PAKISTAN EXPERIENCE IN DRYLAND AFFORESTATION

K. M. SIDDIQUI, DIRECTOR GENERAL, *B.H. SHAH*, DIRECTOR, FORESTRY RESEARCH DIVISION AND *M.NOOR*, ASSISTANT SILVICULTURIST, PAKISTAN FOREST INSTITUTE PESHAWAR

Abstract

Pakistan has a long history of and vast experience in the practice of dry afforestation because about 60-70% area in arid and semi-arid parts in Pakistan is subjected to desertification to varying degree for climatic reasons and due to misuse of land for agricultural and pastoral purposes over a long period of time. A number of government agencies have been engaged in the afforestation of vast dry areas in the country. Most of the efforts in this regards have so far been patchy, sporadic and scattered, and were therefore, only partially successful and did not have a lasting impact over a long period in the face of increasing pressure of growing human and cattle population. The Pakistan Forest Institute started systematic research on efficient use of available rain water for dryland afforestation in the 1980's under PL-480 Assistance Programme of the Pakistan Agricultural Research Council and USAID Forestry Planning and Development Project on both public and private lands. A number of water conservation, harvesting and planting techniques were investigated for the establishment of tree plantations in the dry regions. The roaded catchments, microcatchments, and individual basins proved effective and economical for dry afforestation. Plastic mulching, drip irrigation, pitcher irrigation and deep planting were also successfully used for this purpose. A number of multipurpose tree species adapted to the desert environmental conditions in Thal were identified. These were *Acacia albida, Acacia tortilis, Acacia elata, Tecoma undulata, Acacia victoriae, Tamarix aphylla, Acacia modesta, and Prosopis cineraria.* For semi-arid area of Kharian, *Eucalyptus camaldulensis, Acacia saligna, Acacia elata, Acacia albida* and *Leucaena leucocephala* were found to be quite successful.

Introduction

Desert is an area with moisture deficiency and sparse or absent vegetation in the temperate, subtropical and tropical zones (UNDCP, 1977). The area receiving mean annual precipitation of 250 mm or less is considered as desert. Desertification on the other hand, is land degradation in arid, semi-arid and dry sub- humid areas resulting from adverse human impact (UNEP 1990). There are hardly any natural deserts. Desertification leads directly to soil degradation which make it difficult for any type of trees, shrubs, grasses or crops to grow and leads to increased soil erosion mostly by wind and some times by water.

* **Paper presented in National Workshop on Combating Desertification in Pakistan, April 5-7, 1994, National Agricultural Research Centre, Islamabad, Pakistan.**

More than 70 % area in Pakistan is arid receiving less than 250 mm. Another 18 % receives 250 to 500 mm annual rainfall and is therefore, semi-arid. A major portion of the population in the country e. g. more than 70 percent, which is mostly rural population, depends upon arid and semi-arid land resources for its livelihood through agricultural and pastoral activities as well as for energy for cooking and heating. In this tract, agriculture is practised under both rain-fed and irrigated conditions for growing crops and fodder. This tract also supports extensive tree growth on the farmlands. There is tremendous human and cattle pressure on this fragile ecosystem. Consequently, desertification is affecting about 60 percent of the area of Pakistan in arid and semi-arid parts of the country. The main deserts of Pakistan cover an area of about 10.3 million ha; and include Thal, Cholistan, Tharparkar, Makran, Kharan and Kohistan deserts. There are also some cold deserts in the northern hilly regions of the country. These deserts covering vast areas provide an opportunity for development for the purpose of human settlement to meet the challenges of growing needs of increasing human and livestock population for food, fibre, feed and fuelwood.

The characteristics of desert environment are: low soil fertility, high evapotranspiration due to extreme temperatures, high wind velocity, erratic and low precipitation, salinity, depleted ground water, scanty vegetal cover due to cutting and uprooting of trees for fuelwood and fodder, overgrazing of herbaceous vegetation, reduction in the species diversity and sand dune formation. Revegetation is the only way to reverse or halt desertification, increase biodiversity, meet the energy crisis and reduce the problem of land limitation for human settlement.

Dry afforestation techniques

Any tree planting established with natural rainfall and without the help of artificial irrigation may be termed as dry afforestation. Soon after the establishment of provincial forest departments in the Indo-Pakistan subcontinent, the extent and gravity of deforestation in the arid and semiarid areas was realised and dry afforestation activities were started in different parts of the subcontinent. A number of techniques were evolved for this purpose in thirties and forties. Initially, emphasis was placed on afforestation of semiarid areas in the northern and north-eastern submontane parts of the country in which deforestation had caused widespread soil erosion due to fairly high but erratic and high intensity summer monsoon rainfall causing hardships for local people. It was not only that fertile top soil was lost as a result of water erosion, but considerable damage was caused to life, property and means of communication by the annually recurring floods. These activities of dry afforestation are continued till today as the job was never completed and private land owners were not trained and motivated to continue this activity on their own after the completion of a programme. The programmes of afforestation were generally limited in scope, patchy, scattered and lacked continuity and sustainability. A number of government departments and agencies have been preparing and executing these programmes in the past without any effective coordination among them. Therefore, no significant progress was achieved with regards to arresting deforestation and increasing afforestation. The problem is not only with us today but istead has aggravated over a period of time due to increase in human and cattle population. The official executing agencies included provincial forestry, agriculture and soil conservation departments and authorities established in Sindh and Punjab to develop arid and desert areas.

Review of dry afforestation programmes

In Balochistan, sand dune stabilization was started in 1954 in Mastung valley. About 5,600 ha. area was stabilized by planting *Tamarix gallica, Arundo donax*, and *Calligonum polygonoides*. In the coastal areas of Pasni, Gwadar and Pishukan, the Forest Department started planting of sand dunes with *Prosopis juliflora* with irrigation with brackish water in 1970. But the job was not completed by them due to paucity of resources. Later, it was taken up by the Navy and local municipal authorities to protect the ports and towns from moving sand dunes. In other parts of Balochistan, work on rehablitation of of rangelands and ground water recharge was udertaken through different development projects by the Forest Department. One of the earliest range management project in Pakistan in Maslakh over 4800 ha. which was started in 1957. Protection and range improvement works were continued in this area for 10 years. In 1984, World Bank assisted were started in Balochistan province for ground water recharge in Quetta valley, Karkhasa watershed, Maslakh and Gadabar area in Loralai district. The main activities at these sites are contour trenches, percolation ditches, check dams and dry afforestation.

Afforestation in Thal desert in Punjab was started in 1950 with the creation of Thal Development Authority. *Calligonum polygonoides, Tamarix aphylla* and *Zizyphus maurtiana* were planted with one or two hand waterings. Dryland afforestation on sand dunes and interdunal flats was carried out in 1964 at Dagarkotli and Chubara. The planting was undertaken during monsoon, wthin 24 hours of the first shower. The plants were raised in baked earthen tubes, 25 cm. long and 11 cm. diameter and open at both ends. *Prosopis cineraria* and *Zizyphus naurtiana* were planted without removing earthen tubes. Range reseeding and tuft planting of *Cenchrus ciliaris* and *Lasiurus hirsutus* were successfully carried out on flats and sand dunes. In 1969, the cover percent of palatable vegetation was 25 and 3 in Dagarkotli in developed and undeveloped areas respectively. The Sindh Arid Zone Development Authority and Forest Development are also engaged in dryland afforestation for some years. Their extent of activities is however, not known.

Afforestation in arid and semi-arid zones is generally accomplished by pit and trench planting or sowing, with or without hand watering. A number of water conservation and harvesting techniques have been used for dry afforestation in arid and semi-arid zones of the world. No systematic research was conducted in Pakistan on the use of water conservation/harvesting techniques for dryland afforestation till 1980. The Pakistan Forest Institute stated research in desertified areas to determine effective dryland afforestation techniques in the 1980's with the financial assistance programme of PL-480/Pakistan Agricultural Research Council and USAID Forestry Planning and Development Project. These research studies aimed at maximum utilization of rain water to ensure the availability of soil moisture to the plants for a longer period of time to enhance survival and growth. These were laid out in arid and semiarid arid areas in Dagarkotli, Bhabarband, D.I.Khan and Kharian. The following techniques were investigated:

Dryland afforestation techniques

1. Drip irrigation
2. Rain water conservation/harvesting

3. Mulching
4. Deep planting
5. Water conservation and soil amelioration
6. Pitcher irrigation

Rakh Dagarkotli is located at 31°-33' North latitude and 71°-07' East longitude. The sand dunes are oriented NW-SE. The summer temperatures may rise to 45°C. The frost is common in winter season. About 60% of the 200 mm annual rainfall occurs during summer monsoon season. A number of research studies were laid out in pasture 13-A from 1980-86. Twenty five multipurpose tree species (indigenous and exotic) were planted on sand dunes and inter-dunal flats, using different conservation and planting techniques. Their results are summarised below:

Drip irrigation on sand dunes: *Acacia nilotica, Acacia tortilis, Acacia elata, Tecoma undulata, Acacia victoriae, Tamarix aphylla* were planted, using drip irrigation technique. Water was taped through a hand pump in a G.I. sheet drum of 45 gallons capacity placed at dune top. A G.I. pipe of 10 cm diameter was used to take water from the drum. The plastic pipes were connected through nozzles to the plants. Planting was done at 2x2 meters spacing in pits. Thirty plants of each species were planted in a replication using split plot design in 1982. Frequency of water application was scheduled at 10, 20 and 30 days.

Survival height and diameter data recorded in May 1993 showed that sand dune stabilization with multipurpose tree species can be achieved using drip irrigation with 30 days time interval.

Table 1: Growth performance of multipurpose tree species in 30 days drip irrigation frequency at Dagarkotli.

Tree species	Survival %	Average height (meters)	Average diameter(dbh) (cm)
Acacia tortilis	75	6.5	10.6
Acacia modesta	65	2.5	2.9
Tecoma undulata	65	1.4	2.6
Acacia elata	70	5.9	9.5
Acacia nilotica	72	6.0	9.0

Water conservation/harvesting techniques: Rainwater harvesting/ conservation techniques were compared with pit and surface planting in 1980 to raise multipurpose tree species at Dagarkotli and Bhabarband.

1. Roaded catchment, one meter slope (1:3) with a trench 0.3 meter deep.
2. Roaded catchment, one meter slope (1:3) without trench.
3. Trench 0.3 meter wide and 0.3 meter deep.
4. Pits 0.3 meter deep with 0.3 meter diameter.
5. Surface planting (control).

The study was laid out in split plot design using four replications. Four plants of each tree

species were planted at one meter spacing. Growth data recorded (Table 2) in April 1993 showed that roaded catchment and roaded catchment with trench techniques enhanced survival, height and diameter (dbh) growth appreciably of tree species.

Table 2: Growth performance of multipurpose tree species under various water conservation/ harvesting techniques in 1993.

Parameter	*Acacia albida*	*A. aneura*	*A. tortilis*	*A. modesta*	*A. victoriae*	*Prosopis cineraria*	*Tecoma undualta*	*Parkinsonia sp.*	Average for treatment
Surface Planting									
Survival out of 16 plants.	8	5	10	12	10	11	14	4	9
Height (meters)	2.2	4.2	5.4	3.0	3.5	3.0	3.3	3.4	3.5
Dia meter (cm)	4.5	3.9	4.5	3.9	5.5	5.3	5.6	3.3	5.2
Pit planting									
Survival	10	6	7	16	10	12	15	1	9
Height(m)	3.3	3.8	5.7	3.5	4.3	3.6	3.2	3.9	3.9
Dia(cm)	8.1	3.8	11.0	4.3	7.1	5.3	6.4	3.3	6.2
Trench planting									
Survival	14	8	12	14	5	12	13	2	10
Height(H)	5.2	3.8	5.7	3.7	4.0	3.6	3.3	3.9	4.2
Dia (cm)	9.4	2.9	12.2	4.9	4.6	5.9	5.5	3.6	6.3
Roaded catchment and trench planting									
Survival	13	4	8	12	2	11	15	7	9
Height(m)	4.9	4.4	5.8	3.4	5.1	3.0	3.5	3.3	4.2
Dia (cm)	9.8	2.9	11.7	4.4	5.1	5.9	6.1	3.2	6.2
Roaded catchment planting									
Survival	14	7	12	16	5	12	16	7	11
Height(H)	5.3	3.5	6.1	3.8	4.2	4.6	3.1	2.9	4.2
Dia(cm)	10.8	2.6	12.2	5.1	6.9	8.5	5.1	2.8	6.8

Continued

The average survival, height and diameter of all the species increased substantially in roaded catchment water conservation technique compared to conventional pit planting.

Effect of mulching on survival and growth of tree species; This experiment was laid out in March 1980, using split plot design with five replications. Eight plants of each of *Acacia modesta and Acacia tortilis* were planted. Plastic apron, pitched stone and grass cover were used for mulching in the pits. Growth data recorded in May 1993 showed that survival, height and diameter at breast height (Table 3) of tree species enhanced appreciably, by plastic mulching.

Table 3 : Growth performance of tree species under various mulches in May 1993 at Dagar Kotli

Mulches	Acacia modesta			**Acacia tortilis**		
	Survival out of 8 Plants	Average height (meters)	Average diameter (cm)	Survival out of 8 plants	Average height (meters)	Average diameter (cm)
Grass	5	2.1	3.2	2	5.4	9.8
Control	5	2.1	3.4	3	6.2	10.8
Store	5	2.0	3.0	2	5.0	8.5
Plastic	7	2.4	3.4	3	6.1	11.2

Effect of depth of planting on the establishment of tree species:This study was laid out in split plot design using 6 replications in July 1980. Twenty five plants of each species were planted in each depth of planting in a replication at 2x2 meter spacing. The plants were planted at 30 cm and 18 cm depth in the pits of 0.5 meter diameter. Growth data recorded in May 1993, showed no appreciable difference in the deep and shallow planting depths (Table 4).

Table 4: Growth performance of tree species under shallow and deep planting depth in May 1993 at Dagarkotli.

Species	Deep Planting (30 cm)			**Shallow planting** (18 cm)		
	Survival %	Ht. (m)	Dia (cm)	Survival %	Height (m)	Dia (cm)
Acacia aneura	16	2.4	4.1	8	2.0	3.1
Acacia Tortilis	56	5.2	10.2	48	5.5	9.63
Tecoma undulata	44	2.75	3.78	28	2.7	3.28

Provenance trial of Acacia nilotica on inter-dunal flats: Eleven provenances of *Acacia nilotica* from India and Pakistan were lanted in RCB design with 4 replication in July,1984. Thirty six plants of each provenance were planted in a plot at a spacing of 3x3 meter in roaded catchment. The provenance from Haryana, India exhibited best survival and height at Dagarokotli in April 1992 (Table 5).

Table 5: Growth data of *Acacia nilotica* provenances at Dagarkotli in April,1992.

Species prove-nance	Source	Survival (Percent)	Ave. height (meters)	Ave. dia (cm)
Acacia nilotica	S-3 Maharashter India	70	5.5	9.0
	S-1 U.P. India	70	2.6	5.9
	S-4 Utarperdes India	48	3.3	5.9
	S-6 Maharashter India	46	3.3	5.9
	S-5 Haryana India	80	7.6	12.0
	S-2 Maharashter India	44	3.1	6.5
	S-10 Patoki Pakistan	59	5.5	10.0
	S-7 Muzafargarh Pakistan	73	5.2	8.5
	S-9 D.G. Khan Pakistan	36	3.3	8.1
	S-11 Gadani Pakistan	47	4.5	7.4
	S-8 Dargai Pakistan	75	4.9	10.5

Biomass determination: The biomass of tree species/provenances growing under different experiments in roaded catchments was measured in 1988. Thirty trees of *Acacia nilotica*, 8 of *Acacia albida*, 12 of *Acacia tortilis* and 9 of *Prosopis cineraria* were felled to the ground level. The green biomass of the entire above ground parts of each tree was recorded. The height (m) and diameter (cm) at breast height were recorded for each tree. Airdrying weight was recorded after airdrying each tree for 3 months.

Table 6: Biomass of different tree species (planted in 1980) at Dagarkotli in 1988

Species	Diameter (cm)		Height (m)		Total biomass (kg)	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
Acacia nilotica	12.6	6.7	6.9	4.5	70	11
Prosopis cineraria	11.1	4.1	5.5	3.6	34	4
Acacia albida	19.7	6.0	9.6	5.0	184	9
Acacia tortilis	19.7	6.0	9.6	5.0	253	7

Bhabarbund Sind: The area is a part of Kirthar, Kohistan tract at a distance of about 79 km. from Karachi along Karachi- Hyderabad Supper Highway at 25°-07' North latitude and 68°-40' East longitude. Soil is formed of lime stone. The texture of surface soil is sandy loam. Summer temperature may reach 40°C. Summer monsoon contribute to the precipitation. Average annual rainfall ranges from 150-200 mm. 15 multipurpose tree species were planted with various planting and moisture conservation techniques. Deep planting and shallow planting techniques were used to raise the tree species. The preliminary results recorded on survival and height showed that survival and height of tree species can be appreciably enhanced by deep (30 cm depth) planting, mulching and roaded catchment and roaded catchment with trench (Table 7 & 8).

Table 7: Survival and height of multipurpose tree species at Bhabarbund, Sind in 1984.

Species	Deep planting (30 cm)	Shallow planting (18 cm)
	Survival %	
Aacacia aneura	30	30
A. tortilis	66	45
Tecoma undulata	60	35
A. modesta	47	43
	Average height(cm)	
A. aneura	102	79
A. tortilis	298	290
Tecoma undulata	156	104
A. modesta	45	52

Table 8: Growth performance of multipurpose tree species under various water conservation/harvesting techniques in 1984.

Species	Treatments									
	Roaded catchment		Roaded catchment with trench		Trench		Pits		Surface planting	
	Survival (%)	Height(cm)	Survival(%)	Height (cm)	Survival (%)	Height(cm)	Survival (%)	Height (cm)	Survival(%)	Height (cm)
Acacia modesta	67	45	92	54	92	58	75	31	83	42
A. tortilis	92	72	100	72	75	104	92	86	80	62
A. victoriae	92	62	100	61	92	34	80	51	80	56
Prosopis cineraria	58	44	75	40	58	72	80	32	92	23
Tecoma undulata	58	42	92	54	66	38	50	23	50	27
Ave. for treatment	74	53	92	56	77	61	75	45	77	42

Rainwater conservation/harvesting and soil amelioration technique for dry afforestation at D.I.Khan.

This research study was laid out at Ratta Kulachi (D.I.Khan) for afforestation of *Acacia nilotica* in clayey soil under barani conditions in August 1992, using RCB design with 4 replications. Twenty, one year tubed plants were planted in each treatment. The treatments were roaded catchment with simple pits, roaded catchment with soil amelioration (pits were refilled with soil, organic matter and sand in 1:1:1 ratio) individual basins and traditional pits. Data recorded in December 1993 indicated that water conservation and soil amelioration techniques enhanced the survival and growth substantially as compared with pit planting (Table 9).

Table 9: Effect of water conservation/harvesting and soil amelioration on survival, height and dia meter of *Acacia nilotica* at D.I. Khan.

Treatment	Survival %	Height meters	Dia-meter cm. (0.3 meter from ground)
Roaded catchment and soil amelioration	86	2.17	4.6
Roaded catchment	95	2.2	4.7
Individual basin	97	2.32	4.9
Pits	81	1.41	2.5

Kharian

A research study was laidout in 1988, at Kharian which is in semiarid zone with 550 mm annual rainfall. A split plot design with 3 replications was used. Twenty plants of each multipurpose tree species were planted in a plot. The water conservation techniques were V-shaped microcatchments, gradonii, conservation trenches and conventional pit planting. Survival and height data (1991) showed a substantial increase in survival and height of plants (Table 10).

Table 10: Survival and height of plants under various, water conservation techniques at Kharian in 1991.

Water conservation techniques	Species							
	E.camaldulensis		L.leucocephala		A. nilotica		Acacia modesta	
	Survival %	Ht. (cm)	Survival %	Ht. (cm)	Survival %	Ht. (cm)	Survival %	Ht. (cm)
Conservation trenches	72	206	65	172	45	108	36	48
Micro catchments	55	169	65	168	40	132	39	59
Gradonii	38	177	62	189	48	135	40	49
Simple pits	25	59	59	122	23	60	26	46

Future action programme

A. Development

The forest department of the provinces should undertake dryland afforestation programme by creation of new dryland afforestation divisions as the project based activities do not make significant impact on combating desertification.

The dry zone afforestation techniques developed by research institutions should be adopted by the forest departments as these are effective and cheaper method of afforestation.

Extension service should be created to introduce the afforestation techniques as well as the suitable tree species for each region to the farmers for planting on the private land.

Seed orchards of successful exotic and indigenous tree species be established in each ecological zone for regular supply of seed for raising nurseries for large scale afforestation programme in dry zone area.

B. Research and training

The successful research experience in dry afforestation of P.F.I. and PARC may be

replicated in other areas with different edaphic and climatic conditions.

Establish the seed orchards of the successful multipurpose tree species for their extensive introduction in dry zone area.

Continuation of introduction trial of exotic tree species and their improvement.

Preparation of pamphlets on dryzone afforestation for distribution to extension workers and farmers.

Training of forest department staff in dryland afforestation techniques.

REFERENCES

1. Ashraf, M. Mirza and G. Akbar 1989. Status of Desertifiction in Pakistan- A review Pakistan J. For. 39: 79-87.
2. Britannica, 1990. Micropaedia, Ready Reference Vol. 4. 15 edition Encyclop[illegible] Britannica Inc. London.
3. Hussain, W.R. and M.I. Sheikh, 1986. Final Technical Report. To develop techniques for utilizing Arid and Semi-arid lands through planting under dry conditions. Pak. Forest Institute, Peshawar.
4. Hussain, W.R. 1989. Modelling for Determination of Biomass of *Acacia nilotica, Acacia albida, Acacia tortilis* and *Prosopis cineraria* in Arid areas. Pakistan Jour. Forestry; 39: 183-198.
5. Kust, G.S. 1992. Decertification Assessment and mapping in the Pre- Aral region. United Nations Environment Programme (UNEP). Desertification Control Bulletin 21:38-43.
6. Sheikh, M.I. 1986. Afforestation of Arid and Semi-arid Areas in Pakistan. Field Document 13.
7. Shah, B.H. 1990. Efficacy of water conservation Techniques for the Afforestation of watersheds in the Scrub Zone of Pakistan. Pakistan Jour. Forestry 40: 278-286.
8. Pakistan Forest Institute, Peshawar 1993. Annual Progress Report 1992-93.
9. U.N., 1977. The Decertification problem in (AIIP) Afghanistan, India, Iran and Pakistan. In proceedings United Nations Conference on Decertification.