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Evaluation of Suitability of Forage Crops and Amendments for the Rehabilitation of Gypsum Mined Soils

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ABSTRACT. *This investigation was aimed to study the adaptability and growth of forage crops and to assess the efficacy of amendments like compost, coir waste and waste cotton on gypsum mined soils containing varying amounts of soluble salts as measured by electrical conductivity (EC). To achieve this objective, a pot culture experiment was conducted with three groups of gypsum mined soils with four treatments and four forage crops. The effect of the type of soil, amendment and forage species on biomass yields were significant at 0.01 level. The growth and yield of forage crops were influenced by soluble salt content indicated by EC of mined soils. Soils with low salt content (EC<1 dSm^{-1}) produced higher green biomass and dry matter yields of forage crops. Application of amendments to the mined soils produced increased green biomass and dry matter yields. Among the amendments compost produced highest yields. Among the forage crops, Cenchrus glaucus registered highest yields. The combined effect of mined soil with low EC values, compost treatment and Cenchrus glaucus were responsible for high biomass and dry matter yields in the present investigation.*

INTRODUCTION

Soil degradation refers to the decline in the soils' productivity through adverse changes in nutrient status. The process of soil degradation is indicated due to deforestation and removal of natural vegetation, improper management of agricultural land and industrial activities. Among the industrial activities, mining of minerals is one that causes soil degradation (Soni *et al.*, 1991). At global level, about 1965 million hectares of land had been affected by soil degradation, of which 25 million hectares were affected by industrial activity (Oldeman *et al.*, 1991). In India, there are about 5000 mining leases which spread over about 0.7 million hectares (Soni *et al.*, 1991). Several workers have identified salinity, acidity, poor water holding capacity, inadequate supply of plant nutrients, accelerated rate of erosion and coarse texture as major problems in mine spoil areas that affect revegetataion process (Reeder and Berg, 1977; Jha and Singh, 1990). Proper reclamation measures are necessary to rehabilitate and restore natural productivity. Cultivation of forage crops and leguminous crops are necessary for the reclamation of mine spoil (Yamanaka and Holl, 1984). Mulches help in the establishment of vegetation, reducing soil erosion while adding organic matter (Plass, 1978).

The present investigation was carried out to find the suitability of forage crops and soil amendments for the rehabilitation of gypsum mined soils which are distributed in Coimbatore and Thiruchirapalli districts of Tamil Nadu State, India.

MATERIALS AND METHODS

Surface soil samples were collected at different locations of gypsum mined soils and analysed for electrical conductivity. EC values of the mined soils were found to vary from 0.50 to 3.00 dSm^{-1}. Hence, mined soils were grouped based on EC values, under three categories as S_1 (EC<1 dSm^{-1}), S_2 (EC 1-2 dSm^{-1}) and S_3 (EC>2 dSm^{1}). Bulk surface samples (0-30 cm depth) representing the three catagories of mined soils were collected and transported to the green house. The samples were air dried and sieved.

A pot culture experiment with factorial completely randomized design and four replications involving three categories of gypsum mined soils [S_1, S_2 and S_3], four treatments with soil amendments (T_0 - control with blanket recommendation of 25 kg N, 40 kg P_2O_5 and 20 kg of K_2O ha^{-1}; T_1 - composted coirpith @ 12.5 tons ha^{-1} with N, P_2O_5 and K_2O as in T_0; T_2 - compost @ 12.5 tons ha^{-1} with N, P_2O_5 and K_2O as in T_0; T_3 - waste cotton @ 5 tons ha^{-1} with N, P_2O_5 and K_2O as in T_0) and four forage crops (F_1 - *Andropogon gayanus*, F_2 - *Cenchrus glaucus*, F_3 - *Pennisetum pedicellatum* and F_4 - *Panicum maximum*) was carried out. Ten kilograms of mined soils were used for filling the pots. Calculated quantity of amendments and fertilizers for the different treatments were mixed with the mined soils. The plants were regularly watered to maintain soil moisture at field capacity level. The first cutting of forage crops was done at 75 days after sowing. Second and third cuttings were carried out at 45 days intervals after each cutting.

RESULTS AND DISCUSSION

Green biomass yield

Soil effect

The green biomass yield recorded for the three experimental soils in the three cuttings showed significant variations (Figure 1). High biomass yield of 76.95 g pot^{-1} was registered in the second cutting. The yields obtained in first and third cuttings were 53.56 g pot^{-1} and 37.85 g pot^{-1}, respectively. Among the three soils, S_1 gave high green biomass yield in all the three cuttings compared to S_2 and S_3 . These results reveal that electrical conductivity resulting from the sparingly soluble gypsum in the mined soils has great impact on the establishment and growth of forage crops tested in the experiment. Mauria *et al.* (1987) had also observed similar results in their study.

Treatment effect

Significant differences (at 0.01 level) were observed in the individual cuttings and total green biomass yield due to treatment effect (Figure 1). Second cutting recorded an yield of 76.96 g pot^{-1} followed by first cutting (53.55 g pot^{-1}) and third cutting (35.40 g pot^{-1}). Among the treatments, T_2 registered high yield of 191.34 g pot^{-1}. T_0, T_1 and T_3 gave the green biomass yield of 143.98, 170.43 and 157.89 g pot^{-1} respectively. The treatments T_2, T_1 and T_3 registered 32.9, 18.7 and 9.7 per cent higher yield over T_0. This was partly due to the possible improvement in soil physical properties and partly due to the addition of an extra quantity of nutrients (N, P and K) by the amendments. Among the treatments, T_2 (compost) produced higher yields followed by T_1 (composted coirpith) and T_3 (waste cotton) as it contained more mineralisable plant nutrients compared to other two amendments. Similar observations were reported by Lakshminarashiman *et al.* (1993).

Crop effect

Higher green biomass yield was recorded in second cutting (76.95 g pot^{-1}) followed by first cutting (53.41 g pot^{-1}) (Figure 1). Low green biomass yield of 35.40 g pot^{-1} was obtained in third cutting. Among the forage crops, F_2 (*Cenchrus glaucus*) registered high yield in the first cutting followed by F_4 (*Panicum maximum*), F_1 (*Andropogon gayanus*) and F (*Pennisetum pedicellatum*). In second and third cuttings, high yields were recorded by F_3

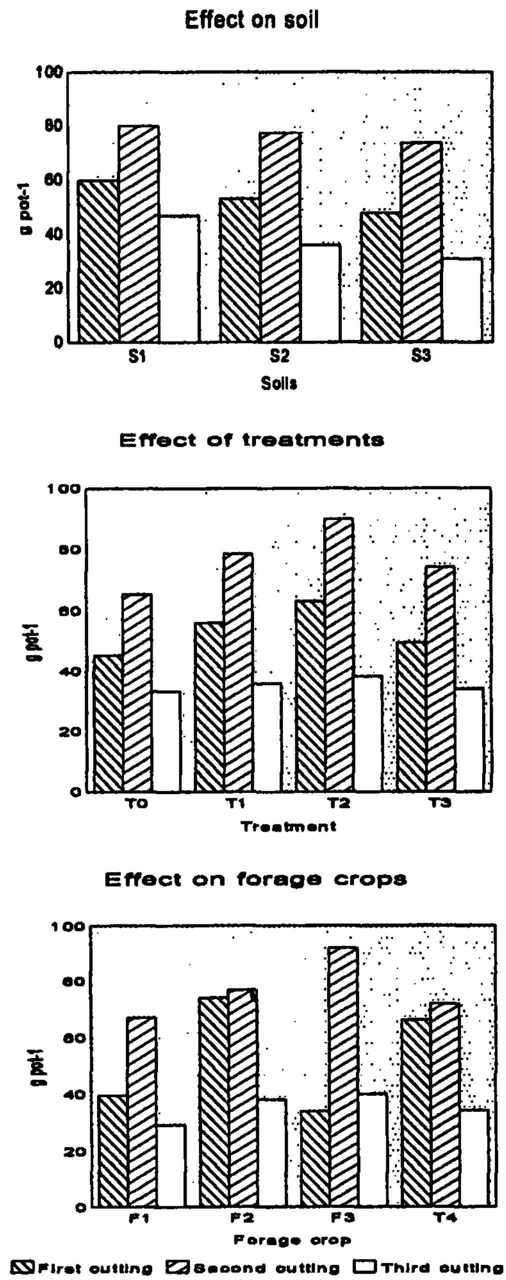

Figure 1. **Effect of mined soils, treatments and forage crops on green biomass yield.**

followed by F_2, F_4 and F_1. The total green biomass yield produced by F_1, F_2, F_3 and F_4 respectively were 136.00, 188.87, 166.12 and 172.05 g pot^{-1} and they were significant at 0.01 level. The results are agreeable to the findings of Mauria *et al.* (1987) who compared the performance of different forage species under varying soil salinity levels and grouped the *Cenchrus* spp. as salt tolerant. The comparison of green biomass yields obtained in each cutting showed that higher yields were recorded in second cutting followed by first and third cuttings irrespective of soil or treatment or crop effects.

Interaction effect

The results of interaction between soils and crops, crops and treatments and soils and treatments are presented in the Table 1. S_1F_2, F_2T_2 and S_1T_2 interactions registered higher green biomass yields than other interaction effects. These results reconfirmed that the combined effect of growing *Cenchrus glaucus* in soils with low EC (<1d Sm^{-1}) with compost was responsible for higher green biomass yields.

Dry matter yield

Soil effect

Dry matter yield of 29.23 g pot^{-1} was obtained in second cutting which was high when compared to first cutting (181.32 g pot^{-1}) and third cutting (53.50 g pot^{-1}) (Figure 2). Among the soils, S_1 registered high dry matter yield of 62.79 g pot^{-1} followed by S_2 (51.85 g pot^{-1}) and S_3 (45.89 g pot^{-1}). The results proved that mined soils with low salinity levels (S_1) produced high dry matter yield than soils with high salinity levels (S_2 and S_3). Similar kind of results were also reported by Mauria *et al.* (1987).

Treatment effect

High dry matter yield (66.04 g pot^{-1}) was recorded by T_2 followed by T_1 (55.17 g pot^{-1}), T_3 (49.28 g pot^{-1}) and T_0 (44.93 g pot^{-1}) (Figure 2). A dry matter yield of 25.58 g pot^{-1} recorded by second cutting, which is more than third cutting by 2 ½ times and 37 per cent more than first cutting. In first and third cuttings, the drymatter yields of T_3 and T_0 treatments were on par. In

Table 1. **Interaction effect of soils and treatments on green biomass yield of forage crops (g pot^{-1}).**

Soils	Forage Crops				
	F_1	F_2	F_3	F_4	Mean
S_1	143.8	200.1	187.9	184.6	179.1
S_2	139.4	189.9	160.7	174.2	166.0
S_3	124.9	175.4	149.7	158.3	152.3
Mean	136.0	188.4	166.1	172.7	-

	Soils	Crops	Soils x Crops
SE_d	1.48	1.71	2.96
CD (0.01)	2.96	3.42	5.92

Forage Crops	Treatments				
	T_1	T_2	T_3	T_4	Mean
F_2	168.3	194.9	211.8	178.9	188.4
F_3	139.8	171.5	196.1	157.0	166.1
F_4	153.9	175.6	193.8	167.6	172.7
Mean	144.0	170.4	191.3	157.4	165.8

	Crops	Treatments	Crops x Treatments
SE_d	1.71	1.71	3.42
CD (0.01)	3.42	3.42	6.84

Soils	Treatments				
	T_1	T_2	T_3	T_4	Mean
S_1	155.9	185.0	207.0	168.5	179.1
S_2	145.4	169.5	189.2	159.9	166.6
S_3	130.6	156.7	177.7	144.0	152.3
Mean	144.0	170.4	191.3	157.4	-

	Soils	Crops	Soils x Crops
SE_d	1.48	1.71	2.96
CD (0.01)	2.96	3.42	5.92

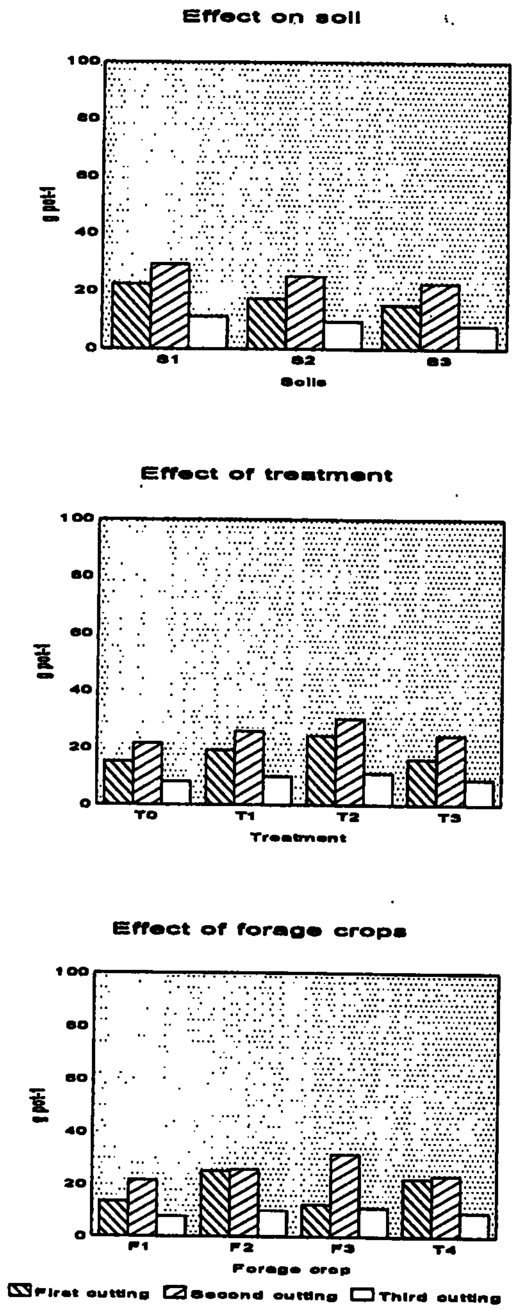

Figure 2. **Effect of mined soils, treatments and forage crops on dry matter yield.**

Table 2. Interaction effects of soils and treatments on dry matter yield of forage crops (g pot[-1]).

Soils	Forage Crops				
	F_1	F_2	F_3	F_4	Mean
S_2	42.43	59.61	52.35	53.05	51.86
S_3	35.97	53.70	46.27	47.25	45.72
Mean	60.17	60.99	55.20	44.87	-

	Soils	Crops	Soils x Crops
SE_d	0.52	0.6	1.03
CD (0.01)	1.04	1.2	2.06

Soils	Treatments				
	T_1	T_2	T_3	T_4	Mean
S_1	52.70	63.62	75.35	59.55	62.80
S_2	43.77	54.25	61.13	48.30	51.86
S_3	38.37	47.45	54.17	43.20	45.72
Mean	44.94	55.10	63.55	50.35	

	Soils	Treatments	Soils x Treatments
SE_d	0.52	0.6	1.03
CD (0.01)	1.04	1.2	2.06

second cutting dry matter yield differed significantly among treatments. T_2 registered the highest yield of 30.44 g pot^{-1} in second cutting. Hence, more dry matter yields were resulted by the application of soil amendments to the mined soils. Mayalagu *et al.* (1983) obtained similar kind of results with various soil amendments. The performance of compost was better than composted coirpith (T_1) and waste cotton (T_3) in the present study.

Crop effect

F_2 registered higher dry matter yield (60.97 g pot^{-1}) as it had yielded more green biomass compared to other forage crops. The dry matter yield of F_3 and F_4 were on par (Figure 2), eventhough F_3 registered low green biomass yield in the first cutting due to its slow initial growth. F_3 had produced higher yield in second and third cuttings so that the dry matter yield of F_3 was on par with F_4.

Interaction effect

The interaction existed between soils and crops, soils and treatments are represented in the Table 2. S_1F_2 interaction registered higher yield than other soil and crop interaction treatments. Among the interaction effect between soils and treatments, S_1T_2 interaction produced higher dry matter yields than other soil and treatment interaction effects. These results indicated that presence of gypsum in the surface layers of mined soils and application of amendments to the mined soils influenced the dry matter yield of forage crops significantly.

CONCLUSIONS

The present study showed that the growth and yield of forage crops were influenced by soluble salt content of mined soils. The effect of kind of soil, amendments and forage species on biomass yields was significant at 0.01 level. Soils with low salt content (EC<1 dSm^{-1}) produced higher green biomass and dry matter yields than the other soils with medium and high salt content. Among the forage crops, *Cenchrus glaucus* registered high yields than the other forage crops. Among the amendments, application of compost produced higher yields. The interaction effect confirmed that the combined effect of growing *Cenchrus glaucus* in soils with low EC values with compost treatment were responsible for higher green biomass and dry matter yields.

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