

Prospect of aromatic grass cultivation

in salt affected soils of semi-arid region in India

B. B. Basak¹, Ajoy Saha², Anil Chinchmalatpure³ and P. Manivel⁴

Directorate of Medicinal and Aromatic Plants Research, Boriavi, Anand (Gujarat) 387 310

In India about 6.73 million ha land is affected by salinity and alkalinity problems. Reclamation of such problem soils is a costly affair for small-and marginal-farmers. There are various methods (physical, chemical and biological) for land reclamation but biological methods are quite cheaper as compared to other conventional methods. Choosing right species for vegetation is very important in biological measure. In these respect grass species are considered the best due to their strong resistance to adverse conditions, and fast growing features. Similarly aromatic grass (aroma producing) has various kinds of favourable characteristics and function such as rapid growth, huge biomass, massive and long roots for rehabilitation of degraded land. Aromatic grass has gained considerable economic importance as its oil is used in costly export oriented product and formulation of different blends of flavours, pharmaceuticals, beverages, soap etc. Therefore, cultivation of aromatic grass in salt affected soil might be promising enterprise for the farmers while rehabilitation of the degraded soils.

Key words: Aromatic grass, Cultivation, Salt affected soils, Semi-arid region

SOIL, a non-renewable resource, is central to all primary production system. Over the years, countries like India, due to high population rate, suffered from different types of extreme pressure and degradations. In arid and semi-arid region, indiscriminate use of saline water for irrigation often causes accumulation of salts in soil which limits the crop productivity. Reclamation of such problem soils is a costly affair for farmers of India, specially for resource poor farmers. Studies indicated that aromatic grass species may be successfully grown in salt affected soils. Aromatic grasses appear suited for growth in salt affected soils and able to withstand salinity in soil and irrigation water to a great extent than traditional agricultural crops. Besides having a usually high benefit to cost ratio, aromatic grasses could be useful sources of high value, essential oils that are in great demand in the cosmetic, pharmaceutical, and

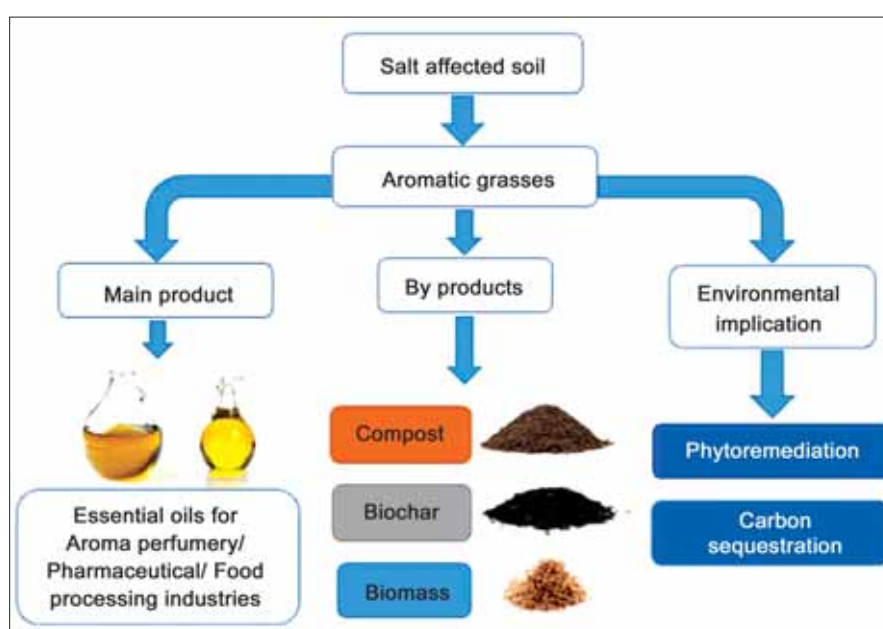


Fig. 1. Advantage of aromatic grass cultivation in salt affected soil

flavoring industries of India and abroad (Fig. 1). It was also found that these species may reduce salinity and alkalinity status of the problem soil.

Salts affected soils

Salinity is a major constraint in plant growth and productivity worldwide. The National Academy of Sciences of the United States

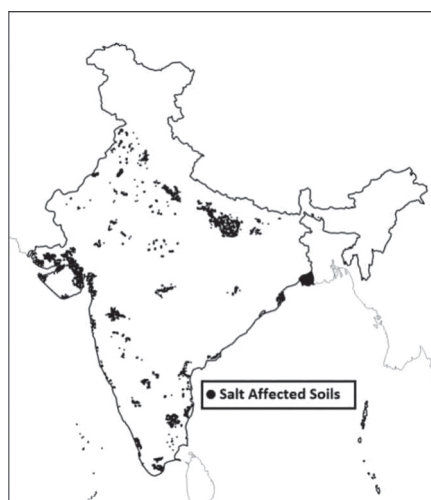


Fig. 2. Salt affected soil map of India

Table 1. Distribution of salt affected soils in India

Salt affected soil	Area (ha)
Saline soil	1,710,673
Alkali soil	3,788,159
Costal saline soil	1,246,136
Total	6,744,968

America includes salinization of soils and water as one of the leading processes contributing to a worldwide catastrophe. The utilization and subsequent improvement of salt affected wastelands, which occupies about 6.73 million ha of lands in India, is of significant importance (Table 1, Fig. 2). Successful cultivation on salty wastelands however, requires suitable reclamation and management strategies. The process by which the saline soil formed is called 'Salinization'. Saline soil occurs mostly in arid or semi-arid regions. In arid regions saline soils occur not only because there is less rainfall to leach and transport the salt but also because of high evaporation rates, which concentrate the salts in soils and in surface waters. Restricted drainage is another factor that contributes to the salinization of soils and may involve the presence of a high ground watertable or low permeability of the soil. When excess soluble salts accumulate in these soils, sodium (Na) frequently becomes the dominant cation in the soil solution. In arid regions as the soil solution becomes concentrated through evaporation or water absorption by plants, the solubility limits of calcium sulphate (CaSO_4), calcium carbonate (CaCO_3)

Table 2. Yield potential of aromatic grasses

Aromatic grass	Scientific names	Biomass Yield (tonne/ha)	Essential oil yield (kg/ha)	Oil content (%)
Vetiver	(<i>Vetiveria zizanioides</i>)	3.6	36.6	1.00
Lemon grass	(<i>Cymbopogon flexuosus</i>)	25-30	100-150	0.3
Palmarosa	(<i>Cymbopogon martini</i>)	37.2	159.1	0.1-0.4
Citronella	(<i>Cymbopogon winterianus</i>)	40-45	250-300	0.5-0.8

and magnesium carbonate (MgCO_3), in which case they are precipitated with a corresponding increase in sodium concentration. Under such conditions, a part of the original exchangeable calcium (Ca^{2+}) and magnesium (Mg^{2+}) is replaced by sodium (Na^{+2}) resulting alkali or sodic soils. Saline-alkaline or saline-sodic soils are form as a result of the combined processes of salinization and alkalization. The area and distribution of different types of salt affected soils are given in the Table 2.

Technological improvements of these soils seldom works and current interest is directed at viable alternate strategies, such as breeding salt resistant or tolerant plant varieties or introducing non-traditional crops to cope with salt problems. Some aromatic grasses appear suited for growth in salt contaminated soils, which are able to withstand salinity in soil and irrigation water to a great extent than traditional agriculture crops.

Aromatic grass

Aromatic (aroma producing) are those plants which produce a certain type of aroma. Their aroma is due to the presence of essential oil rich in terpene compounds. In India, almost 1,300 species are known to contain aromas, but only about 50 of these oil derived plants are demanded in trade and industries. The essential oil industry was traditionally a cottage industry in India. The essential oils from plants produced in India are *ajowain* oil, cedar wood oil, celery oil, citronella oil, davana oil, eucalyptus oil, geranium oil, lavender oil, lemon grass oil, mentha oil, palmarosa oil, patchaouli rose oil, sandal wood oil, turpentine oil and vetiver oil. Presently the total world production of essential oils is about 110,000 - 120,000 Mt out of which India produces 15%, holding third place after China and Brazil in the world

production, while in value its share is better with 21 to 22%. Although the production of major oils are highly organized, however, in developing countries, a number of volatile oil rich flora is not fully utilized or cultivated. The United Nation Industrial Development Organization has taken steps to inform on the setting up of rural based small-scale essential oil industries.

Potential of aromatic grass cultivation

The aromatic grass studies indicated that they are well suited in salt affected soil and perform better in saline and sodic condition as compared to normal soil. Some aromatic grasses, Vetiver (*Vetiveria zizanioides*), Palmarosa (*Cymbopogon martinii*), Lemongrass (*Cymbopogon flexuosus*), and Java citronella (*Cymbopogon winterianus*) appear suited for growth in salt affected soils, which are able to withstand salinity in soil and irrigation water to a great extent than traditional agriculture crops (Table 3). Palmarosa can withstand adverse salt and moisture stress. Salinity up to 15 dSm^{-1} did not adversely affect the yield and quality of essential oil. Palmarosa could be successfully grown with saline water irrigation having EC 16.0 dSm^{-1} and sodic water with RSC 16 meqlitre⁻¹. A 50% reduction in herb yield of palmarosa over control was recorded at soil ESP of 52. The geranylacetate content in the palmarosa essential oil increased with increases in soil sodicity. Lemongrass plant is harder

Table 3. Upper permissible limit of soil salinity and sodicity for some aromatic grasses.

Crops	Salinity (Ec dSm^{-1})	pH	ESP
Palmarosa	11.5	9.5	55
Lemon grass	10.0	9.0	50
Vetiver	12.0	9.5	55
Citronella	5.5	8.5	25

than palmarosa and adapts to a range of adverse soil conditions, including soil and moisture stressed conditions. Like palmarosa, lemon grass can be successfully grown with the saline water irrigation having EC_{iw} 10.0 dSm^{-1} and sodic water of RSC 16.0 $mEq\ litre^{-1}$. High salinity and sodicity has no adverse effect on citral content in the essential oil of lemongrass. It is more remunerative than common arable crops prescribed under such adverse conditions. Vetiver is another candidate, which can withstand soil salinity as high as EC_{up} to 12.0 dSm^{-1} and soil alkalinity up to pH 10.0. Sodicity of irrigation water up to RSC 16.0 $mEq\ litre^{-1}$ and SAR 31.9 did not significantly influence the shoot and root yield of vetiver. Vetiver grown on salt affected soils sometimes give better yield and quality essential oil as compared to normal soil condition. Aromatic grasses like jamarosa and citronella could withstand up to salinity 12.5 and 5.5 $EC\ dSm^{-1}$, respectively.

Available estimates indicated that these aromatic grasses are grown in more than 30,000 ha of lands in the country, giving net return of ₹ 15,000 to 25,000 depending upon the soil and climatic conditions. Soil degradation become a serious problem in both rainfed and irrigated areas of India. India is losing a huge amount of money from degraded lands, salinization and alkalization. There is plenty of scope in increasing the acreage under aromatic crops through successful utilization of degraded lands, which will generate employment in rural sector, and besides production of aromatic plants on salty land, spare productive fertile agricultural fields for other food, fiber, and fodder crops.

Rehabilitation of salt affected soils

Information regarding ameliorative potential of aromatic grass species for improving saline and alkaline soil is limited. Some of the aromatic grasses have the potential for hyper accumulation of salt, which helps in reclaiming the saline soil e.g. palmarosa, a hyper salt accumulator. It has been reported that aromatic grasses such as, palmarosa, and lemon

Table 4. Ameliorative potential of aromatic grass in salts affected soils

Aromatic grass	Land situation	Soil quality improvement
Vetiver grass (<i>Vetiveria zizanioides</i>)	Salt affected sandy areas	Planting 1, 2 and 3 rows of vetiver can reduce soil sediment erosion into ponds as much as 47.5, 84.4 and 153.8 $t\ ha^{-1}$
	Degraded land	Phyto-stabilization, Phyto-amelioration and Revegetation of degraded land.
	Calcareous soils, Saline water	Vetiver viable under saline irrigation conditions.
Palmarosa (<i>Cymbopogon martini</i>)	Saline and alkaline soil	Vetiver could withstand with soil salinity as high as EC up to 12.0 dSm^{-1} and the soil alkalinity up to pH 10.0.
	Salt affected soil	Improved the physicochemical properties and fertility status of soil
	Calcareous soils, Saline water	Palmarosa viable under saline irrigation conditions.
Lemon grass (<i>Cymbopogon flexuosus</i>)	Saline and alkaline soil	Salinity up to 15 dSm^{-1} did not affect the yield. Successfully grown with saline water irrigation having 16.0 dSm^{-1} and sodic water with RSC 16
	Soil Sodicity	Palmarosa relatively more tolerant to sodicity than lemongrass.
	Calcareous soils, Arid soils, Saline water	Lemongrass viable under saline irrigation conditions
Citronella	Saline water irrigation	Decreased the pH and SAR of irrigated soils and increased the yield.
	Saline and alkaline soil	Successful grown with saline water irrigation having 16.0 dSm^{-1} and sodic water with RSC 16 $mEq\ litre^{-1}$.
Citronella	Saline soil	Citronella can tolerate salinity up to 5.0 dSm^{-1} and reduction in yield moderately up to 10.0 dSm^{-1}

grass (*C. flexuosus*) can be grown successfully on moderately alkali soils having pH up to 9.0 and 9.5, respectively. These grasses not only produce essential oils used for industrial purpose but also ameliorate the degraded soil (Table 4). Palmarosa, lemongrass and vetiver grown for two years on sodic soils having pH 10.6, 9.8 and 10.5, respectively, the reduction in pH was noticed as 9.4, 8.95 and 9.50 in each soil, respectively. The continuous growing of palmarosa may reduce the sodicity and improve the physico-chemical properties of sodic soils. Like other aromatic grasses vetiver can reduce the sodicity and improve the physico-chemical properties of sodic soils.

Environmental implication

Apart from economic or on-farm benefits to farming communities, cultivation of aromatic grasses under salt-affected soil will also help in environment conservation through improvements in physical properties of salt-affected soils and decreases in salinity and sodicity level. Moreover

it will improve the the availability status of nutrients and carbon sequestration in the post-plantation in present changing climatic condition particularly increasing atmospheric CO_2 concentration and global warming. This issue may be effectively addressed through sequestration of carbon in plants and soils by aromatic grass based cropping system. It has been found that the aromatic grasses like lemongrass, palmarosa and citronella have high potential to sequester carbon in its shoot and root biomass, and the values are higher than many arable crops, trees, and plantation crops. Besides C-sequestration, these grasses provide sustainable solutions to ameliorate the degraded land through phyto-remediation and soil conservation.

Economic importance

The volatile essential oil is the main economic produce from aromatic grasses, which have tremendous economic potential in national and international market. A number of essential oil industries was

Table 5. Economic importance of aromatic grass

Crops	Cost of cultivation (`/ha <sup>-1</sup>)	Gross returns (`/ha ⁻¹)	Net returns (`/ha ⁻¹)	B:C ratio
Palmarosa	35,000	1,50,000	1,15,000	3.28
Vetiver	75,000	2,25,000	1,50,000	2.0
Lemon grass	45,000	1,60,000	1,15,000	3.33
Citronella	45,000	1,60,000	1,15,000	3.33

established for large-scale production of essential oils, oleoresins and perfume in India. Apart from high economic return and benefit to cost ratio (Table 5), aromatic grasses could be useful sources of high value, essential oils that are in great demand in the cosmetic, pharmaceutical, and flavoring industries of India and abroad. The essential oils from aromatic grasses being produced in India include citronella oil, lemon grass oil, palmarosa oil, and vetiver oil. Lemon grass leaves are used in culinary preparations in Asia. Nearly 300 tonne of lemongrass oil is produced in the world. Lemon grass oil contains nearly 75 to 90% citral and is widely used in perfume industry where it is used to manufacture citral and ionones (β and α) and in scenting detergents, washing soaps etc. The major chemical constituent in palmarosa oil is geraniol (75 to 95%) and other minor constituents include geranyl acetate, citral, citronellol and linalool. Palmarosa oil is widely used in perfumery for scenting soaps, cosmetics and in the manufacture of geraniol and geranylacetate, which are used in high-grade perfumes and cosmetics. Vetiver oil is used in perfumery, fixative and odour stabilizer and in flavoring tobacco

and cold drinks and its world production is estimated at 250 tonne. So, the cultivation of aromatic crops provides sustainable means of natural source of high value industrial raw material for pharmaceutical, agro-chemical, food and cosmetic industries and opens up new possibilities for higher level of gains for farmer with a significant scope for progress in rural economy.

Research and future prospect

The assessment of the effect of saline soil on the growth, physiology, morphology, essential oil yield, composition of essential oil of aromatic crops should be considered before using as phyto-remediation crop. Moreover, there is a need to identify high, medium and mild-salt tolerant aromatic crops, and should be categorized for their maximum exploitation in economic phyto-remediation of saline soil through its cultivation. Thus, screening of aromatic crops for salt tolerance is necessary to develop efficient strategy for remediation and management of saline soil at different salinity level (i.e. high, medium and low). So, developing of salt-tolerant plant genotypes through the use of plant-breeding strategies will further help this mitigation strategy. Soil quality,

nutrient status associated with the cultivation of aromatic plants in saline soil is important and should be considered. The solid waste of aromatic grasses left after extraction of essential oil can be recycled in salt affected soil to increase its fertility. Aromatic crops are found all over the world and salinity problems are also global issue. Therefore, country/region/location specific aromatic crop should be used for remediation and utilization of salt affected soils due to their easy availability, native nature, local tolerance and adaptability with the use local and well-known agronomic practices and uses. Besides this, selection should consider market value of the produce or its potential use on the farm.

SUMMARY

Aromatic grasses have tremendous potential to rehabilitation of salt affected soil as well as generate additional income source for small- and marginal-farmers. The eco-friendly reclamation technique for salt affected soil includes three aspects: soil quality improvement, environmental sustainability as well as additional income generation for farmers.

¹Scientist and Head, ⁴Director (Acting), DM&APR, Boriavi (Anand) Gujarat, Directorate of Medicinal and Aromatic Plants Research, Boriavi 387310, Anand, Gujarat, ³Scientist, Central Inland Fisheries Research Institute, Bengaluru (Karnataka) 560 089 Central Soil Salinity Research Institute, Regional Research Station, Bharuch 392012, Gujarat Corresponding authors' e mail: biraj.ssac@gmail.com

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