Agroforestry Research Messages For Farmers And Forest Officials

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TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

Cutting of forest and growing of crop is a very old practice all over the world. Traditionally and historically forestry and agriculture are looked upon as competitive and not complementary activities. The ecological system is currently under great stress owing to growing pressure of human and livestock population on the one hand and acute shortage of food, fuel and fodder on the other. This has forced the people to change their attitude towards the exploitation of the ecological system. In the present time, integration of forestry with agriculture can only solve the problem.

The aim of agro-forestry practice is to optimise positive interactions between various biological components like tree/shrubs and crops/animals and between there components and the physical environment so as to obtain higher, more diversified and more sustainable production system from the available land resources than is possible with other from of land use under the prevailing ecological and socio-economics conditions. Farmers of different parts of the world are practising agroforestry since time immemorial, but they never accepts an imposed technology. Our latest technology in the field of agroforestry can only be accepted by the farmers, provided our extension workers work along with farmers to examine requirements of the farmers and accordingly tested models/designs are modified.

NEED OF RESEARCH IN AGROFORESTRY

In the present decade research work on different components of agroforestry systems are in progress in Agricultural universities and ICAR regional research stations. However, more emphasis on on-station research needs to be given in each agroclimatic zone, to develop demonstration models at district level, so that farmers can be motivated and trained after demonstration at the research station.

Once scientists are satisfied with their model design only then technology should be transferred to the farmers field in collaboration with farmers and extension workers. After implementation of programme extension worker should analyze the percentage adoptability and constraints faced by the farmers etc. and if required model should be modified as per farmer's need. Under this condition transferred technology will create permanent impact over the villagers and programme will be a success.

In general research on agroforestry will help in knowing.

* How and which trees and crops can be grown better than what they are growing now (Under agroforestry systems in specific biophysical condition)

* Which agroforestry system will be more economical.

* Which system will improve the productivity of site and can maintain the fertility status of soil and reduce the soil erosion problems and conserve more moisture.

* Identification and evaluation of multipurpose tree species having deep root system, nitrogen fixing ability, coppicing ability and nutritions palatable leaves for each agroclimatic zone.

* To study the best design for rehabilitation of hill slopes, with maximum soil conservation and increase in water retention capacity.

* To establish the simplest design/model under agroforestry system (e.g. Alley cropping etc.) which may be followed by the farmers with maximum efforts.

* To study the role of mycorrhiza and non symbiotic nitrogen fixing bacteria in relation to the productivity of crops and trees under agroforestry system.

* How can control the salinity and waterloges conditions in farmers land.

WHICH TYPE OF RESEARCH FARMER CAN ACCEPT

Farmers of different parts of the world are practising agroforestry since time immemorial. Mostly agroforestry research is conducted in the agricultural experimentation centres, but generally the results of the experimental stations remain unused or one should say that newly proposed models tested in on-station trial are not accepted by the farmers. Farmers never accept an imposed technology. Under above condition impact remains for short period. Our latest technology in the field of agroforestry can only be accepted by the farmers,

provided our extension workers work alongwith farmers to examine requirement of the farmers and accordingly tested models/designs are modified. If scientist/extension worker follows all steps during transfer of on-station model to farmers field (on farm trial), the farmers acceptance of the model as a continuing feature on long term basis can be ensured. During the last ten or more years most of the agroforestry research had been conducted under controlled condition.

MORE EMPHASIS ON ON-FARM RESEARCH TRIAL

* To test on-station design in the different edaphic and psycho-socio-economic condition of farmers.

* Modification in on-farm trial/design as per psycho-socio-economic and biophysical constraints of the farmers and introduction of modified model by the farmers under supervision of scientist/extension workers. This will create desired socio-economic impacts on the farmers life. These village laboratories will be a continuous features on long term basis.

* To study the psycho-socio-economic condition and pattern of migration to the remote forest area or migration to urban areas, by the farmers before and after implementation of agroforestry models.

CHAPTER-II

RESESARCH ON TREE/CROP INTERFERENCES IN INDIA

2.1 AGROFORESTRY RESEARCH IN CHOTA NAGPUR PLATEAU OF BIHAR

This study was conducted in Kumbaria village of Chotanagpur Platueau of Bihar. In this site silvipastoral system was introduced by the participants in 1984. Farmers started harvesting grass from 1986. The tree species planted were teak (*Tectona grandis*) Gamhar (*Gamelina arborea*) Sissoo (*Dalbergia sissoo*), *Acacia auriculiformis*. The spacing was 4 x 3, 4 x 4 m and grass species grown was cenchrus. On an average farmers harvested 4.0 t/ha fodder in the year 1987 and 4.1 t/ha in the year 1989. Maximum average height was recorded in *Acacia auriculiformis* and minimum in teak. In 1989, the plots were handed over to the farmers. In 1989, the farmers up rooted, burned root slips of grasses and started growing cash crop. Introduction of Silvipastoral trial improved the soil fertility so much crop cultivation was possible. Change in the nutrient status encouraged farmers to grow cash crop alongwith tree species, the farmers also harvested 150 trees for timber and fuel wood and replanted the site by new seedling in 1989.

Message

Silvipastoral is the best system near the foothills of Pakistan. The farmers should plant teak, Gamhar, Sissoo and *Acacia auriculiformis* along with grass species cenchrus having space 4x3, 4 x 4m in these areas. This system will improve the soil fertility and nutrient status which increase the per ac re yield of cash crop and the income of the farmers.

2.2 Effect of tree roots on associated agricultural crops

Singh and Dangal (1974) had studied the effect of roots on associated agricultural crops. They dug a 15m x 1m trench along the field bouldery of a 15 year old plantation of Dalbergia sissoo and *Acacia nilotica* planted on peripheral bunds of cotton and tobacco fields and evaluated the crop yields. In this semi-arid situation elimination of D. Sissoo roots from the crop-root zone increases the yield of cotton from 956 kg ha. to 4056 kg ha by pruning the roots of the *Acacia nilotica*. However, Dadhwal and Narain (1984) did not find any significant

effect from trenching along eucalyptus rows on maize under high rain fall conditions.

2.3 Silvopastoral system on a bouldery river bed.

Vishwanathan and Joshie (1980) successfully utilized the bouldery river beds in Dehra Dun by raising *Dalbergia sissoo* and Acacia catechu trees in conjunction with Chrysopogan Fulvus and Eulaliopsis binata grasses. The yield from such a system over a period of 19 years is given in table 1.

Message

Farmers should plant the tree species with grass on a bouldery riverbed. *Dalbergia sissoo* and *Acacia catechu* with *chrysopogon* fulvus and *Eulaliopsis binata* are the suitable species having space 9.15 x 9.15 and 4.55 x 4.55 m respectively. This system will increase the yield of both species.

Table-1: Yield from a silvopastoral system on a bouldery riverbed.

Treatment	Yield
Dalbergia sissoo (9.15 x 9.15) + *Chrysopogon fulvus*	64.0 t wood ha^{-1} 5.5 t grass ha^{-1} yr^{-1} (average of 17 years)
Acacia catechu (4.55 x 4.55m) + *Eulaliopsis binata*	71.3 t wood ha^{-1} 5.3 t grass ha^{-1} yr^{-1}

Source: Vishwanathan and Joshie, 1980

2.4 Effect of poplar on yield of crop in High-Hill moist temperature Zone (above 1600m)

This study was carried out in High Hill moist temperature zone by Gupta in 1983. in this experiment Agricultural crop were raised between 5-7 years old populous deltoid trees planted at 5m x 3m, 5m x 4 m, 5mx 5m spacings.

The yield of all crops except raya decline in combination with poplar. The decline was more at closer spacing of poplar (Anonymous, 1987, 1988, 1989 a, b).

Table-2: Yield of crop (kg/ha) in field planted with poplar.

Poplar Spacing	Wheat	Lentil	Gram	Soybeen	Cowpea	Sun flower	Mustard	Raya
No	623	556	440	722	613	540	200	120
Poplar 5mx3m	348	148	128	183	105	100	87	97
5mx4m	355	122	346	191	123	119	112	122
5mx5m	493	168	364	223	112	144	167	259

Ref. Anonymous, (1987, 1988, 1989 a,b).

Message

Raya alongwith poplar deltoidei ~~in~~ is the best combination in High Hill Moist temperature zone. Therefore, farmers should plant Raya and poplar deltuider, having space 5m x 5m.

2.5 Shelterbelts at Jodhpur Research Farm.

CHAPTER-III

RESEARCH ON TREE/CROP INTERFERENCE IN PAKISTAN

Part-A Research on Shelterbelts and Agricultural crop

Shelterbelts are wide strips of trees, shrubs and grasses planted in rows raised at right angles to the wind direction to reflect air currants, reduce wind velocity and give general protection to roads, canals and agricultural fields. Woody stem branches and thick foliage help reduce wind hazards.

Studies have been conducted in different ecological zones of the country towards the positive and negative effects of trees, Such as *Dalbergia sissoo, Acacia nilotica, Eucalyptus camaldulensis* and Poplar on the yield of Agriculture crops (wheats, cotton, sugar cane).

3.1 Effect of shelterbelt on yield of wheat at Mastung Valley

This experiment was carried out at Mastung in Baluchistan by Rehman in 1978 to study the effect of shelterbelts on yield of wheat. *Tamarix gallica*, formed first row *T. gallica* and *Arundo donax* the second and *T. Gallica, Aroundo donax* and *Calligonum polygonoides* the third leaving 21 m between the rows where wheat was sown. The grain yields obtained from each plot of 21 x 15 m under different treatments is shown in Table-3.

Table-3 Yield of grains (kg/ha) in shelterbelt system

Replication	Control	One row	Two row	Three row
1	2089	2171	2359	2273
2	2067	2213	2314	2321
3	2013	2327	2352	2340
4	1911	2225	2365	2314
5	2076	2127	2390	2327
Average/ha	2031	2213	2356	2314

Message

Farmers of Mastung Valley should plant tree species along with agricultural crops on their land in the following manners:

Ist row *Tamarix gallica*,
2nd row *T.gallica, Aroundo donax*
3rd row, *T.gallica, A. donax*, call: *gonum polygonoides*
Agricultural crop = wheat
Spacing = ?
This shelterbelt will give more yield of grains than control.

3.2 Shelterbelts at Jodhpur Research Farm.

Three shelterbelts were planted on sandy soils at the Jodhpur Research Farm in 1973. Belts had 3 rows of trees each and spacing between and within rows was 3 m. They were laid out perpendicular to the wind direction. The length of each belt was 300 m and they were spaced 165 m apart centre to centre. The outside rows were made up of 33 plants each of a) *Acacia tortilis* b) *Prosopis Juliflora* (Israel variety) and c) *Cassia siamea* on either side of the belts randomly in the pattern abc, bca and cab. The centre rows were planted with *Azadirachta indica*, *Albizzia lebbek* and *Eucalyptus camaldulensis*, respectively in the Ist, 2nd and 3rd shelterbelts.

The shelterbelts were easily established and grew well. Grain yield of bajra (*Pennisetum americanum*) sown between the belts increased with distance from them reaching a maximum at 25 m belt height and then declining. Average yield between the belts was higher than in control plots. *Acacia tortilis* were more effective in reducing wind speed than those of *P. juliflora.*

Message

should

Farmers of Jodhpur showed plant tree species along agricultural crop on sandy soil in the following manner:

Ist row = *Acacia tortilis* or *Cassia Siamea*
2nd row = *Azadirachta indica* or *Eucalyptus camaldulensis*
3rd row = *Acacia tortilis* or *Cassia siamea*
Agricultural crop = Bajra
Spacing = ?

Direction = Perpendicular to wind direction

Belts of C.Siamea and *Acacia tortilis* will reduce the wind speed and also increase the yield of Bajra.

3.3 Effect of Shelterbelt (*Dalbergia sissoo*) on yield of wheat crop at Samtia

This research was carried out on Ghulam Raza Farm at Samtia. In this the wheat was sown between 7 years old *Dalbergia sissoo* rows, planted 60 m apart and 3 m in row spacing. The yield of wheat at different distances from shelterbelt is shown in Table-4. Maximum yield was obtained between 15-30 m from the wind break.

Table-4 Yield of wheat at different distance from shelterbelt.

Distance from wind break(m)	Yield obtained tonnes/ha
0-1	2.07
1-3	2.50
3-5	2.97
5-10	3.47
10-15	3.60
15-20	4.75
20-25	4.42
25-30	4.40
30-35	3.80
35-40	3.72
40-45	3.65
50-55	3.77
55-57	3.17
57-58	3.07
59-60	2.35
Average:	3.47

Message

The farmers of Samtia should plant Shelterbelts of *Dalbergia sissoo* along a wheat crop in the following manners.

Tree species = ~~7 year old~~ *Dalfergia sissoo*

Optimum distance from tree = 15-30 m

Direction = wind direction

3.4 Effect of Windbreaks (Trees rows) on the yield of wheat

This study was carried out at various place in Peshawar and Mardan districts. The studies were as follows:

3.4.1 Research on shelterbelt of hybrid poplar with wheat in Khata Kurnna.

Location	Khata Kuruna	
Date of sampling	17-5-1975.	
Description of tree rows:	Species	Hybrid Poplar
	Av. height of trees.	13.8 meters
	Direction of Belt.	North East-South West.
	No. of rows	1
	Spacing of trees	75 cm

Table-5 Yield of wheat in shelterbelt of hybrid poplar

Distance from tree row (meters)	Height of crop (Cms)	No. of plants per quadrat	No. of ears	Average length of ears (Cms)	Yield per quadrat (qm)
5	63	9	18	6.5	15.2
10	70	9	24	7.2	17.0
15	70	10	25	6.5	19.1
20	70	17	33	7.2	25.0
25	70	9	23	7.3	19.8

Message

Farmers of Khata Kurnna should plant Hybrid Poplar with wheat crop on their land in the following manners.

Tree SPP	-	Hybrid poplar
Crop	-	Wheat
Spacing	-	20 m from tree row
Direction	-	North East-South West

3.4.2 Research on shelterbelt of poplar nigra with wheat in Risalpur Civil Bazar

Location	Risalpur Civil Bazar	
Date of sampling	16-5-1975	
Description of tree row	Species	Poplar nigra
	Av.height of trees.	11 meters
	Direction of belt	East - west
	No. of Rows	1
	Spacing of Trees	90 C.M.

Table-6 Yield of wheat in shelterbelt of poplar nigra

Distance from tree row (meters)	Height of crop (Cms)	No. of plants per quadrat	No. of ears	Average length of ears (Cms)	Yield per quadrat (gm)
5	70	6	27	8.7	35.8
10	65	6	16	8.1	22.8
15	68	8	29	8.5	38.8
20	70	12	35	7.0	38.7
25	72	8	20	8.6	26.0

Message

Farmers should plant shelterbelt of poplar nigra along wheat in Risalpur Civil Bazar in following manners.

Tree species	=	Poplar nigra
Crop	=	wheat
Direction of belt	=	East-West
Spacing	=	15-20 m

3.4.3 Research on hybrid poplar with wheat in Sardar Gari

Location	Sardar Gari	
Date of sampling	16-5-1975	
Description of tree row	Species	Hybrid Poplar
	Av.height of trees.	15.8 meter

Direction of belt	North-South
No. of Rows	1
Spacing of Trees	60 Cms.

Table-7 Yield of wheat in shelterbelt of hybrid poplar

Distance from tree row (meters)	Height of crop (Cms)	No. of plants per quadrat	No. of ears	Average length of ears (Cms)	Yield per quadrat (qm)
5	64	16	16	5.1	9.8
10	72	11	19	6.8	21.0
15	98	14	53	8.1	56.6
20	79	15	27	6.9	25.8

Message

Farmers of Sardar Gari should plant shelterbelt of Hybrid Poplar with wheat in their land in following manners.

Tree Species	=	Hybrid poplar
Crop	=	Wheat
Direction of Belt	=	North - South
Spacing	=	15 m from tree rows

3.4.4 Research on willow with wheat in Shah Daud

Location	Shah Daud	
Date of sampling	16-5-1975	
Description of tree row	Species	Willow
	Av.height of trees.	8.7 meter
	Direction of belt	North-west
	No. of Rows	2
	Spacing of Trees	1 meter

Table-8 Yield of wheat in shelterbelt of willow

Distance from tree row (meters)	Height of crop (Cms)	No. of plants per quadrat	No. of ears	Average length of ears (Cms)	Yield per quadrat (qm)
5	70	26	36	6.3	27.9
10	70	18	30	7.2	30.1
15	73	24	37	7.3	37.7
20	73	19	36	7.0	38.8
25	73	20	38	6.8	32.0

Message

Farmers of Shah Daud should plant shelterbelt of willow with wheat on their land in following manners.

Tree Species	=	willow
Crop	=	Wheat
Direction of Belt	=	North - west
Spacing	=	15-20 m

3.4.5 Research on hybrid poplar with wheat in Buchai

Location	Buchai (Near Dairy Farm)	
Date of sampling	17-5-1975	
Description of tree row	Species	Hybrid Poplar
	Av.height of trees.	7.8 meter
	Direction of belt	East-west
	No. of Rows	1
	Spacing of Trees	1 meter

Table-9 Yield of wheat in shelterbelt of hybrid poplar

Distance from tree row (meters)	Height of crop (Cms)	No. of plants per quadrat	No. of ears	Average length of ears (Cms)	Yield per quadrat (qm)
5	78	15	30	6.7	31.7
10	80	14	27	7.3	35.5
15	75	19	38	6.8	36.8

Message

Farmers of Buchai should plant shelterbelt of willow with wheat on their land in following manners.

Tree Species	=	Hybrid poplar
Crop	=	Wheat
Spacing	=	10-15 m
Direction of Belt	=	East - west

3.4.6 Research on hybrid poplar with wheat in Amazo Gari

Location	Amazo Gari	
Date of sampling	17-5-1975	
Description of tree row	Species	Hybrid Poplar
	Av.height of trees.	11.1 meter
	Direction of belt	East-west
	No. of Rows	1
	Spacing of Trees	30 Cms.

Table-10 Yield of wheat in shelterbelt of hybrid poplar

Distance from tree row (meters)	Height of crop (Cms)	No. of plants per quadrat	No. of ears	Average length of ears (Cms)	Yield per quadrat (gm)
5	83	6	31	7.8	25.8
10	90	8	42	7.3	38.4
15	85	6	42	7.5	32.4
20	90	7	32	7.2	28.2

Message

Farmers of Amazo Gari should plant shelterbelt of hybrid poplar with wheat on their land in following manners.

Tree Species	=	Hybrid poplar
Crop	=	Wheat
Spacing	=	10-15 m
Direction of Belt	=	East - west

This system will give more yield of wheat having spacing 10-15 m.

3.5 Tree rows of Shisham and Simal with wheat in Chichawatni

This study was carried out at Chichawatni during 1986 under irrigation condition to assess the effect of tree windbreaks of Shisham and Simal on the yield of wheat crop. In this experiment a row of eight years old Simal (*Bombex ceiba*) tree with a length of 35 meters and oriented east-west along water channel was selected to study it influence on the yield of wheat crop. The tree planted 3 m apart, had an average height of 1 mm and average dbh 40 Cm. The farm was canal irrigated. Wheat variety WL-711 was sown in December, 1985 with seed at 85 Kgs per ha. DAP, 2.5 bags (50 kgs per bag) per ha. at the time of seed bed preparation and 6.25 bags (50 Kg per bag) of Urea per ha. with subsequent irrigation after sowing were applied. Overall five irrigated were given.

The average gain yield from sample of four transects has been tabulated in table. The average yield data at different points from the windbreak has been plotted graphically in fig. alongwith average control yield.

Data tabulated shows that the trees had depressed the yields of wheat upto a distance of 8.5 m on northern side of the windbreak. However, beyond this distance increase in yield can be seen in comparison to control. On the other side there is no effect of tree shade on the yield of wheat crop on the southern side of the windbreak.

In addition to this it has been observed that the yield on the northern side is less than on the southern side. This is because the windbreak was oriented east-west and wheat on northern side received less light and heat during ripening season as compared to southern side.

Table-11 Yield of wheat at various distance on southern side of the Simal tree row.

Distance from the tree row to sample plot (m)	Av. yield in qms/m^2	Projected average yield in kgs/ha	Projected difference from control in Kgs/ha
2	442.50	4425.00	+ 375.00
6	433.75	4337.50	+ 287.50
10	416.25	4162.50	+ 112.50
14	401.25	4012.50	- 37.50
18	418.25	4187.50	+ 137.50

Table-12 Yield of wheat at various distance on Northern side of the Simal tree row

Distance from the tree row to sample plot (m)	Av. yield in qms/m^2	Projected average yield in kgs/ha	Projected difference from control in Kgs/ha
0.5	285.00	2850.00	- 1200.00
4.5	307.50	3075.00	- 975.00
8.5	388.75	3887.50	- 162.50
12.5	416.25	4162.50	+ 112.50
16.5	417.50	4175.00	+ 125.00

Message

Farmers of Chichawatni should plant trees rows of Simal along wheat on their land under irrigated condition in the following manners:

Tree Species	=	8-years old Simal
Crop	=	Wheat
Spacing	=	No effect of tree shade
Direction of Belt	=	East - west

Effect of Shisham on Yield of Wheat.

On this farm effect of single row of Shisham (*Dalbergia sissoo*) trees on the yield of wheat crop was studied. Average height of the tree was 13 m with average (dbh) 13 Cm. Age of the Shisham trees was six years. Length of windbreak was 36 m with north-south orientation and tree to tree distance was 2.5 m.

WL-711 wheat variety was sown in December, 1985 using seed at 85 kgs/ha by broadcast methods. At the time of seed bed preparation 2½ bags (50 kgs each) of fertilizer per ha was added. On the whole seven irrigations were given to the crop.

Yield of wheat from control was recorded and estimated at 3200 kgs/ha. Average yield of respective sample plots in all transects has ben tabulated in table alongwith projected difference from the control. The projected average yield data at different points from the windbreak has been plotted graphically in fig alongwith average control yield.

It is obvious from the tabulated data that the maximum negative effect of Shisham tree is at 1.5 m distance from the windbreak. At 13.5 m distance, the grain yield is more as compared to control.

Table-13 Yield of wheat at different distance on the western side of the Shisham tree row.

Distance from the tree row to sample plot (m)	Av. yield in gms/m²	Projected average yield in kgs/ha	Projected difference from control in Kgs/ha
1.5	243	2430	- 770
4.5	323	3230	- 30
7.5	359	3590	+ 396
10.5	330	3300	+ 100
13.5	349	3490	+ 290

Message

Farmers of Chichawatni should plant shelterbelt of Shisham along wheat on their land under irrigated conditions in the following manners.

Tree Species	=	Singe row of Shisham
Crop	=	Wheat
Spacing	=	7.5-13.5 m
Direction of Belt	=	North-south orientation.

3.6 Effect of *Acacia nilotica* on wheat crop in village Bheaky District Sialkot.

This study was carried out in village Bheaky, District Sialkot. Forty Five trees of *Acacia nilotica* were selected to determine their effect on wheat crop. All the trees varied in diameter and height and were on the Southern side of the wheat field. The trees were divided into seven diameter classes i.e.

D1	=	20 - 24.9 cm.
D2	=	25 - 29.9 cm.
D3	=	30 - 34.9 cm.
D4	=	35 - 39.9 cm.
D5	=	40 - 44.9 cm.
D6	=	45 - 49.9 cm.
D7	=	50 - 55.9 cm.

Effect of *Acacia nilotica* on crop height was significant. Similarly the tree size did not have any significant effect on crop height. The reduction in biomass and grain yield was noted upto 11 meters from the tree trunks.

As far as economics is concerned, total loss of grain yield and wheat bhoosa yield was Rs. 359/ha during crop growing period of six months. Where as income from trees was Rs. 1071/- hence net profit was Rs. 712/- per hectare.

Message

Farmers should plant shelterbelt of Acacia nilotica along wheat crop in Bheaky village District Sialkot in the following manners.

Tree Species	=	Acacia nilotica
Crop	=	Wheat
Spacing	=	11 meters from tree trunks.
Direction of Belt	=	Wind direction.

Although this system decrease the yield of wheat but net profit is more than loss of grain yield.

3.7 Effect of Eucalyptus tree orientation on the yield (q/ha) of maize

Distance from tree line(m)	Direction		Average	Direction		Average
	North 1987 yield	South 1988 (q/ha)		East 1987 yield	West 1988 (q/ha)	
0 - 2	27.5	16.8	22.1	30.0	15.9	22.9
2 - 4	28.0	20.8	24.4	30.0	15.9	23.3
4 - 6	30.0	17.6	23.8	29.9	15.2	22.5
6 - 8	29.6	23.5	26.5	30.5	24.6	27.5
8 - 10	29.4	21.4	25.4	30.9	25.4	28.1

Eucalyptus height crown dia (cm) and DBH (cm) were not effected significantly with the planting aspect of tree (1987 to 1988)

Message

Farmers should plant shelterbelt of Eucalyptus along with maize on their land in the following manners

Tree	-	Eucalyptus
Crop	-	Maize
Direction	-	North-South, East-west
Spacing	-	8-10 m.

PART B STUDY ON TREE/CROP INTERFERENCES

3.8 Effect of Acacia nilotica on the growth and the yield of intercrops.

Treatment	No. of plants per plot	Plant height (cm)	Yield (q/ha)		Gross returns
Moong (Local)	766	74	1.29	19.11	1513
Moong (K-851)	750	60	3.47	14.02	2727
Bajra (Local)	640	210	18.59	50.78	3734
Bajra (RCB-2)	626	218	16.23	53.05	3381

Table shows that highest gross return results was obtain when Bajra (Local) was taken as intercropped with *Acacia nilotica*.

Message

Farmers should plant *Acacia nilotica* in agricultural crop on their land Bajra (Local) is the best to be intercropped ~~will~~ with *Acacia nilotica*. This will give more gross returns.

3.9 Effect of *Dalbergia sissoo* on the growth and yield of intercrop.

Treatment	No. of plants per plot	Plant height (cm)	Yield (q/ha)		Gross returns
Moong (Local)	730	51	3.61	11.85	2901
Moong (K-851)	753	41	4.81	11.20	3718
Bajra (Local)	616	210	15.51	50.66	3689
Bajra (RCB-2)	608	213	12.29	53.15	3048

Table shows that Moong (K-81) and Bajra (Local) were good intercropped with *Dalbergia sissoo*.

Message

Farmers should plant *Dalbergia sissoo* in agriculture crop on their land. Moong (K-851) and Bajra (Local) are the best intercropped with *Dalbergia sissoo*. The yield of above two crop will increase when planted with *Dalbergia sissoo*.

3.10 Effect of single Shisham tree on wheat crop.

Distance	Decrease in yield %age.
10'	30.88 %
15'	23.60 %
20'	12.70 %

The decrease in yield %age was compared with the yield in the centre of field. The yield decrease in narrow strip e.g. 6'-10' width. Overall increase in yield was 15% to 45%.

Message

Farmers should plant Shisham in agricultural crop on their land. Wheat is best intercropped with *Dalbergia Sissoo*. Tree species will increase the yield of agriculture crop.

3.11 Effect of Forest Tree Species on the ground vegetation at Pabbi Forest Kharian.

In this context, observation were made on %age cover and Forage production of ground vegetation (grasses) under four year old plantations. *Eucalyptus camaldulensis, Acacia nilotica* and *Leucaena leucocephala* had a greater allelopathic effect on the growth of ground vegetation (grasses) under them than *Ziziphus mauritania, Acacia nilotica, Dalbergia sissoo* and *Albizzia lebbek.*

The cover was lowest (8.25%) under Eucalyptus and highest (83%) under *Ziziphus mauritania.* The cover under *Acacia modesta, Dalbergia sissoo, Albizzia lebbek, Acacia nilotica* and *L. leucocephala* was 64, 60, 53, 29 and 16% respectively. Forage production data showed the same trend (4675, 4050, 3200, 2450, 1775, 775 and 662 kg/ha) in the plots planted with *Ziziphus mauritania, Acacia modesta, Dalbergia sissoo, Albizia lebbek, Acacia nilotica* and *L. leucocephala* and *E. Camaldulensis* respectively.

Message

Farmers should plant *Ziziphus mauritiania, Acacia modesta, Dalbergia sissoo* and *Albizia lebbek* in Pabbi hills around Kharian, because these trees have more cover and will increase the forage production.

3.12 Effect of Shisham (*Dalbergia sissoo*) Trees on the yield of wheat

This study was carried out in village Satrah District Sialkot to determine the effect of Shisham on the yield of wheat crop.

For this study 50 trees of *Dalbergia sissoo* at village Satrah were selected to see the tree effect on wheat crop. Al trees varied in diameter and height and were on the southern side of the field. The trees were divided into seven diameter classes i.e. D1 = 15-19.9 cm, D2 = 20 - 24.9, D3 = 25-29.9 Cm, D4 = 30-34.9 cms, D5= 35-39.9 cm, D6= 40-44.9 cms, D7= 45-49.9 cm. The wheat variety Pak-81 was sown on November 14, 1987. A basal dose of fertilizer 140 kg nitrogen, 100 kg P_2O_5/ha in the farm of Urea and single super phosphate, respectively was applied. All P_2O_5 and half of nitrogen was applied at the time of sowing. While subsequently nitrogen was applied with second irrigation. Four irrigations were applied during entire growing period of the crop.

The data of Table-1 for wheat crop hight shows that although the crop height is directly related to the distance from tree trunk. The average crop height increased from 91 cms to 95.6 cms upto a distance of 11.0 meters from the tree trunks the height remain constant at further distance indicating that the trees did not have any effect beyond 11.0 meters distance. Data also indicated that tree size did not have any effect on crop height.

Message

Farmers should plant *Dalbergia sissoo* in their agriculture crop. Wheat Pak-81 is the best intercropped with *Dalbergia sissoo* in Satrah village District Sialkot. Trees will increase the height of wheat crop ~~having spacing~~ at a distance of 11 meter away from tree trunk.

Table-14 Effect of distance from tree on wheat crop Height, Biomass and grain yield.

Distance from tree (m)	Average crop height (cm)	Average biomass yield (gm)	Average grain yield (gm)
1.0	91.0	380.2	173.5
3.5	92.4	524.2	236.7
6.0	94.1	598.1	275.7
8.5	95.2	790.9	360.8
11.0	95.6	804.4	366.3
Control	95.5	740.7	362.2

3.13 Poplar in Agroforestry Systems

This study was carried out at PFRI Research Centre during 1990-91.

An experiment with spacing of 1.5 x 6.1 m, 1.5 x 9.2 m, 1.5 x 12.2 m for poplar was designed in 1990 and laid out during February, 1991 in the Research Garden PFRI, Faisalabad. The distance between poplar rows was kept 6.1 m, 9.2 m, and 12.2 m, whereas distance from plant to plant within the rows was 1.5 m in all the treatments. Poplar plant was planted during February 1991. Maize crop was raised for fodder during Kharif 1991. It was followed by wheat crop during Rabi season.

The data regarding maize fodder is given in following table.

Table-15 Yield of maize fodder intercropped with poplar.

Sr.No.	Poplar				
	Treatments Poplar Spacing	Yield in Kg/ha			Gross returns. Rs.
		1991	1992	1993	
1.	1.5 x 6.1 m	23654	13504	10402	10128
2.	1.5 x 9.2 m	23654	14934	18774	13842
3.	1.5 12.2 m	27220	13669	23210	15330

The above yield figure shows that during first two years various poplar spacings did not have any effect on the yield of maize fodder. However during the 3rd year the effect of various poplar spacing on the yield of maize fodder is apparent.

Wheat crop

Two crop wheat were raised and data regarding grain and straw-yield were collected. The grain yield dat is given in Table-16. The figures of wheat yield indicate that different spacings of poplar have not affected the grain yield of wheat, because of fact that poplar trees are leafless during the period when wheat is intercropped with it. Wheat crop could be grown with poplar upto 4th, 5th and 6th year of the poplar age.

Table-16 Yield of wheat grain intercropped with Poplar

Sr.No.	Treatment poplar spacing	Grain yield in Kg/ha			Gross return (Rs.)
		1991	1992	1993	
1	1.5m x 6.1m	-	2883	2356	19718
2	1.5m x 9.2m	-	2177	2384	17346
3	1.5m x 12.2m	-	2695	2302	18816

Message

Farmer of Gutwala (Faisalabad) should plant poplar with agriculture crop on their land. The maize and wheat is the best intercropped with poplar. The optimum distance require for poplar and maize is 1.5 x 12.2 m, but for wheat different spacings of poplar ~~have no effect on yield of wheat~~ can be adopted according to the value of agri crop compared to tree crop.

3.14 Effect of Forest trees on the yield of Agricultural crops.

To study the effect of forest trees on the yield of agricultural crops grain with them, *Dalbergia sissoo*, *Euc. citriodora*, *Populous deltoides* 63/51 and *Bombax ceiba* were planted in the Pakistan Forest Institute in January and February 1978. The trees were planted at 4.3 x 4.3 m spacing with entire plants of poplar and Eucalyptus and root-shoot of shisham and simal.

On 22-10-1979 the area was irrigated to prepare it for wheat sowing. On 5-11-1979 pavan variety of wheat was sown in drills 45 cm apart between the lines of trees. The drill next to the line of trees was 80 cm away from it. Seed rate was 135 kg/ha. Urea was applied on 4-12-1979 at the rate of 230 kg/ha. Two irrigations of 10 cm depth each were given to the crop on 4-12-1979 and 14-4-1980. From sowing to harvesting on 2-5-1980 240 mm rain was received.

At harvest the size range of the trees was as follows:

Species	Height (m)	Dbh (cm)
Eucalyptus	3 - 7	3 - 7
Poplar	6 - 10	6 - 12
Simal	2 - 3	6 - 10
Shisham	3 - 5	4 - 7

Taking each trees as the centre, wheat was harvested along one meter length in each of the four rows to the east and four rows to the west of the trees. The first row was 80 cm from the base of the tree, the second 125, the third 170 and the fourth 215. The cut material was dried in the sun for 3 days and grain was extracted from each lot by hand. The average yield in grams per 1 m line of wheat is summarized below for each species.

Table-17 Average yield in grams per 1m line of wheat

Species	Row-1		Row-2		Row-3		Row-4	
	E	W	E	W	E	W	E	W
Eucalyptus	129	160	114	124	128	135	113	131
Poplar	98	76	86	80	109	81	94	82
Simal	119	132	127	124	130	152	110	113
Shisham	170	151	130	145	125	143	137	148

No statistically significant difference was found in the yield of wheat at distance of 80 cm to 215 cm from the base of the tree.

Effect of tree species on yield of wheat

After taking the spot observation as mentioned above the wheat crop was harvested and threshed plot wise. The data are summarised below:-

Table 18 Yield of grain (kg/ha)

Replication	Eucalyptus	Simal	Shisham	Poplar
1	3,829	4,009	5,828	2,369
2	4,131	3,467	3,416	2,649
3	2,643	2,879	3,086	2,322
4	2,588	4,054	3,256	2,979
Average	3,298	3,602	3,896	2,705

Table-19 Yield of straw

Replication	Eucalyptus	Simal	Shisham	Poplar
1	3,829	4,009	5,828	2,869
2	4,131	3,467	3,416	2,649
3	2,643	2,879	3,086	2,322
4	2,588	4,054	3,256	2,979
Average	3,298	3,602	3,896	2,705

Message

Farmers should plant Simal and Shisham in their agriculture crop. Wheat is the best intercropped with above two tree species in Peshawar city. These will increase the yield of grain having spacing 80 cm to 215 cm.

3.15 Effect of shade of *Acacia nilotica* and *Dalbergia sissoo* on the yield of wheat

In this experiment five trees of *Acacia nilotica* and five *Dalbergia sissoo* were selected in two different localities in the country viz. Chichawatni and Change Manga. As far 95 possible trees of uniform height, diameter and crowns spread were selected as under:-

Name of the Species	Av.ht.(m)	Av.dia.(cm)	Av.Crown spread(m)
Acacia nilotica	15.3	53.3	13.2
Dalbergia sissoo	16.2	55.2	13.3

Taking each tree as a replication and its trunk as centre, circles of a radius of 2, 4, 6 and 9 meter were drawn in the wheat field (Variety Chenab-70). Sample were taken with a 0.1 m square frame at 8 fixed spots conforming to directions, E,W,N, S,NE NW, SE, and S,W.

Total and mean height of sample according to distance and direction are given in Table.

Table-20. Height of sample according to distance (gms)

Distance Replication	2 m	4 m	6 m	9 m
I	63.5	70.0	80.5	103.5
II	64.5	74.0	83.5	103.0
III	63.0	79.5	82.0	93.5
IV	67.5	79.5	83.5	95.0
V	73.0	83.5	88.0	96.5
Total	331.5	386.0	417.5	491.5
Mean	8.29	9.66	10.46	12.29

Effect of distance

As the distance of crop increase from the trees, so does the yield, control (9 m) has given the highest yield followed by sample taken at 6 m and 4 m which form one group. The lowest yield has been obtained from the nearest distance (2 m) and it is significant at 1% level.

Table-21 Height of samples according to direction (gms)

Direction(d) Replication	E	S	N	W	NE	NW	SE	SW
I	40.0	40.0	36.0	41.0	37.0	38.0	44.0	41.5
II	40.0	40.0	36.5	44.0	37.5	39.0	43.5	44.5
III	40.5	41.0	37.5	41.0	35.0	35.5	42.5	45.0
IV	39.0	40.5	39.0	43.5	38.0	39.0	46.0	40.5
V	42.5	44.0	39.5	45.0	40.0	37.0	46.5	46.5
Total	202.0	205.5	188.5	214.5	187.5	188.5	222.5	218.0
Mean	10.10	10.27	9.42	10.72	9.37	9.42	11.12	10.90

Effect of direction

The following groups exhibited highly significant (1%) level difference for the yield.

NE, N, NW
E, S
W, SW, SE

Plots due SE, SW and W of the trees have given the maximum yield followed by E and S and last NE, N, NW.

Message

Farmers should plant Acacia nilotica in agriculture crop on their land. Wheat variety Chenab is the best intercropped with Acacia nilotica in Chichawatni having spacing 9 m and direction SE, SW and W.

Dalbergia sissoo

Total and mean weight of sample according to distance and direction are given in Table.

Table-22 Height of sample according to distance (gms)

Distance Replication	2 m	4 m	6 m	9 m
I	93.0	97.5	127.0	140.0
II	93.0	100.0	130.5	143.0
III	96.0	102.5	137.5	145.0
IV	96.5	112.0	134.5	145.0
V	96.0	99.5	131.5	145.5
Total	474.5	511.5	661.0	719.0
Mean	11.86	12.79	16.52	17.97

Effect of Distance

The yield follows the same pattern as that of Acacia. It is progressively higher with the increase in distance from the tree. Acacia control (9 m) has given highest yield.

Table-23 Height of sample according to direction (gms)

Direction(d) Replication	E	W	N	S	NE	NW	SE	SW
I	60.0	60.0	51.0	62.0	54.5	50.0	60.0	59.0
II	58.5	59.0	52.5	64.0	53.0	51.5	64.0	64.0
III	60.0	61.0	54.5	67.0	56.5	55.5	64.0	62.5
IV	64.0	65.0	55.5	62.5	55.5	57.5	64.0	64.4
V	61.5	59.0	54.5	64.0	56.5	53.2	63.0	61.0
Total	304.0	304.0	268.0	319.5	276.0	267.5	316.0	311.0
Mean	15.20	15.20	13.40	15.97	13.80	13.37	15.80	15.55

Effect of direction

Sample taken from S, SE and SW direction have given the higher yield followed by W, and E which form the intermediate group. NE, N and NW have given the minimum yield (0.1) level.

Message

Farmers should plant *Dalbergia Sissoo* in their agriculture crop on their land. Wheat in the best to be intercrop with Dalbergia Sissoo in Changa Manga areas, having spacing 9 m and direction SE, SW and S. In these direction crop will give more yield.

3.16 Effect of Poplars on the yield of wheat at Changa Manga irrigated plantation.

In this study the Sonalika variety of wheat was sown in the second week of February 1983. The crop was fertilized at the rate of 5 bags of Urea/ha. The crop was canal irrigated. Sample of wheat were taken in a square quadrat (0.5-0.5) on all the 4 sides at the distance of 0.75, 1.75 and 2.75 m from the base of the selected trees.

The results indicate that effect of tree shade and competition of trees with wheat crop for water and nutrients is nil. Due to difficulty of soil working within about half a meter radius around the tree, germination of wheat was poor. This could be improved by ploughing close to the tree or working the area manually.

Table-24 The average grain yield (gms/0.25m^2) at respective distance on the four sides of tree.

Tree No.	Distance from the base of tree (m) with yield of grain			
	0.75	1.75	2.75	Total yield
1	91	83	107	281
2	89	97	94	280
3	83	88	76	247
4	85	80	58	223
5	54	71	59	184
6	62	91	83	236
7	84	77	104	256
8	68	71	84	223
9	82	72	65	219
10	92	86	87	265
11	84	94	77	253
Total	874	910	894	2678
Average	79.5	82.7	81.3	81.2

The average yield of grains per 0.25m^2 quadrat comes to 81.2 gms when converts to hectare and acre basis it is 32.5 quintals per ha/or 35.2 mds per acre.

The total yield of grains from the study area 1.192 hectares (2.944 acres) is reported 3400 kg (85 x 40). Since effective area of wheat crop excluding blanks species is 1.15 hectare (2.840 acres), the average yield turned out to be 2957 kg per hectare (32.1 per acre).

Message

Farmer should plant poplar in agriculture crop on their land. Wheat is the best intercropped with poplar in irrigated plantation of Changa Manga. The effect of tree shade on wheat crop is nil. Therefore poplar can be planted at any spacing in wheat crop.

CHAPTER-IV

AGROFORESTRY RESEARCH ON SALT AFFECTED SOIL

With the development of technologies for reclamation of salt affected soils, the importance of Agroforestry research of salt affected soil has also been enhanced. Productivity of 952 million ha in the world is reduced by high soil salinity and alkalinity (Szaboks 1977). These soils are spread mainly in the arid, semi-arid and in the coastal regions. Salt affected soils are mainly of two types i.e. saline and alkaline soils. Saline soil exist mostly in areas having less than 500 mm annum rainfall adversely affect the plant growth due to the presence of excessive soluble salts like chlorides and sulphate of sodium, calcium and magnesium. Many crops and trees are however known to tolerate much higher concentrations of these salts.

4.1 Crop Cultivation on reclaimed alkali soil.

The technology evolved at CSSRI, Karnal and other Institutes includes land levelling, soil amendments with gypsum/pyrite etc. and then growing crops. The profitable crop rotation is rice-wheat. By following different steps, the farmers in seven villages (Kachhwa, Saqqer, Sambhil, Bir-haraina, Guddha, Begampur and Dadlana) under operational Research Project in Karnal district were able to get 45 Q/ha rice on demonstration plots set up in highly deteriorated alkali soils having pH values more than 10.2 and EC (1:2) values of 2.6 dS m^{-1} (Mehta & Mondal, 1988). Even in the initial years they were able to get 30 Q/ha of rice in the amended areas other than the demonstration plots. Farmers were able to get 12 to 20 Q/ha of wheat also in the Ist year after reclamation. The yields progressively increased due to continuous improvements of the soil brought about the cropping and irrigation. A survey conducted on 20 farmers fields revealed that rice yield increased steadily and got stabilized at about 60 Q/ha. Wheat yields stabilized about 30 Q/ha. There is still possibilities of wheat yield increase.

4.2 Eucalyptus Plantation on Reclaimed Alkali Soils

Once the alkali soils were reclaimed, the farmers were encouraged to plant tree like Eucalyptus near tubewells, on field bunds and even in blocks.

S. Darshan Singh had studies in the village who had reclaimed his 4 ha of alkali land in 1975 by gypsum application. He got good crop fields and in 1981 planted 0.4 ha land under Eucalyptus. During this period soil surface pH was reduced to 8.7. A total of 600 trees were planted without any gypsum application. Periodic height and girth observations revealed satisfactory growth. During the initial three years berseem crop (*Trifolium alexandrines*) was grown during winter in between the eucalyptus plantings. This was sold at Rs. 2500/- per ha. In forth year, earthing was done so as to provide support and avoid dislodging of trees during rains. This blocks plantation was sold outright for Rs. 35,000/- or say Rs. 97,500 per ha in December, 1989 and the field was cleared in January 1990. At that time the rate of eucalyptus by weight was Rs. 35 per quintal. The field was cleared from roots as well by the purchaser. There was some income from the loppings and fallen trees in between also. Total detail of income and expenses in Eucalyptus are presented in Table. the main findings were:

* The net economic returns from rice plus wheat crop were Rs. 3800/- to 4400/- per ha per annum. The total net returns were Rs. 35750/- during 1981-90. After adding interest @ 10 percent it amounted to Rs. 53946. Thus the net returns per annum were Rs. 5472 per ha. On the other hand the net returns from Eucalyptus were Rs. 4263 per ha per annum which were less than that of crop cultivation. However, the farmers invested Rs. 7050 ha in the first year and continued to invest Rs. 3000 to 4800 upto 8th year. It appears expenditure after 3rd year was incurred on berseem which was sold at a loss (Rs. 2500/- ha). Further, no attempt was made to utilize coppice shoots after first harvesting on the purchaser dug out the root portion as well. These explain the apparent loss compared to crops.

* The economic returns from crop production were regular i.e.; after every six months, whereas in case of Eucalyptus the returns were mainly at the end of nine years though two coppice crop at shorter rotation should have been taken.

* There were adverse effects of Eucalyptus on the nearby crops after four years of growth.

Table-25 Comparative net economic returns from crop cultivation and Eucalyptus planting on a semi-reclaimed alkali field in village Kachhwa during 1981-90

Year	Grain Yield Q/ha Rice	Wheat	Net returns Rs./ha	Expense on Eucalyptus berseem growing Rs./ha	Loss due to Eucalyptus on adjacent crops Rs./ha	Returns from sale of Eucalyptus and berseem Rs./ha
1981-82	59	27	3800	7050	-	2500
1982-83	58	29	3800	4700	-	2500
1983-84	57	30	3850	4700	-	2500
1984-85	60	30	4000	4900	-	-
1985-86	56	32	3800	4800	380	1000
1986-87	54	30	3900	4700	400	-
1987-88	57	30	4100	4000	550	-
1988-89	56	30	4300	3800	660	-
1989-90	55	31	4400	3000	960	87500
			35750	41650	2950	96000
Interest upto 1990			18196	23876	485	11326
			53946	65526	3435	107326
	After deducting expenses & loss to crops					38365
	Net returns Rs./ha/annum 5472					4263

Message

Farmers should apply the technology which evolved at CSSRI, Karnal includes land levelling, soil amendments will gypsum/Pyrite on the alkali soil having pH values more than 10.2. Then they should grow rice and wheat.

Farmers can plant Eucalyptus and berseem on there alkali soil because these reduce the pH value of soils and increase the net returns.

Avoiding Adverse effects of Eucalyptus

As the adverse effects were due to shade, moisture and nutrient depletion following remedial measures are suggested (Mehta and Mondal 1988).

* Eucalyptus planting on field bounds should be in North South direction so as to minimise shade effect.

* Water channel should be providing along the trees rows for trees to get sufficient moisture.

* Additional dose of fertilizers should be applied near the tree row so that crops do not suffer due to competition from the trees.

* The distance between tree to tree should be more than two meter.

4.3 Agroforestry On saline soils.

In India, systematic research on reclamation of saline soil has been carried out only in the recent years and accordingly very limited work on agroforestry has been done. Saline occur in more than 4 million ha of land mainly in the arid and semi-arid areas in the states of Gujrat, Rajastan, Andhra Pradesh and Bihar, Haryana, Punjab, Karnataka, Maharashtra, Modhya Pradesh and Uttar Pradesh.

The problem of soil salinity in arid and semi-arid regions is so varied that different combination of amendment measures have to be adopted which may be as follows:-

1. Problems:
   Soil Saline, water table deep and canal water available.

   Solution
   Leaching will help to push the salts downward. Crops requiring excessive irrigation like sugar cane and rice should not be grown as it can raise water table and create further waterlogging and salinity problem.

2. Problem

Soil Saline, water table deep and ground water brackish and canal water absent.

Solution

Salt tolerant trees, bushes, or crops should be grown keeping in view the amount and distribution of rain fall. Some of the important tree species tolerant to salinity are *P. juliflora, Acacia nilotica, Tamarix sp; Casuarina equisetifolia* and *Eucalyptus camaldulensis.*

3. Problem

Soil saline and water logged. Water table fluctuating within 0 to 3 meters. Canal water available in plenty.

Solution

Salt tolerant and waterlogging crops like rice and sugar cane may be grown. Check up ground water and if found suitable, use it though tubewell which will over down the water table to some extent. Open or pipe drains may be required to drain out the excessive salts and water but due consideration should be accorded to the problem of disposal of drained out water and socio-economic aspects. If disposal problem is there the area may be put under trees like *Prosopis, Acacia, Eucalyptus* etc. depending upon severity of the salinity problem.

4. Problem

Soil saline and waterlogged. Canal water available only in small quantity.

Solution

Grow salt tolerant trees shrubs by using limited quantity of canal water for establishing the trees/shrubs. For this, sub-surface method of planting may be adopted with advantage. The pit is kept 40 cm dia at the top and 30 cm dia at bottom and 20 cm deep. Planting at the end of August or early September are more suitable. Frequent irrigation helps in high survival and better growth.

4.4 Effect of *Acacia nilotica* on Salt Concentration under Saline Soils

Tree has great potential in reclaiming saline soils which was evident from the studies conducted at CSSRI Research Farm Sample during 1987-88. ***Acacia nilotica*** were planted on the saline soil in 1984. During 1987-88 soil samples from 0-15 cm soil depth at 15 cm interval were takes during different months both from the Acacia field as well as from the adjacent barren field where no trees were planted. It was observed that:

* Salt concentration was less in all the layers in Acacia planted fields as compared to the barren saline field. At the soil surface (0-15 cm) the salt concentration was reduced to half or 1/4th. During March it was 18.5 dS m^{-1} in Acacia field. Similar was the trend in other months also.

* Moisture content was almost static in surface as well as deeper layers in case of barren field in all the months. It was lower in the upper 60 cm soil layer in Acacia field especially during the summer months of May and June which seems attributable to combined effect of evapo-transpiration.

Message

Tree has great potential in reclaiming saline soils. Therefore, farmer should plant different tree species in different situation of saline soils. Tree species suitable to saline areas are as follows:

- *Acacia nilotica*
- *P. Juliflora*
- *Tamarix sp.*
- *Casuarina equisetifolia*
- *Eucalyptus Camaldulensis*

Salt tolerant crop:

- Rice
- Sugarcane

CHAPTER-V

AGROFORESTRY IN THE ARID, SEMI ARID AND DRY-LAND

5.1 Agroforestry in the Arid Zones

The arid and semi-arid lands are characterized by hostile environmental conditions such as low and erratic rainfall, intense solar radiation and high wind velocity. During most of the year, the evapotranspiration far exceeds precipitation. The productivity potential of the land is also usually low. The soil are immature, structure less and very coarse in texture with low water holding capacity and poor nutrient status. Under such agroclimatic conditions, crop production is a gamble if not possible. Therefore, people in the arid parts of India depend mainly on livestock production for their sustenance. However, growing agricultural crops under the tree crops is also an age old tradition in this region.

Experiment No.1

A trial at CAZRI consisted of treatments with three levels of N (0, 20 and 40 kg/ha) and two level of P_2O_5, (0 and 20 kg/ha) and combinations of them on silvopastoral systems of *Prosopis cineraria*, *Acacia tortilis* and *Albizia lebbek*, along with five grasses, namely *Chrysopogon fulus*, *Cenchrus ciliaris* (CV Molopo, and 3108), *Sehima nuruosum* and *Cenchrus setigerus*. Fertilizer application improved grass production, but trees did not affect it. The maximum recorded dry-forage yield was in *C. fulus* with 40 kg/ha (5,200 kg/ha) as compared to the control (1,200 kg/ha). No significant effect of fertilizer was observed in the other three grasses.

Experiment No. 2

In another study reported by Muthana et al; (1985) it was observed that growth of *Acacia tortilis* was suppressed during the first three years when the tree seedlings were raised with cenchrus spp. After the third year the plants achieved a better growth rate indicating that the plants had, by then, developed a deeper root system and made the optimum use of the soil moisture. In addition to height, the collar diameter (CD), diameter at breast height (DBH) and clear bole length were also recorded. Although trees had no significant effect on grass production, CD and DBH of Acacia tortilis were depressed when grown with grasses, whereas clear bole length increased. This suggested that in the early stages when

there was competition with grasses the main shoot of the tree grew straight to get the maximum solar radiation. The economic analysis of this system revealed that a combination of tree with grasses would yield better returns in comparison with separate plots of trees and grasses.

Table-26 Mean annual height increment (cm) of *Acacia tortilis* seedlings when planted with and without grass (*Cenchrus ciliaris*)

Treatments	1978	1979	1980	1981	1982	1983	1984
S_1 G_1	32.4	56.2	67.2	74.1	62.0	74.4	23.1
S_1 G_1	14.6	60.1	67.3	95.0	68.9	69.2	19.2
S_1 G_0	60.7	129.5	114.6	43.5	66.3	34.8	15.2
S_2 G_0	31.3	198.3	108.4	58.2	54.4	48.4	23.1

Where S_1 = 10 x 5 m spacing of tree
S_2 = 10 x 10 m spacing of tree
G_0 = Trees without grass
G_1 = Trees with grass

Table-27 Economics of the Silvopastoral Systems with *A. Tortilis* seven years after establishment

Treatments	Fuel yield (q/ha)	Grass yield (q/ha)	Revenue (Rs.		
			Fuelwood	Grass	Total
S_1 G_0	60	-	3,000	-	3,000
S_2 G_0	32	-	1,600	-	1,600
S_1 G_1	50	55.8	2,500	1,395	3,895
S_2 G_1	28	52.9	1,400	1,323	2,793
Grass only	-	46.0	-	1,150	1,150

Source: Mothana et al; 1985

Message

In the arid and semi-arid areas of Pakistan the silvipastoral system is the best with the application of N and P_2O_5. Therefore, people of this areas should plant the following trees species and grass species on the land.

Tree species

Prosapis cineraria
Acacia tortilis
Albizia lebbek

Grass species

Chrysopogon fulus
Cenchrus ciliaris
Sehima nuruosun
Cenchrus setigerus

This system will give more return.

Experiment No. 3

Muthana and Arora (1977) studied the effect of *Holoptelia integrifolia* on crops of mung bean and cluster bean (guar) under different treatments.

a. Crops grown between rows of unlopped eight-year old trees.
b. Crops grown under lopped trees.
c. Control (crops without trees).

Under unlopped trees, the grain yield was low which indicated that shade had a negative effect on grain yield. Thus, lopping not only provided fodder for cattle but also enable the crops to give higher grain yields. In traditional land-use systems, it is a common practice to frequently harvest the foliage of *prosopis cineraria* and *Zizyphus nummularia* for fodder as well as higher grain yield.

Table-28 Grain yield (kg/ha) under lopped and unlopped eight-year old *Holoptilia integrifolia*

Species	Unlopped tree	Lopped tree	Crop without trees
Mung (Vigna mungo)	201.75	252.06	246.21
Guar (Cyamopsis tetragonoloba)	93.90	244.14	253.14

Experiment No. 4

In another study initiated in 1983, six-month old seedling of *Acacia albida* and *prosopis cineraria* were planted at 5x5 m, 5x10 m and 10x10 m distances, pearl millet, cluster bean and mung bean were planted in between the rows of trees. Pearl millet was discontinued after the first year. The results of grain production for three consecutive years revealed that *P. cineraria* did not interfere with grain production of mung and cluster bean, under different spacing treatments. However, during the third year "guar" yield was adversely affected when it was grown with *A. albida*. In the closer tree spacing the yield was reduced drastically; in wider tree spacing, the "guar" grain yield was 1,280 kg/ha, while in closer spacings it was down to 650 kg/ha (5x5 m) and 760 kg/ha (5x10 m). The yield reduction in closer spacings may perhaps be due to competition for moisture.

Table-29 Grain yield of mung and guar under different tree species 1983-85

Treatments	Mung (g/ha)			Guar (g/ha)		
	1983	1984	1985	1983	1984	1985
T_1 G_1	7.85	8.50	0.68	3.60	7.15	1.16
T_1 G_2	8.68	7.80	1.11	3.70	6.53	1.34
T_1 G_3	7.44	6.08	0.75	5.45	5.14	1.28
T_2 G_1	8.08	9.30	0.81	3.32	6.11	6.65
T_2 G_2	7.92	7.51	0.74	0.34	0.34	1.28
T_2 G_3	7.08	6.70	0.61	5.08	5.37	0.76
Crops without trees	6.40	7.30	1.06	3.20	6.41	0.95

Message

In the arid and semi-arid areas farmers should plant tree species with Agriculture crops in the following manners:

- *Holoptelia integrifolic* in combination with mungbean and cluster bean under lopped tree.
- *Acacia albida* and *Prosopis cineraria* with pearlmillet, cluster bean and mungbean.

5.2 Development of Agroforestry Model using Water Harvesting System in Semi-arid and Arid zones.

This study was laid out at Pabbi Forest, Kharian, District Gujrat. The experimental site has sandy loam soil supporting natural scrub vegetation with *Acacia modesta* as dominant species. Roaded catchments were prepared 30 meters in length and four meter wide cropping area. The treatments of the roaded catchments were two slope length viz. 5 meter and 4 meter and three slope gradient, 7%, 10% and 15%. The experimental design was split plot with slope length as major treatment and slope gradient as minor treatment. A total of 18 roaded catchments were prepared for the study. At both ends of catchments trenches of 0.4 cm. width and 30 cm. depth were dug out for planting *Eucalyptus camaldulensis*. The length of each trench was 14 m in case of catchments with 5 m slope length and 12 m long in catchments with 4 m slope length. From the center of the trench a metallic outlet was provided for collecting overflow into earthen dug out water tanks with a storing capacity of 4 cubic meter. As the outlet for outflow from cropping area was kept at 20 cm height above the flat cropping area, therefore, 10-20 cm depth of water is retained in the cropping area at each event of run off.

Crop production

Both winter and summer crops were grown in the cropping area. The summer crop was Mash while winter crops were Taramira and Sunflower. Mash crop cultivated during Summer 1991 was damaged by heavy rains and run off while Sunflower was cultivated during winter 1989-90 and Taramira production is presented in Table.

There was positive effect on Taramira production with the increase in slope length and gradient of the roaded catchment. The production of Taramira in cropping area with 7, 10 and 15% gradients was 500, 583 and 694 kg/ha respectively and it was 500, 513 and 652 kg/ha in plots with catchments having 4 m. slope length and similar gradients respectively. The production was only 383 kg/ha in the plots having no water harvesting system. The same trend was observed in case of Sunflower production. The production was 333, 533 and 733 Gram/plot in cropping area associated with catchments having 5 m slope length and 7, 10 and 15% gradients respectively. While the production in plots without water harvesting was only 200 kg/ha. The Mash production was 383, 458 and 500 kg/ha in cropping area of the catchment with 5 m slope length and having 7, 10 and 15% gradient respectively and it was 325, 375 and 450 kg/ha in the cropping area of

catchments having same gradient on 4 m slope lengths respectively. The plot without water harvesting had 225 kg/ha.

There is no significant difference in the crop production in different catchments with different slope gradients and length but it was significantly higher in them as compared to that in the plots without water harvesting.

Growth of Eucalyptus camaldulensis

The data on *E. camaldulensis* growth is presented in Table. The results show that *E. Camaldulensis* gave highly positive response to water harvesting system at Kharian. There was no significant difference in height and diameter growth of *E. camaldulensis* planted in catchments having different slope length and gradient because with every outflow from cropping area of each catchment, the trenches were filled up irrespective of treatments of slope length and gradients. The growth of seedlings planted with water harvesting was almost three times, than those planted without water harvesting system. Average height growth of plants at the age of 3.5 year planted in the trenches along the catchments having 5 m slope length and with 7, 10 and 15% gradients was 11.4, 10.8 and 11.2 meters with DBH of 15.3. 13.4 and 13.8 cm respectively. The average height and diameter at breast height of the tree planted along catchment having 4 m slope length and with 7, 10 and 15% gradient were 11.3, 11.6 and 12.2 meters and 13.5, 14.8 and 15.0 cm respectively. While the seedlings planted without water harvesting system in simple pits gained on average height of 3.2 m and 5.4 DBH.

The average growth rate of *E. camaldulensis* planted with water harvesting system was 3 m per year in height and 4 cm per year in diameter which is comparable with the growth rate of *E. camaldulensis* planted in irrigated plantation.

Table-30 Crop production cultivated in cropping area associated with different water harvesting treatments

A-Taramira (Exuca Sativa) kg/ha

Treatments	5 M - slope length			4 m - slope length			Control
	7%	10%	15%	7%	10%	15%	
R-I	0.5	7	8	6	6.5	7.5	4
R-II	5.5	7	9	6	6.0	8.0	5
R-III	6 0	7	8	6	6.0	8.0	5
Total	18.0	21	25	18	18.5	23.5	14
Average	6.0	7	8.33	6	6.16	7.83	4.6
Production/ha	500	583.3	694.14	500	513.13	652.47	383
B-Mash (kg/ha)							
R-I	400	500	550	325	400	450	215
R-II	400	425	450	300	325	400	250
R-III	350	450	500	350	400	500	210
Total	1150	1375	1500	975	1125	1350	675
Average	383	458	500	325	375	450	325
C-Sunflower (Grams/per plot)							
R-I	400	600	850	400	550	750	250
R-II	350	500	800	300	400	500	200
R-III	250	600	550	300	400	750	150
Total	1000	1600	2200	1000	1350	2000	600
Average	333	533	733	333	450	666	200

Message

In arid and semi-arid zone farmers should plant Eucalyptus and agriculture crop such as Sunflower, Taramira and Mash under water harvesting systems.

Under this system the yield of above crop increase as compared to control without water harvesting system.

5.3 Agroforestry system on dryland areas

Most of the dryland areas in the country as a whole and Rajasthan in particular are characterised as poor, degraded and marginal lands. Their productivity is low and depleting year by year due to lack of proper management of these lands. Arable cropping on these lands is non-remunerative. In addition to this a large part of the cultivable land is not suitable for arable farming. Rainfall pattern of most of these areas is erratic, uncertain and often untimely. Which results in frequent drought situation with failure of arable crops in drylands and even of grasses on unprotected and untreated grasslands.

For this, different experiments were laid out with major objectives of identifying the most suitable tree species for plantation in shallow-marginal lands for developing silvipastoral system.

Experiment No. 1

A long term field experiment was laid out at Agriculture Research Station, Arjia, Bhilwara during 1987-88 on silty loam soil having 8.2 pH, shallow depth (less than 25 cm), wasteland of the station left for grazing of animals. The treatment combinations included two soil moisture conservation methods i.e. i) bunding with mould bourd plough and (ii) chiselling in between two rows of trees and five forest trees species viz. *Eucalyptus spp. Acacia tortilis, Prosopis juliflora, Parkinsonia aculeate* and *Pithecellobiun dulce* planted at 5x3 m spacing in large sized plots of 24x10 m each plot was having 16 plants in two rows. The plantation was done in properly dug out pits of 60x60x60 cm size, which were filled with a recommended mixture of soil, F.Y.M; Gypsum and fertilizer. The plantation of all the tree species was done in July 1987 with the on set of rainy season. No irrigation was applied to the experiment. Naturally grown grasses were allowed to grow in the interspace. Annual data on grass yield in each plot and growth of trees in terms of height and collar girth were recorded.

Dry grass yield obtained under interspace of different tree species are presented in table. Show that the maximum near dry grass yield (based on 6 years data) of 2.87 t/ha was recorded in bunding treatment, which was 11.24 percent higher over chiselling treatment.

So far as effect of different soil moisture conservation treatments on growth of tree species is concerned, the growth was relatively higher in bunding treatment with a mean height and bottom girth of 480 and 29.7 cm respectively, as against 461 cm and 26.0 cm respectively in chiselling treatment.

Table-31 Combined results on dry grass yield (t/ha) under different tree species

Tree Species	Soil moisture conservation treatments													
	Bunding							Chiselling						
	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	Mean	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	Mean
Eucalyptus Spp.	3.3	2.3	1.0	2.88	2.75	3.1	2.56	2.3	3.1	1.3	3.6	2.9	2.7	2.6
Acacia tortilis	3.8	3.5	1.46	3.3	3.1	3.1	3.1	3.4	3.3	1.4	2.6	2.9	3.2	2.9
Prosopis juliflora	4.7	3.46	1.4	3.88	2.4	3.5	3.2	3.2	2.25	0.94	2.6	2.1	3.08	2.8
Pakinsonia aculeate	3.25	3.5	1.46	2.75	2.5	2.9	2.7	3.5	2.8	1.16	2.25	2.5	2.9	2.58
Pithecellobium dulce	2.5	3.25	1.35	3.2	2.75	3.46	2.75	2.65	2.46	1.0	2.1	3.50	3.77	2.67
Mean	3.5	3.2	1.1	3.2	2.7	3.2	2.81	2.9	2.8	1.1	2.6	2.8	3.1	-

Table-32 Cumulative growth of tree species at six years age (May 1993)

Tree Species	Soil moisture conservation treatments					
	Bunding		Chiselling		Mean	
	Height (cm)	TBG (cm)	Height (cm)	TBG (cm)	Height (cm)	TBG (cm)
Eucalyptus spp.	925	51.3	861	40.3	893	45.8
Acacia tortilis	526	29.7	431	24.4	478	32.0
Prosopis juliflora	286	20.3	335	28.5	310	24.4
Parkinsonian aculeate	350	17.0	352	16.9	351	17.0
Pithocellobium dulce	312	20.5	327	20.0	319	20.2
Mean	480	29.7	461	26.0		

TBG = Trunk bottom girth.

Experiment No. 2

The experiments were conducted in the natural grassland of the University. The site lies between 30° 51' N latitude and 70° 11' longitude and situated at an elevation of about 1300 m above m.s.l. under mid-hill conditions of H:P. The grasslands contain, Khair trees (*Acacia catechu*) of all sizes that are scattered over the whole area. To highlight the effect of individual Khair trees on the production of green grass, 50 trees of different sizes were randomly selected. Under each tree four directions, viz. N(360°), E(90°), S(180°) and W(270°) were marked with the help of prismatic campass and ranging rods. On each of these directions, five distances viz. 50 cm (T_1), 100 cm (T_2), 200 cm (T_3), 400 cm (T_4) and open area-away from tree (T_5) were selected at such a place where there was no effect of shade of tree. 1000 sample plots of 1x1 m size were laid out at these marked points and measurements were made for green grass yield. The data were statistically analysed from the observations recorded in the experiment.

The effect of distance from the Khair trees on green grass is presented in Table-33. It is evident that there is a significant effect on the tree canopy on the grass yield. Open area gave maximum yield (8.38 t/ha) followed by 400 cm away from Khair tree i.e; (8.22 t/ha) and lowest was recorded with 50 cm away from tree (7.72 t/ha).

Table-33 Effect of Khair tree on grass yield

Treatment (Distance from tree cm)	Green grass yield (t/ha)
50	7.22
100	7.26
200	8.03
400	8.22
Open area	8.38
C.D. 5%	0.86

Table-34 Effect of direction on grass yield

Treatment	Green grass yield (t/ha)
90^0 E	10.24
180^0 S	9.55
270^0 W	9.80
360^0 N	9.71
C.D. 5%	0.51

The effect of direction from Khair trees on grass yield is given in Table-34. There was a significant effect of the direction from tree on the green grass yield. Maximum green grass yield (10.2 t/ha) was obtained in east direction followed by west direction (9.55 t/ha). The lowest grass yield was found in south direction from Khair trees.

Message

In the marginal dry land area of Pakistan, people should plant trees species with grass species under bunding with mould bourd plough treatment. Tree species which are suitable in these areas are:

Eucalyptus spp.
Acacia tortilis
Prosopis juliflor
Parkinsonian aculeate
Pithecellobium dislce
Acacia catechin etc.

CONCLUSION

Agroforestry practice include short term cash crops and long term tree crops, the systems are expected to ensure steady income for subsistence farmers. Short term crops provide him his immediate need of food, fodder fuel etc. while tree crops when matured would give him financial benefit in couple of years later. Pimental et al. (1983) have reported much higher yield of agricultural crop when grown along with tree crops.

Different research are carried out on tree crop interference at different places, i.e. plain areas, saline area, sand dunes, marginal land and dry land etc. The results of which are as fallows:

Effect of shelter belts on crops.

Location	Tree species	crop	Direction	Appropriate distance from tree base	Effect
Khata Kuruna	Hybrid poplar	wheat	North-east South-west	20 m	Significant
Risalpur Civil Bazar	Poplar nigra	wheat	East-west	15-20 m	"
Sadar Gari	Hybrid poplar	wheat	North-south	15 m	"
Shah Daud	Willow	Wheat	North-west	15-20 m	"
Buchai	Hybrid poplar	wheat	East-west	15 m	"
Amazo Gari	Hybrid poplar	wheat	East-west	10 m	"
Chichawatni	Simal	wheat	East-west	8.5 m	"
"	Shisham	wheat	North-south	13.5 m	"
Samtia	Shisham	wheat	Wind direction	15-30 m	
Jodhpur Research Farm	*Acacia tortilis* *Prosopis Julifora* *Cassia siamca*	Bajra	Wind direction		"
Mastung in Baluchistan	*Tamarix gallica* *Arundo donax* *Calligonun polygonides*	wheat	wind direction		Significant

-	Eucalyptus	Maize	East-west North-south	8-10 m	"
High hill moist temperature zone	Poplar	Diff. crops	wind direction	5x5 m	Non significant
"	Poplar	Raya	"	5x5 m	Significant
Bheaky Sialkot	*Acacia nilotica*	wheat	East-west	11 m	On crop negative but net in positive
Satrah Sialkot	Shisham	wheat	East-west	11 m	Significant

Effect of trees on inter crops

Location	Tree	Crop	Appropriate distance	Effect
-	*Acacia nilotic*	Moong Bajra	-	Significant for A.nilotic and Bajra local
-	*Dalbergia sissoo*	Moong Bajra	-	Significant for Moong (K-81) Bajra local
-	Shisham	Wheat	10"	Significant
Pabbi hill Kharian	*Ziziphns mauritiana* *Acacia modesta*	Ground vegetation	-	Significant
PFRI	Poplar	Maize	1.5x12.2 m	Significant
PFRI	Poplar	Wheat	1.5x6.1 m	Significant
PFRI Peshawar	*Dalbergia* *Eucalyptus critriodor* *Poplus deltoides* *Bombex ceiba*	Wheat (Pavan)	80 cm - 215 cm	Significant for Shisham and Semal
Chichawatni Changa Manga	*Acacia nilotica*	Wheat (Chenab-70)	9 m	Significant for Se and SW direction
"	*Dalbergia sissoo*	"	9 m	Significant for S, Se, SW
Changa Manga	Poplars	Wheat (Sonalike)	0.75-2.75 m	Significant

Kumbaria-village in India	*Tectona Sissoo* *Acacia auriculiformis*	Grass cenchrus	4x3 4x4 m	Significant
Kumbaria village of Bihar	*Dalbergia sissoo* *Eucalyptus hybrid* *Gmeline arborea*	Gorrapoddy arhar	25 cm	significant

- Tree root of *Dalbergia sissoo* and *Acacia nilotic* have positive effect on cotton and tobacco.

- On a bouldery river bed farmer should raise *Dalbergia sissoo* and Acacia cotechu trees in conjunction with *Chrysopogon fulns* and *Eulaliopsis* binata gave more yield.

- Results shows that trees and crops have great potential in reclaiming saline soils. Technology evolved at CSSRI includes land levelling, soil amendments with gypsum/pyrite etc. increase the yield of rice and wheat.

- In Kachhwa village a semi-reclaimed alkali-soil the yield of Eucalyptus and berseem is significant.

- The studies conducted at CSSRI Research Farm shows that *Acacia nilotica* can reduce the salt concentration to half or 1/4th in soil layers.

- The experiment with treatment, three levels of N (0, 20 and 40 kg/ha) and two level of P_2O_5 (0 and 20 kg/ha) of CAZRI shows that silvapustoral system of *Prosopis cineraria Acacia tortilis* and *Albizia lebbek* along with *Chrysopogum fulus* is best.

- The economic analysis of *Acacia tortilis* with grass *Cenchrus ciliaris* revealed that a combination of tree with grasses would yield better returns in comparison with separate plots of trees and grasses in arid zone.

- Muthana and Arora had studied that the effect of *Holoptelia integrifolia* on crops of mungbean and cluster bean under lopped tree treatment is significant than unlopped tree and crop without trees, treatments.

- The study show that *P. Cineraria* did not interfere with grain production of mung and cluster bean, under different spacing treatments but guar

yield was adversely affected when it was grown with *A. albida.*

- The results show that Agriculture crops (such as Sunflower, Taramira and Mash) and *E. Camaldnlensis* gave highly positive response to water harvesting system in semi-arid and arid zone.

- The experiment at Agriculture Research Station Arjia, Bhilwara show that the growth of Eucalyputs, *Acacia tortilis* was relatively higher in banding treatment as against in chiselling treatment.

- The study shows that there is a significant effect of the Khair tree canopy on the grass yield in grass land of University. Direction of tree also have significant effect. Maximum green grass yield was obtained in east-direction.

LITERATURE CITED

1. Bhawan, K. (1987-89). All India Co-ordinated Research Project on Agroforestry. Biennial Reports (124).

2. Hafeez, S.M. and Mrs. Nighat Mansoor (996). Review of Agroforestry Research.

3. Hafeez, S.M. and M. Hafeezullah (1993). Suitable spacing for planting of poplar in agroforestry system. P.J.F. Vol-43 No.4.

4. Jha, L.K. (1995). Advance in Agroforestry.

5. Jha, L.K. and P.K. Sen Sarma. (1993). Agroforestry Indian Perspective.

6. Jafri, L.H., N. Hafeez, Naeem Hussain and M. Rafiq. (1991). Effect of trees rows on the yield of wheat. P.J.F. vol. 41 No. 3.

7. Khattak, G.M. and M.I. Sheikh (1980). Effect of forest trees on the yield of agricultural crops. P.J.F. Vol. 30 No.3.

8. Nair, P.K.R. (1986). Agroforestry. A decade of development.

9. Nair P.K.R. (1989). Agroforestry systems in the tropics. Vol.31.

10. Pathak, P.S. and M.M. Roy. (1994). Agroforestry systems for degraded lands Vol-2.

11. Rashid, W. and Muhammad Hafeez. (1991). Effect of shisham on the yield of wheat crop. P.J.F. Vol-41 No. 2.

12. Rehman, S. (1978). Effect of shelterbelts on yield of wheat - crop in Hastung (Baluchistan). P.J.F. Vol-23 No. 3.

13. Shah, B.H. (1992). Development of Agroforestry model using ater harvesting system in semi arid and arid zones. P.J.F. Vol-42 No. 4.

14. Sheikh, M.I. and Amjad Mahmood Chima. (1976). Effect of wind breaks on the yield of wheat crop. P.J.F. Vol-26 No.1.

15. Sheikh, M.I. and Raza-ul-Haq (1978). Effect of shade of *Acacia nilotic* and *Dalbergia sissoo* on the yield of wheat. P.J.F. Vol-28 No. 4.

16. Sheikh, M.I. and Afzal Cheema (1983). Effect of poplar on the yield of wheat at Changa Manga irrigated Plantation. P.J.F. Vol-33 No.4.