Plant Archives Vol. 20 Special Issue, 2020 pp. 1301-1304 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

AGRONOMIC STRATEGIES FOR AFFORESTATION OF COASTAL SALINE WASTELANDS WITH *ACACIA FERRUGINEA* DC

Rex Immanuel R.* and M. Ganapathy

Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar-608002 (T.N.) India.

Abstract

A field experiment was conducted at Northern Coastal Tamilnadu, India, to determine the effect of agro-techniques on the survival and growth of *Acacia ferruginea* DC in coastal saline wastelands. Due to poor soil moisture retention capacity and accumulation of salt in these soils, it requires good soil working techniques and suitable amendments and is considered as an essential silvicultural practice for obtaining desirable establishment and growth. Soil working techniques *viz*., pit and auger hole method of planting and combination of organic ameliorative amendments such as FYM, composted coir pith and pressmud along with gypsum, $ZnSO_4$ and biofertilizers were used for tree planting. After three years of experimentation, the results revealed that auger hole method of planting in combination with composted coir pith @ 9 kg pit^{-1}, gypsum @ 180 g pit^{-1}, $ZnSO_4$ @ 20 g pit^{-1}, *Azospirillum* @ 50 g pit^{-1} and Phosphobacteria @ 50 g pit^{-1} was significantly registered the maximum establishment percentage of 83.25, plant height of 211.39 cm, girth at collar region of 14.79 cm, RGR of 1.59 cm month^{-1} and taproot length of 121.14 cm.

Key words: afforestation, land degradation, organic amendments, planting methods, saline soils, waste lands.

Introduction

Land, a non-renewable resource, is fundamental to all primary production systems. Land degradation is caused by biotic and abiotic pressures. Wastelands are the degraded and unutilized lands excluding current fallows due to various constraints. In these lands, the biomass production is less than 20 percent of its overall potential. Such lands are ecologically unstable and are unsuitable for economic cultivation due to decline in their quality and productivity. Saline wastelands occupy a considerable area along the relatively long coastline of India and Tamilnadu and obstruct for raising crops (Rex Immanuel and Ganapathy, 2019a). Good rhizosphere soil environment is fundamental to establishment and growth of tree crops in coastal degraded soils. In these regions, sufficient annual rainfall is available while the entire quantity is received with in a period of two or three weeks and causes severe water deficit situation. Water holding capacities of these soils are also very low. Soil organic matter and nutrients are practically absent (Rex Immanuel and Ganapathy, 2019b, Rex Immanuel, 2018b). In most of the situations, failure occurs to the establishment of economically important tree species (Rex Immanuel *et al*., 2018a). Adopting economically viable, scientifically acceptable and environmental friendly agronomical management practices and reclamatory measures for wastelands are appear to be promising key to bring more area under vegetation cover (Rex Immanuel, 2019).

Acacia ferruginea DC (Family-Mimosaceae), commonly known as 'Rusty Acacia' (Arimedah, Parambai, Safed khair) is a medium sized drought tolerant deciduous tree native to India and Sri Lanka. International Union for Conservation of Nature and Natural resources (IUCN) has enlisted this tree under the category of Red list (vulnerable species). It grows in areas where temperatures can be up to 40°C and the mean annual rainfall is within the range 350-750 mm. Young leaves are used as fodder. The bark is steeped in cane sugar and then distilled, yielding intoxicating liquor. The wood is mostly used in cartwheels, posts, beams and agricultural implements. A good gum, similar to gum arabic is obtained from the tree. This species has a symbiotic association with soil bacteria and form nodules on the roots and fixes

***Author for correspondence :** E-mail: rrximmanuel@gmail.com

atmospheric nitrogen. The fixed nitrogen is utilized by the growing plant and some can also be used by other plants growing nearby. Hence it has been assumed to be the suitable species for reclamation coastal saline wastelands. This study was planned to evaluate the feasibility of using suitable agro-techniques for afforestation in wastelands.

Materials and Methods

The geographically the study area is located at 13°22′ N Latitude and 80°16′ E Longitude with an altitude of +12.5 m mean sea level. The site experienced dry sub-humid climate with the mean annual rainfall of 1300 mm of which 80 per cent is received during North-East monsoon (October - December) with<30 rainy days. The potential evapotranspiration varied from 1650 mm resulting in an annual water deficit of 470 mm. The length of the moisture available period was 90 days. The mean annual maximum and minimum temperatures were 35.6°C and 24.5°C, respectively. The pH, EC (dsm^{-1}) and SAR of the study area were 8.41, 12.68 and 11.93, respectively. The nutrient status is low in organic carbon (0.16 %), N (91.25 kg ha^{-1}), P_2O_5 (6.80 kg ha^{-1}) and K_2O (70.25 kg ha^{-1}). The study site comes under the LCC of Vc (Salinity, light textured, too dry and low soil fertility).

The experiments were laid out in split plot design with three replications. The treatment consisted of two soil working techniques (M_1 - Pit method and M_2 - Auger hole method) in main plots and four organic amendments in sub plots (S_1 - FYM @ 12 kg pit^{-1}, S_2 - Pressmud @ 14 kg pit^{-1}, S_3 - Composted coir pith @ 9 kg pit^{-1} and S_4 - Control (without amendments)). Along with the organic amendments, gypsum @ 180 g pit^{-1}, $ZnSO_4$ @ 20 g pit^{-1}, *Azospirillum* @ 50 g pit^{-1} and Phosphobacteria @ 50 g pit^{-1} were applied. To restore the wastelands, six months old *Acacia ferruginea* seedlings were planted under high density planting (1,111 plants ha^{-1}) with the spacing of 3×3m and the plot size of 150m^2. The field was fenced, cleaned, ploughed and leveled. Then the planting pits were prepared according to the treatment schedule.

The size of the normal pit was 0.60m^3. The auger holes were prepared with a dimension of 0.20m and at a depth of 0.90m by using mechanical auger. The pits and holes were filled with mixture of original soil and amendments and the seedlings were planted. The observations such as establishment per cent, plant height, girth and relative growth rate (cm month^{-1}) (RGR) at 36 months (cm) after planting were recorded. Homogeneity in sapling size is highly recommended since a comparison of tree species, which differ in initial size. Hence, the RGR measurements start with one year old (12 and 36 months of planting) instead of very young seedlings. RGR of was determined by using the following equations suggested by Hunt (1982) and South (1991).

$$RGR_H = (\ln H_2 - \ln H_1) / (T_2 - T_1)$$

$$RGR_G = (\ln G_2 - \ln G_1) / (T_2 - T_1)$$

$$RGR = (RGR_H + RGR_G) / 2$$

Where, RGR_H - Relative height growth rate, RGR_G - Relative girth growth rate, *H*- height (cm), *G* - girth at collar region (cm), *T*- Time (months). Subscripts refer to initial and final measurements (12 and 36 months after planting, respectively). To study the treatment effects on root development, root systems were exposed in the field after one year following wet excavation methodology (Bohm, 1979).

Results and Discussion

The results of the agro techniques on afforestation of coastal wastelands with *Acacia ferruginea* revealed that the auger hole method of planting (M_2) significantly recorded a higher establishment percentage of 76.75, plant height of 187.55cm, girth at collar region of 12.69 cm, relative growth rate (RGR) of 1.41 cm month^{-1} and taproot length of 98.01cm. For amelioration with amendment treatment, composted coir pith @ 9 kg pit^{-1} and its combinations (S_3) recorded a higher establishment percentage of 80.04, plant height of 199.76cm, girth at collar region of 14.32cm, RGR of 1.47cm month^{-1} and taproot length of 115.09cm. The interaction between land management methods and ameliorative amendments were found to be significant. The treatment M_2S_3 (auger

Table 1: The effect of planting methods and amendments on the establishment per cent and plant height (36 months after planting).

Treat-ments	Establishment percentage			Plant height (cm)		
	M_1	M_2	Mean	M_1	M_2	Mean
S_1	70.25(57.58)	79.24(62.84)	74.75(59.45)	173.32	191.85	182.59
S_2	68.50(55.90)	74.60(58.91)	71.55(57.01)	168.26	182.75	175.51
S_3	76.83(61.70)	83.25(64.95)	80.04(62.15)	188.13	211.39	199.76
S_4	63.48(52.14)	69.90(54.15)	66.69(53.47)	155.21	164.21	159.71
Mean	69.77(56.83)	76.75(60.21)		171.23	187.55	

	S.Ed	CD (P = 0.05)	S.Ed	CD (P = 0.05)
M	1.53	3.15	4.03	08.12
S	1.30	2.64	4.76	09.56
M × S	1.97	2.00	6.04	12.10

(Figures in parenthesis indicate arc-sine transformed values)

Table 2: The effect of planting methods and amendments on the girth and relative growth rate (36 months after planting).

Treat-ments	Girth (cm)			RGR (cm month^{-1})		
	M_1	M_2	Mean	M_1	M_2	Mean
S_1	12.09	13.37	12.73	1.22	1.46	1.34
S_2	11.91	12.32	12.12	1.27	1.38	1.33
S_3	13.85	14.79	14.32	1.35	1.59	1.47
S_4	09.62	10.28	9.95	1.12	1.19	1.16
Mean	11.87	12.69		1.24	1.41	
	S.Ed	CD (P = 0.05)		S.Ed	CD (P = 0.05)	
M	0.29	0.68		1.46	0.08	
S	0.41	0.85		1.38	0.12	
M × S	0.43	0.91		1.59	0.12	

hole method with composted coir pith @ 9 kg pit^{-1}, gypsum @ 180 g pit^{-1}, $ZnSO_4$ @ 20 g pit^{-1}, *Azospirillum* @ 50 g pit^{-1} and Phosphobacteria @ 50 g pit^{-1}) significantly registered a higher establishment percentage of 83.25, plant height of 211.39 cm, girth at collar region of 14.79 cm, RGR of 1.59 cm month^{-1} and taproot length of 121.14 cm.

It is being realized that less productive coastal salt affected soils can be place under tree canopy for correcting ecological imbalance. However it requires proper agronomic technologies. In afforestation of salty soils, excess of salts and scarcity of soil moisture are the major problems which adversely affect the establishment and growth of tree seedlings. Auger hole method of planting helps to attain a maximum survival and growth of *A. ferruginea.* The principal hypothesis behind the auger hole planting technique is the management of root zone of the plants by modifying the soil environment with limited amount of amendments to a greater depth of soil profile, which has a vital role for the establishment and survival of saplings under early stages (Rex Immanuel and Ganapathy, 2019b). Auger hole method of site preparation also pierced the kankar layers and encouraging of deeper rooting. Thus the tree seedlings are able to pierce deeper soil layers for water and nutrients and withstand adverse dry conditions during moisture stress periods (Pazhanivelan *et al*., 2006).

Soil salinity imposes ion toxicity, osmotic stress, nutrient (N, Ca, K, P, Fe, Zn) deficiency and oxidative stress on plants, and thus limits water and nutrient uptake from soil. The use of soil amendment mixture such as composted coir pit is necessary to retain the moisture for a longer period and counteract the harmful effect of soluble salts and also to meet plants nutritional requirements. Coir pith has very high moisture retention capacity of 500-600 per cent and can be as high as 1100 percent of dry weight (Evans *et al*., 1996). It retained

Table 3: The effect of planting methods and amendments on the taproot length (cm) (12 months after planting).

Treatments	Girth (cm)		
	M_1	M_2	Mean
S_1	096.87	102.32	99.60
S_2	084.12	095.16	89.64
S_3	109.03	121.14	115.09
S_4	065.59	073.40	69.50
Mean	088.90	098.01	
	S.Ed	CD (P = 0.05)	
M	3.68	07.43	
S	5.14	10.35	
M × S	5.49	11.15	

the maximum moisture after 90 days of composting (Mbah and Pdili, 1998). As a nutrient source, coir pith has not much value. But, it can be composted, coir pith have more amount of nutrients and it can be further enriched by addition of specific nutrients (gypsum and $ZnSO_4$) and cultures of beneficial microbes (*Azospirillum* and Phosphobacteria) capable of enhancing the fixation and availability of nutrients. These enrichment techniques would make coir pith compost better equipped to influence plant growth more efficiently. The physical, chemical and biological properties of salt affected soil are improved by the application of gypsum leading to enhanced plant growth and development (Chaudhry, 2001). Zn greatly maintains the structural and functional integrity of cell membranes (Cakmak, 2000). Hence sufficient Zn supply could reduce Na accumulation and contributed to salt tolerance in plants.

Microorganisms play a significant role because of their unique properties such as tolerance to saline conditions, synthesis of compatible solutes, production of plant growth promoting hormones and their interaction with crop plants. Beneficial rhizosphere microorganisms can improve plant performance under stress environments and, consequently, enhance the growth both directly and indirectly. High moisture retention capacity of coir pith compost enhanced the activity of beneficial microorganisms. *Azospirillum* inoculation in planting pits involved in growth promotion through the production of bioactive molecules *viz*., Abscisic acid, Gibberellic acid, Indole 3-acetic acid, etc. which enhanced nutrient uptake, accelerating mineralization, reducing plant stress, stimulating nodule formation and nitrogen fixation (Somers *et al*., 2005, Perrig *et al*., 2007, Mallik and Williams, 2008, Rex Immanuel and Ganapathy, 2019c). Phosphobacteria produces organic acids which are involved in solubilizing inorganic phosphate compounds which helps in better RGR and root length of tree sapling. The synergistic and cumulative effects of composted coir pith, gypsum, micronutrient and enriched microbes make it ideal for use as a soil amendment especially for salt affected wastelands in the coastal regions.

Conclusion

The results of the study revealed that that auger hole method of planting in combination with composted coir pith @ 9 kg pit^{-1}, gypsum @ 180 g pit^{-1}, $ZnSO_4$ @ 20 g pit^{-1}, *Azospirillum* @ 50 g pit^{-1} and Phosphobacteria @ 50 g pit^{-1} is the most appropriate and sustainable agronomic management technique for afforestation of coastal saline sandy wastelands with *Acacia ferruginea*.

Acknowledgement

Indian Council of Agricultural Research - National Agricultural Technology Project (ICAR-NATP), Government of India, New Delhi is greatly acknowledged for providing financial support.

References

Bohm, W. (1979). Methods of studying root systems. Ecological studies. Springer, New York., 186.

Cakmak, I. (2000). Role of zinc in protecting plant cells from reactive oxygen species. *New Phytol.*, **146:** 185-205.

Chaudhry, M.R. (2001). Gypsum efficiency in the amelioration of saline-sodic/sodic soil. *Int. J. Agric. Biol.,* **3:** 276-280.

Evans, M.R., S. Konduru and R.H. Stamps (1996). Source variation in physical and chemical properties of coconut coir dust. *Horr. Sci*., **31:** 965-967.

Hunt, R. (1982). Plant growth curves: the functional approach to plant growth analysis. City: *Edward Arnold*., 248.

Mallik, M.A.B. and R.D. Williams (2008). Plant Growth Promoting Rhizobacteria and Mycorrhizal Fungi in Sustainable Agriculture and Forestry. In: Ren Sen Zeng, Azim U. Mallik and Shi Ming Luo (Eds.) Allelopathy in Sustainable Agriculture and Forestry, Springer, New York., 321-345.

Mbah, B.N. and P.N. Pdili (1998). Changes in moisture retention properties of five waste materials during short-term mesophilic composting. *Compost. Sci. Utilization*., **6(4):** 67-73.

Pazhanivelan, S., M. Mohamed Amanullah, K. Vaiyapuri, K. Sathyamoorthi, A. Alagesan and C. Sharmila Rahale (2006). Influence of planting techniques and amendments on the performance of Neem (*Azadirachta indica*) and changes in soil properties in rainfed alkali soil. *Research Journal of Agriculture and Biological Sciences*., **2(6):** 443-446.

Perrig, D., M.L. Boiero, O.A. Masciarelli, C. Penna, O.A. Ruiz, F.D. Cassan and M.V. Luna. (2007). Plant-growth-promoting compounds produced by two agronomically important strains of Azospirillum brasilense, and implications for inoculant formulation. *Applied Microbiology and Biotechnology*., **75 (5):** 1143-1150.

Rex Immanuel, R. (2019). Screening of multipurpose tree seedlings for afforestation of degraded coastal agricultural lands. *Plant Archives.*, **19(2):** 653-656.

Rex Immanuel, R. and M. Ganapathy (2019a). Characterization of degraded lands in coastal agro ecosystem of Northern Tamil Nadu, India. *Journal of Emerging Technologies and Innovative Research*., **6(2):** 200-216.

Rex Immanuel, R. and M. Ganapathy (2019b). Agro-techniques for afforestation of degraded coastal agricultural lands with silk cotton (*Ceiba pentendra* (L.) Gaertn.). *Journal of Pharmacognosy and Phytochemistry.*, **8(2):** 1587-1590.

Rex Immanuel, R. and M. Ganapathy (2019c). Standardization of agro-techniques for establishment of cashew (*Anacardium occidentale* L.) plantations in strongly saline sandy loam coastal soils. *Journal of Pharmacognosy and Phytochemistry.,* **8(3):** 734-738.

Rex Immanuel, R., M. Ganapathy and M. Thiruppathi (2018a). Perception analysis of coastal agro ecosystem degradation, its effect on agricultural production and the performance of multipurpose tree species. *The Research Journal of Social Sciences*., **9(12):** 122-135.

Rex Immanuel, R., M. Thiruppathi and V. Mullaivendhan (2018b). Agronomic management systems for rehabilitation and sustained crop production in coastal agro ecosystem of Tamil Nadu, India. *Innovations in Agriculture*., **1(2):** 28-30, doi: 10.25081/ia.2018. v1.i2.1033.

Somers, E., D. Ptacek, P. Gysegom, M. Srinivasan and J. Vanderleyden (2005). *Azospirillum brasilense* produces the auxin-like phenylacetic acid by using the key enzyme for indole-3-acetic acid biosynthesis. *Applied and Environmental Microbiology*., **71(11):** 1803 -1810.

South, D.B. (1991). Testing the hypothesis that mean relative growth rates eliminate size related growth differences in tree seedlings. *J. For. Sci*., **21(2/3):** 144-164.