic soils (Quadir, et al. 2001). The cytoplasmic pH of sesbania is about 4.01 (Uppal, 1955). Therefore, it can neutralize soil alkalinity considerably when buried as green manure. In addition, the oxidation of C to CO_2 results in the formation of carbonic acid, which solubilizes lime and thus helps in the reclamation process (Bajwa et al., 1991; Quadir, et al., 2001). In addition, its tap root system may help to improve the water and air conducting properties of problem soils (Yaseen et al., 1990 ; Bajwa et al., 1991).

In Pakistan, rice-wheat is a very common crop rotation where Sesbania fits in well. Sesbania can be planted in May after the wheat harvest and incorporated into the soil at the end of June, two weeks prior to rice transplanting (Yaseen et al., 1990). As a green manure crop, it can substitute for applied fertilizer N (Raju, Reedy, 2000, Mann, Ashraf, 2000, Subedi, 1998) in addition to supplying organic matter for the restoration of soil physical conditions. The use of sesbania as green manure improves soil productivity through biological N_2 fixation (Zia et al., 1992, Ladha, et al. 2000). Sesbania green manure increases uptake of P, K, Zn, Fe, Mn, Cu by rice plants Sriramachandrasekharan, 2001).

Use of organic soil amendments, such as farm yard manure, heterogeneous composted organic material, is an important component in sustainable agricultural production in many countries (Motavalli et al, 1994, Kumar, et al., 1999). Such amendments promote sustainability because of:

1. long-term positive effects on chemical and physical properties of soil (Sharma, et al. 2001, Quadir, et al. 2001, Ilyas, et al. 1997)
2. recycling plant nutrients within a farm, e.g. feeding harvested fodder to livestock and then applying FYM from those animals back to the land (Parker, 1990, Hemalatha, et al. 2000)
3. substitution of readily available organic inputs for

chemical fertilizers and, therefore, a decreased dependence on costly external sources (Subedi, 1998)

4. general improvement in crop yield and quality obtained when adequate rates of organic soil amendments are incorporated into the soil. In addition to supplying major and micronutrients, FYM adds organic matter to the soil helping to increase productivity by improving soil structure and reducing soil pH and sodicity.

Different agroforestry practices have been successfully used in many parts of the world on marginal lands under different climatic conditions. Surprisingly, there is a lack of data in the literature, relevant to Pakistan, demonstrating the combined effect of plants and organic residues on the mobility and solubility of nutrients in saline-sodic soils.

This study was undertaken to evaluate the effect of sesbania green manure and farm yard manure on growth, yield and N and P nutrition of rice growing on a dense saline-sodic soil.

Description of the Study Area

Field investigations were performed at the Saline Agriculture Research Station, Sadhuke, Punjab, Pakistan, 30 kilometers north of Lahore. It is located at 74° 18' E longitude and 31° 35' N latitude in the northeastern portion of the Indus plain. The Indus plain was formed from alluvium deposited by rivers into an ancient shallow sea. Salts have accumulated in soils from both salty ground water and from a canal irrigation system. With no natural or artificial drainage outlet, salt accumulation in soils resulted.

The study area has an arid and continental climate with high summer temperatures (35-40°C) and mean annual rainfall (325-750mm). In early summer, before the start of the monsoon, potential evaporation is several-fold larger than precipitation (Khan, 1991). The soil at the study site is a fine-loamy, mixed, thermic Typic Natrustalf. The soil is alkaline, calcareous and saline-sodic in nature. It is deficient in N and organic matter, however, potassium and other micronutrients are adequate.

MATERIAL AND METHODS

Experimental Design, Treatments and Other Procedures

The experimental design was a randomized complete block (RCB) design with three replications. The following treatment combinations were employed.

T1 No GM + No FYM (control)
T2 No GM + 05 t/ha FYM
T3 No GM + 10 t/ha FYM
T4 No GM + 20 t/ha FYM
T5 GM + No FYM
T6 GM+ 05 t/ha FYM
T7 GM + 10 t/ha FYM
T8 GM + 20 t/ha FYM

For green manuring (GM), sesbania was incorporated into the soil with a rotavator two months after application of farmyard manure (FYM). After flooding, rice (variety Basmati 385) was grown until maturity under the eight treatments shown above. N and P fertilizers were applied at the rates of 80 and 50 kg/ha, respectively. The remainder of the N was applied at the time of panicle initiation. Data on productive tillers, paddy and straw yield were recorded at the time of harvest. Nitrogen and phosphorus levels in rice grain and straw were determined. Nitrogen was determined by the Kjeldahl method and P colorimetrically (Prevel et al., 1987).

The experimental data for all plant parameters were analyzed statistically, using analysis of variance (ANOVA) using a SAS Program. Treatment means were compared by applying Duncan's Multiple Range Test . An alpha level of 0.05 was specified for all comparisons.

RESULTS AND DISCUSSION

Effect of Sesbania and Farm Yard Manure on Rice Yields

Data on effect of sesbania green manure and farmyard manure on productive tillers, paddy and straw yields are shown in Table 1. Sesbania GM had significant effects on tiller production, paddy and straw yields increased 15.4 and 14.5%. This indicates that sesbania produced tillers with more weight and grains. This may be attributed to a greater amount of N_2 fixation and consequent accumulation and uptake from the soil.

Productive tillers were significantly higher with the initial applications of FYM at rates of 20 and 10 t/ha, while differences due to 5 t/ha were not significant compared to the control. The physical conditions of the sodic soil might have improved because FYM increased the number of tillers. Paddy and straw yields increased significantly with higher rates of FYM application. Increases in paddy yield due to application of 5, 10 and 20 t/ha FYM were 6.8, 24.4 and 37.6 %, increases in straw yield were 7.2, 15.7 and 19.5 %, respectively. Studies of Motavalli et al., (1994), Sharma, et al. (2001) reveal that FYM has considerable positive effect on the physical properties of the soil, which may have translated into an increase in yield.

Effect of Sesbania and Farm Yard Manure on Nitrogen Concentration in Rice

Nitrogen concentrations in rice grain and straw were not affected by green manuring (Table 2) but were

significantly affected by FYM at all rates of application. Differences in N concentration in both rice grain and straw due to 20 and 10, 10 and 5, and 5 and 0 t/ha of FYM were not significant. FYM was probably low in available nitrogen content and as a result did not improve N concentration. Main constituent of FYM is the rice straw and has a wide C:N ratio that reduces N availability. In addition, the N-containing organic compounds in FYM are much more resistant to decomposition and only 1/3 of the N is easily released.

Effect of Sesbania and Farm Yard Manure on Phosphorus Concentration in Rice

Phosphorus content in rice grain and straw were significantly affected by the application of GM and at all rates of FYM (Table 3). Treatment means of 5 and 10 t FYM/ha did not differ significantly from each other. P has the role of strengthening the straw of cereal crops and preventing lodging (Brady, 1999), and the observed increase in P concentration in straw may be related to that role.

Effect of Sesbania and Farm Yard Manure on Nitrogen Uptake in Rice

Nitrogen uptake in rice grain, straw and in grain+straw was all significantly increased by green manuring (Table 4). Sharma et al. (2001), Raju, Reedy (2000), reported an increase in N uptake in rice grain due to sesbania GM. Hemalatha, et al. (2000) reported, that sesbania increased yield of the subsequent rice crop due to high N accumulation and greater uptake, and showed a greater release of N from sesbania green manure than FYM. They observed an increased vailability of N from sesbania green manure during the active vegetative growth period of the rice crop. Higher availability likely resulted in greater N uptake in rice.

Nitrogen uptake in rice grain, straw and grain+straw was significantly increased with each successive increase of FYM, from 0-5, 5-10, 10 to 20 t/ha with the single exception of an increase from 10 and 20 t/ha in rice straw.

Effect of Sesbania and Farm Yard Manure on Phosphorus Uptake

Green manuring did not impact P uptake in rice grain but had a significant effect on straw and as a result, total P uptake was significantly increased (Table 5). It has been reported, that green manuring causes increased utilization of P by the crop from the reserve supplies of soil P and also reduces sorption capacity of the submerged rice soil. Sesbania GM probably caused these soil modifications and in turn greater total P uptake was experienced. Highest P uptake in rice grain, straw, grain+straw were recorded with the application of 20t/ha of FYM. Significant differences in P uptake due to treatments of 20 and 10, 10 and 5, 5 and 0 t/ha of FYM were obtained. The study revealed that FYM improved the P nutrition on alkaline calcareous sodic soil.

CONCLUSIONS AND RECOMMENDATIONS

1. Sesbania green manuring proved a better reclamant than FYM. Higher grain and straw yields were recorded with sesbania treated plots.
2. Sesbania enhanced N and P nutrition by releasing and accumulating nutrients in the soil.
3. The use of FYM as an org. amendment is impaired by its low supply and release rate of nutrients
4. FYM may have improved soil physical properties.
5. The improvement attributed to the amendments in reclaiming saline-sodic soil is low but soil health and plant nutrition may be improved by introducing sesbania permanently in the rotation
6. Further research is needed to optimize economic and biologic factors that could make the Sesbania a permanent feature of the rice-wheat cropping sequence in salt-affected soils of Pakistan.

Tab. 1: Effect of sesbania and farm yard manure application on rice yield

FYM applied (t/ha)	Productive tiller/plant			Paddy yield (t/ha)			Straw yield (t/ha)		
	No GM	GM	Mean	No GM	GM	Mean	No GM	GM	Mean
0	9.00	10.17	9.58b	2.21	2.62	2.41c	2.92	3.15	3.03c
5	8.90	10.60	9.75b	2.36	2.96	2.66bc	3.13	3.60	3.36bc
10	10.55	11.30	10.92a	2.75	3.13	2.94ab	3.38	3.93	3.65ab
20	11.45	11.77	11.61a	3.04	3.26	3.15a	3.49	4.13	3.81a
Means for GM	10.09b	10.96a		2.59b	2 .99a		3.23b	3.70a	

** Means sharing the same letter are statistically not different at p 0.05*
*** No GM = Sesbania was not added, *** GM = Sesbania*

Tab. 2: Effect of sesbania and farm yard manure on nitrogen concentration in rice

FYM applied (t/ha)	N concentration in grain (%)			N concentration in straw (%)		
	No GM	GM	Mean	No GM	GM	Mean
0	1.04	1.08	1.06b	0.63	0.657	0.645c
5	1.16	1.22	1.19ab	0.653	0.68	0.667bc
10	1.16	1.24	1.20 ab	0.7	0.737	0.720ab
20	1.19	1.28	1.23a	0.737	0.77	0.755a
Means for GM	1.14a	1.20a		0.680a	0.711a	

Tab. 3: Effect of sesbania and farm yard manure on phosphorus concentration in rice

FYM applied (t/ha)	P concentration in grain (%)			P concentration in straw (%)		
	No GM	GM	Mean	No GM	GM	Mean
0	0.3	0.293	0.297c	0.173	0.19	0.182c
5	0.307	0.324	0.315b	0.197	0. 23	0.214b
10	0.317	0.337	0.327b	0.233	0.253	0.243a
20	0.35	0.373	0.362a	0.24	0.257	0.249a
Means for GM	0.319b	0.332a		0.211b	0.233a	

Tab. 4: Effect of sesbania and farm yard manure on nitrogen uptake by rice

FYM applied (t/ha)	N uptake in grain (kg/ha)			N uptake in straw (kg/ha)			Total N uptake in grain+straw (kg/ha)		
	No GM	GM	Mean	No GM	GM	Mean	No GM	GM	Mean
0	22.4	28.4	25.4d	18.4	20.7	19.5c	41.2	49	44.9d
5	27.3	36.1	31.7c	20.4	24.5	22.4b	47.8	60.6	53.5c
10	31.8	38.6	35.2b	23.6	28.3	25.9a	55.4	66.9	61.15b
20	36.2	41.2	38.7a	25.7	25.5	25.6a	61.9	66.7	65.6a
Means for GM	29.43b	36.1a		22.0b	24.8a		51.1b	61.4a	

Tab. 5: Effect of sesbania and farm yard manure application on phosphorus uptake by rice

FYM applied (t/ha)	P uptake in Grain (kg/ha)			P uptake in straw (kg/ha)			Total P uptake in grain+straw (kg/ha)		
	No GM	GM	Mean	No GM	GM	Mean	No GM	GM	Mean
0	6.64	7.67	7.15d	5.07	5.98	5.52d	12.71	13.99	12.68d
5	7.27	9.67	8.47c	6.15	8.29	7.22c	13.42	17.95	15.69c
10	8.74	10.34	9.54b	7.88	9.93	8.91b	16.62	20.51	18.45b
20	10.63	12.17	11.40a	8.36	10.63	9.49a	18.99	22.79	20.89a
Means for GM	8.32a	9.96a		6.86b	8.71a		15.18b	18.67a	

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Received for publication on March 4 , 2004
Accepted for publication on November 16, 2004

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