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USING PARTICIPATORY APPROACHES FOR REHABILITATING SALT AFFECTED LANDS BY FRUIT BASED AGROFORESTRY SYSTEMS

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ABSTRACT : Horizontal expansion of farming on good land is not possible due to reduction in land: man ratio, hence only alternative seems to utilize either degraded lands or to go for intensive farming on fertile lands with assured input facilities for fulfilling the basic needs of our increasing population. Regarding former approach, a sizable land in our country is subjected to various kinds of land degradation problems and about 6.32 million ha alone suffers from salinity and alkalinity. These lands have good potential if managed properly for sustained utilization by putting them under agroforestry land use system. In present study, the suitable agrotechniques have been worked out by series of experimentation on farmers field in participatory mode. The site specific agrotechniques for establishment of various components, management practices and extent of participation have been suggested for efficient utilization of salt affected lands through fruit based agroforestry systems.

Key words : Horti-agri systems; Horti-pastoral systems; Participatory approach, Salt affected lands

Out of 329 million ha geographical area of the country about 107.4 million ha is categorized as degraded lands. Among different categories of degraded lands about 6.32 million ha suffers from salinity and alkalinity (MOA, 1994) and in Uttar Pradesh alone about 1.3 million ha of land is under salt affected soils. The major farming constraints of these lands are high pH, excess of calcium carbonates, chloride, suphate and exchangeable sodium, imbalance of electrical conductivity, low infiltration rate, impeded drainage and poor fertility status. Already a large area has gone out of cultivation in canal commands particularly in arid and semiarid regions because of the waterlogging and salinity buildup, making landscape devoid of vegetation except for a few hardy trees and grasses (Joshi and Agnihotri, 1984 and Singh *et al.*, 1993).

Inspite of several limitations, salt affected lands have good potential for cultivation of hardy fruit types under scientific management (Pathak *et al.*, 1990 and Saroj *et al.*, 1994) and now a days fruit trees are considered as an integral component in various agroforestry systems (AFS) and watershed management both from production and protection point of view (Singh and Singh, 1990 and Saroj, 1996). Considering these facts, efforts were made to utilize the salt affected lands by fruit based, agroforesty systems (AFS), so that permanent vegetation cover may stop further degradation and also rehabilitate these lands in due course of time.

MATERIALS AND METHODS

The U.P. Land Development Corporation undertook a massive programme on fruit based agroforestry systems for salt affected soils in 13 districts of Uttar Pradesh. The area falls in sub humid subtropical zone with an average annual rainfall of about 850-1100 mm. The topography of experimental area was almost flat. Before

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experimentation, the relative categorization of experimental site has been done as A, B and C based on its production potential and resource conditions. During experimental phase various trials were conducted on farmers field in participatory mode for reclamation of salt affected soils, screening of suitable fruit types, intercrops, soil working techniques, management practices etc. and findings of the period 1992-96 have been compiled and presented in the succeeding pages. The system of management for various activities is expressed as extent of participation for different land categories.

RESULTS AND DISCUSSION

Establishment of Fruit Based AFS

Land treatment and layout : After assessing the salinity and alkalinity levels, the white powdery mass on surface soils containing different salts should be removed. Level the land and divide into beds by making bunds. The beds should be treated by gypsum or pyrite (requirement is based on GR value), if the objective is to grow the crops in the whole area, otherwise only pits should be treated. Besides chemical treatment *Sesbania* spp. can also be grown in the first rainy season as a green manure for reclamation. The layout depends upon the objective and system of the management, while the pit size and plant spacing depend upon the soil and plant types, canopy cover and level of management etc. The plant spacing for *aonla*, *ber* and guava is 8 m; *jamun* and *mahua* 10 m; mulberry 7 m and *karonda* 6 m, while pit size is 1 m^3 for all the fruits except mulberry and *karonda* where it is 0.5 m^3.

Pit digging and filling : The appropriate time for pit digging is between October to March, though it can be dug out upto onset of monsoon. The pit should be left open for at least 20 days. If there is any '*kanker*' layer inside the pit, it should be removed. Pit filling should be done in between April to May by appropriate filling mixture as mentioned in table 1. In pit filling mixture, Zn SO_4 and BHC or *neem* cake should be mixed in soil

Table 1. *Pit filling mixture for salt affected soils*

Filling material		Fruit trees	Forest trees
Gypsum[1]	(kg)	10	4
FYM	(kg)	40	10
Sand	(kg)	20	8
BHC/*Neem* cake	(g)	100/500	100/250
Zn SO_4	(g)	50	-

[1]Gypsum requirement/pit (kg) is computed as 2/3rd of 50% GR value

before 7-10 days of plantation. Pit filling mixture should be completely free from gravels, boulders and always use good soil for preparation of filling mixture.

Planting materials : The planting materials must be true to type, healthy and free from pests and diseases. The following standard are recommended for various plants (Table 2).

Table 2. *Standard of planting materials for different fruit trees*

Plant type	Plant height (cm)	Girth (cm)	Propagation method	Remarks
Guava, *Aonla*	50-75	1.00-1.25	Budding/ Grafting	-
Ber	30-50	0.75-1.00	Budding	-
Karonda	40-60	-	Seeds	3-Branches
Tamarind	50-100	0.75-1.25	Budding/ Layering	-
Pomegranate	25-40	0.75-1.25	Cutting/ Layering	Nematode free

Boundary plantation : The boundary plantation have special significance in devlopment of fruit based AFS, not only for protection against hot winds and animals but they also acts as good source of fuel, fodder, fruits etc. The farmers wisdom was also involved in selection, plantation and managment of different plant types grown as boundary plantation (Saroj and Arora, 1994). The *karonda* (*Carissa carandus*), *babul* (*Prosopis juliflora*), agave (*Agave americana*), *jangal jalebi* (*Inga edulis*), *mehndi* (*Lawsonia inermis*) and *Acacia fernitiana* should be planted for protection from biotic disturbances while sheesham (*Dalbergia sissoo*), *neem* (*Azadirachta indica*), *mahua* (*Madhuca latifolia*), *imali* (*Tamrindus indica*), *subabul* (*Leucaena leucocephala*), *Jamun*

(*Syzygium cuminii)* should be planted as wind breaks. The specification for trenches are 1.2 x 1.0 x 0.9 m (vertical depth, top width and bottom width). The excavated soils should be heaped in a form of bund towards inner side by leaving about 30 cm area. The bunds should be utilized for raising live hedges and boundary plantation.

Planting technique : A little care always ensure better results in any plantation programme. July is the best month for planting most of the evergreen plants. The earthball of plants are generally wrapped by polythene or grasses, which should be removed during planting. The union portion of component plant (grafted/budded) should be above the ground level. Soil around the plant should be pressed firmly after planting followed by light irrigation. A small platform should be made to avoid direct contact of water to the plant. Staking may be done if required. About 20 per cent extra plants should be kept in nursery for gap filling.

Selection of Fruit types

There are several fruit trees (Table 3) which can be grown in salt affected lands (Pathak and Srivastava, 1995). The morphophysiological characteristics of these fruit trees are such (like fruiting and flowering should coincide with moisture availability period, deep root system and other xerophytic characters) that they can tolerate various biotic and abiotic stresses.

Table 3. *Salt tolerance limit of different fruit trees*

Tolerance category	ESP (%)	Ece (dSm-1)	pH (1:2)	Fruit types
High	40-50	12-15	9.5-10.5	*Ber*, Date palm, Tamarind, Khirmi, Sapota, *Gular*
Medium	30-40	9-12	8.5-9.5	*Aonla*, Karonda, Barbados cherry, *Phalsa*, *Jamun*, Mulberry, *Kainth*, Custard apple
Low	20-30	6-9	7.5-8.5	Pomegranate, Fig, Guava, *Bael*, Mango, Citrus
Sensitive	15-20	4-6	6.5-7.5	Pine apple, Banana, Jack fruit

Varieties for Salt Affected Lands

The following promising varieties of fruit trees, crops vegetables and grasses have been selected for salt affected lands (Table 4.)

Table 4. *Promising varieties of fruits, vegetables, crops and grasses for salt affected soils*

Plant types	Promising varieties
Fruit trees	
Emblica officinalis (*Aonla*)	Chakaiya, NA 6,7,8
Ziziphus mauritiana (*Ber*)	Banarasi Karaka, Gola, Umran
Aegle marmelos (Guava)	Sardar guava (L-49), Chittidar
Punica granatum (pomegranate)	Ganesh
Morus alba (Mulberry)	K2
Cereal crops	
Triticum aestivum (Wheat)	KRL 1-4, Shekar
Hordeum vulgare (Barley)	Azad, Jyoti, Amber, Lakhan
Vegetables	
Solanum melongena (Brinjal)	Pant Samrat, Pant rituraj, Pusa Kranti, NDDV 2,25
Lycopersicon lycopersicum (Tomato)	Pusa Early Dwarf, Punjab Chhuhara, Pusa Ruby, Pant Bahar, HS 101, NDT 108, 120, 21
Abelmoschus esulentum (Okra)	Parbhani Kranti, P 7
Beta vulgaris (Sugarbeet)	M Marinopoli, Rimlev
Allium cepa (Onion)	Pusa Red, Pusa Ratnar
Allium sativum (Garlic)	G 1, 41
Spinacia oleracea (Spinach)	Pusa Jyoti, All Green, Verginia Sevoy
Lagenaria siceraria (Bottle gourd)	Pusa Summer prolific Long, Pusa Manjari, Pusa Meghdut, Pusa Naveen, Arka Bahar
Cucurbita moschata (Pumikin)	Pusa Biswas, Arka Chandan, Arka Suryamukhi
Luffa spp. (Tori)	Pusa Chikni, Kalyanpur Chikni, Satputia
Memordica charantia (Bitter gourd)	Pusa Domasi, Arka Harit
Grasses	
Cymbopogon citratus (Lemon grass)	Clone 29, LS 48
Cymbopogon maritini (Palmarosa)	PRC-1
Vetivaria zizanoides (Khas)	KS 1,2
Citronella spp.	B 10-13
Matricaria sp.	German

Fruit Based Agroforestry Models

A. Horti-Agri System

1. Fruit trees + Wheat / Barley / Mustard / Safflower: In this model 156 fruit plants ha^{-1} were grown (8m apart) by covering 20 per cent land area in form of basin and bunds in initial three years. Remaining 80 per cent area can be utilized for growing different intercrops. The interspaces in the orchard should be levelled in form of beds for leaching purpose after mixing the gypsum. The tree basin should be made in such a way that the saline water can not enter into the basin during the process of leaching. During first rainy season *Sesbania* should be grown for turning as green manure. From *rabi* season onward above crops can be grown.

2. Fruit trees + Vegetable : Cultivation of vegetables is possible in relatively fertile soils having pH <9.0. Before growing any vegetables it is essential to grow *Sesbania* as green manure and add 15 tonnes of well rotted FYM followed by ploughing. After two crops of vegetables in two consecutive seasons, growing of *Sesbania* is further recommended for green manuring. The crops like okra, spinach, sugar beet, cabbage, tomato etc. should be grown in trenches 30 cm wide and 22 cm deep while bottle gourd, pumpkin, parwal, brinjal, tomato and other cucurbits can be grown in pits of 45 cm^3 after filling the FYM and good soils (1:1)

B. Horti-Pastoral system

1. Fruit trees+Aromatic grasses/Medicinal plants : The soil upto 9 pH can be successfully utilized for cultivation of aromatic grasses without application of gypsum. It was suggested to apply 10-15 tonnes of FYM/ha for better response of grasses. The important hardy grass species which require less management like lemon grass, palmarosa and *khus* grass are planted during July-August by slips. The spacing for lemon grass and *khas* was 60x60 cm It is also observed that the lemon grass and palmarosa were susceptible to water logging. The medicinal plant *Matricaria* can be grown upto 9.5 pH without treating the soil with gypsum. After manuring by *Sesbania* in first rainy season, the slips of *Matricaria* can be planted at 30x30 cm spacing in the month of Aug. - Sept.

2. Fruit trees+Fodder grasses : In the same manner karnal grass, para grass and bermuda grass can be grown with different fruit trees for fodder purpose. However, it was advised not to grow karnal grass with *aonla* as the water requirement of karnal grass was very high and resulted in adverse effect on the growth and fruiting of *aonla*. Karnal grass was planted by stem cutting (having at least three nodes) at a spacing of 30 x 25 cm while para grass can be planted both by stem and root cutting at spacing of 65x25 cm. The appropriate time for plantation was June-July.

3. Mulberry + Grasses : In this model 2500 plants ha^{-1} of mulberry were planted 2 m apart to produce high leaf biomass for rearing of silkworms. The thicker twigs of mulberry were utilized as fuel wood and thinner twigs for basket making. The interspaces of mulbery can be utilized for growing different fodder grasses even without treating the land by gypsum/pyrite.

C. Horti-silvi-pastoral system

1. Fruit trees+Forest trees+Crops : Fruit trees were planted as usual but forest trees were planted along the boundary. For salt affected lands *Casuarina, Eucalyptus, Leucaena* and *Pongamia* should be planted at 5 m apart while plants like *neem, sheesham, arjun, jamun,* mango, *bael* etc. should be planted at 10 m apart. It is further emphasized that at least 5 plants ha^{-1} of *neem* must be planted in AF models with the view that various *neem* products like seed oil, bark, leaves, oil cake etc. obtained from 5 plants are sufficient to control different diseases and pests of fruit trees and crops grown in one ha land (Pathak, 1996).

Participatory Aproach

Salt affected lands are generally neglected holding and left unutilized by most of the farmers. The reason being the lack of information about

Table 5. *Extent of participation in different agroforestry models (ha^{-1} basis)*

Items	Extent of participation	
	Farmers	Corporation
B+/A Class		
Pit digging, preparation of filling mixture, pit filling and plantation	Labour work	Technical knowledge
Gypsum for fruit trees and crops	Labour work	80% of 50% GR value
Fruit plants	Labour work	Desired number of fruit plants
Seed of *Sesbania*	Labour work	48 kg seeds for green manuring in first year and same quantity in subsequent year
B and C Class		
Cleaning, levelling and layout	Labour work	Technical knowledge and wages also if women workers were involved.
Trenching and wind breaks	Labour work	Technical knowledge, seed/plants and gypsum.
Pit digging, preparation of filling mixture and pit filling	Labour work, sand and FYM	Gypsum, neem cake/BHC and Zine. Cost of sand and FYM, wages if women workers were involved.
Irrigation/drainage channel	Labour work	Technical knowledge
Tubewell boring	Selection of site by farming community and mechanic	Pipe and expenditure of boring work
Pumpset	Loan from the bank by individual/group of farmers	Help in obtaining loan
Water for plantation	Irrigation by community approach	(a) for fruit trees : First Yr. - 70 hrs. Second Yr. - 50 hrs. Second Yr. - 60 hrs. (for women group) (b) Fruit+Forest trees : First Yr. - 60 hrs. Second yr. - 60 hrs.
Water for leaching of pits	Labour work	10 hrs
Gypsum for crops	Labour work	80% of 50% GR valuve (upto 10 tonnes)
Gypsum fo windbreak (orcharding)	Labour work	2 tonnes
Water for leaching (crops)	Irrigation by community approach	50 hrs.
Irrigation for crops		
(a) *Sesbania*	Irrigation by community approach	First yr. - 30 hrs. Second yr. 20 hrs. (*Zaid*)
(b) Fodder	Irrigation by community approach	First yr : Fruit+Fodder - 30 hrs. Fruit + Forest - 20 hrs.
Plants	Labour work	First yr : desired no. of plants Second yr-25% plants for gap filling
Seed of crops		
(a) *Sesbania*	Labour work	First yr. - for green manuring -48 kg in *kharif* Second yr. for seed production - 48 kg in *zaid*
(b) Barely	Labour work	First yr. - 80 kg
(c) Wheat	Labour work	First yr. 90 kg
Medicinal and aromatic plants/fodder grass (seed/slips)	Labour work	Planting material and technical
Vegetables	Labour work	Cost of seed/seeding upto Rs. 1200/-
Fertilizers		
(a) For fruits	Labour work	Recommended dose of fertilizers in first year.
(b) *Sesbania*	Labour work	Recommended dose of fertilizers in first year
(c) Barley	Labour work and additional dose of fertilizers	First yr. - 30kg N, 15 kg P_2O_5, 15 kg K_2O and 20 kg Zine Second yr. - 24 kg N.
Incentive	-	Fruit tree plantation : First yr. Rs. 11.5/ plant Second yr. Rs. 10/alive plant Forest tree plantation : First yr. Rs. 5/ Plant Second yr. Rs. 5/ alive plant Mulbery plantation : First yr. Rs. 5/plant

G.R. = Gypsum requirement.

the technological advancement made for the utilization of salt affected lands. Therefore, technical guidance and motivation of the farmers are very essential for management and utilization of these lands. Under this project, farmers were involved at all the stages starting from the land reclamation to evaluation of the system. They were given ammendments and desired inputs free of cost based on land category in first year and practical knowledge in form of training. Farmers did all the operations themselves under the technical guidance of experts. The extent of participation in different AFS is given in Table 5.

Integrated Management

Even after treating the salt affected soils with amendments (gypsum and pyrite), if land was left fallow for one or two years, it remained unproductive by accumulation of salts in upper layers. Hence these soils require permanent cover and/or cropping with appropriate management.

Irrigation, drainage and moisture management: Irrigation plays a crucial role in success of plantation under salt affected soils. The infiltration rate is generally low, hence check basin method of irrigation has been found promising. Application of water through drip system was found very useful not only in term of water saving (only 40% water is required) but also yield becomes 1.6 to 2.1 times more as compared to surface irrigation, though the initial cost of installation was about Rs. 30, 000/ha without subsidy. Drainage is equally important in salt affected soils. The surface water containing various salts should not accumulate near the tree basin. For safe disposal of excess rain water, there should be provision of trenching all around the orchard.

Preparation of inward basins to harvest post monsoon rain followed by mulching by dry leaves grasses were also recommended for *in-situ* moisture conservation. Mulching of basin by 5 kg green leaves of *subabul* mixed with 0.5 kg leaves of *neem* has shown appreciable response not only in moisture conservation but also supplementing nutrients and providing protection against soil borne pests/diseases.

Nutrition : Application of manures (FYM, leaf mould and compost) were useful for supplementing nutrients and improvement of soil properties. It was also suggested that out of total fertilizer requirement about 1/3rd must be supplemented with manures. The amount of fertilizers to be added may be decided based on age and quantity increased upto 10 years in case of *aonla* and 6 years in case of *ber* and guava, there after, constant dose should be given/tree/year. The nutrition requirement of *aonla*, *ber* and guava are given in Table 6.

In salt affected soils, there was also deficiency of micronutrients that resulted in poor yield and several nutritional disorders in trees and crops. These deficiencies can be taken care by foliar spraying of micronutrients.

Table 6. *Nutrition requirment of some fruit trees*

Fruit types	Fertilizers (g/plant)			Dose of application	Time of application
	Urea	SSP	MOP		
Aonla	210	275	125	1/2N, P_2O_5, 1/2 K_2O	January (after fruit harvesting)
				1/2N, 1/2 K_2O	August
Ber	105	150	80	1/2N, P_2O_5, 1/2 K_2O	June (after pruning)
				1/2 N, 1/2 K_2O	Sept.-Oct. (after fruit setting)
Guava	105	150	80	1/2N, P_2O_5, 1/2 K_2O	January
				1/2 N, 1/2 K_2O	September

Plant protection : Insect-pest and disease are not common in salt affected soils but some times they damaged the crop and fruits to a great extent if not managed properly. Among insects, there was a major problem of shoot gall maker which can be controlled by removal of shoots and alternate spray of 0.05% monocrotophos and dimecron. In rainy season, there was problem of hairy cater pillar and scales particularly in those fields where *Sesbania* was taken as green manure. They were controlled by endosulphon and spraying of monocrotophos (0.05%). Similarly, in case of crops, there were different pests and diseases which required timely control. However, weeds were controlled either manually or chemically based on farmers resource situation.

Productivity

Besides other consideration, the adoption of different AF models primarily depend upon the productivity of individual component integrated in the system. Among forest trees, *neem, sheesham*, mulberry and *babul* were largely adopted by the farmers as boundary plantation. However, medicinal and aromatic plants, grasses and vegetables though they performed well they were adopted by a limited number of farmers. The productivity of some fruit trees (7-8 year old) and crops which were adopted by the farming community on a large scale in salt affected lands has been given in Table 7.

Table 7. *Productivity of different fruit trees and crops grown in salt affected soils (9.5 pH)*[1]

Fruit trees	Productivity (t ha^{-1})	Crops	Productivity (t ha^{-1})
Aonla	20.40	Paddy	2.50
Ber	19.50	Wheat	2.00
Guava	15.60	Barley	1.60
-	-	Sesbania	0.75 (seed)
			6.00 (fuel wood)

[1]Average of 18 locations

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