S.S. Rathore
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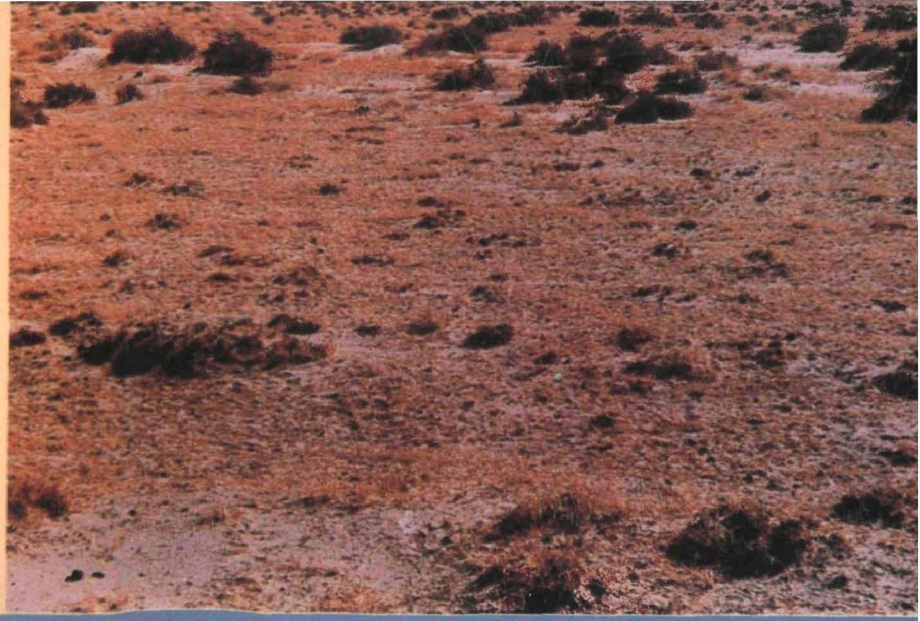

Rehabilitation of Degraded Pasturelands in Arid Rajasthan

Central Arid Zone Research Institute
Jodhpur - 342 003

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Cover Photographs :
Top : Degraded pastureland
Below : Rehabilitated pastureland

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FOREWORD

Total area covered by arid zone of India is 32 million hectares, out of which 62 per cent is in the state of Rajasthan. Livestock is one of the most important components in the farm economy of arid regions. Presently the grazing areas have considerably shrunk and on the other hand, livestock population has increased by manifold over the last 4-5 decades resulting in scarcity of forage. It is therefore, necessary to increase the productivity of the existing grazing lands, rehabilitate the degraded pasturelands and to motivate the individual farmer to bring his land under pasture to meet the fodder requirement. In view of this Central Arid Zone Research Institute, Jodhpur initiated a programme of pasture establishment on degraded pasturelands in Tilwara village of Barmer district, sanctioned under National Mission on Wastelands Development, Ministry of Environment and Forests, Government of India, New Delhi.

The work undertaken on different aspects of rehabilitation of degraded pasturelands at Tilwara in arid region has been compiled by Shri S.S. Rathore, Dr. J.P. Gupta and Dr. B.L. Jain. I am extremely happy to see and hope that the information will be of much use to the scientists, development agencies, extension workers and farmers.

(R.S. Paroda)
Secretary, DARE
Government of India
and
Director General
Indian Council of Agricultural Research
New Delhi

April 10, 1995

PREFACE

Under ever-increasing pressure of animal population, the land resource has been fast degrading. Hence there is an urgent need not only to bring such degraded lands under productive use but also to enhance the per hectare productivity. In view of this Central Arid Zone Research Institute, Jodhpur initiated a programme of rehabilitation of degraded pasturelands at Tilwara village in Barmer district. In this report results of field studies on methods of seeding, use of organic polymer for pasture establishment and fertilizer application for improvement of established pasture are presented. Information on fencing, pasture utilization and silvopasture studies etc. has also been incorporated. It is sincerely hoped that infomation contained in this report will be of great use to scientists, extension workers and farmers.

We wish to record our deep sense of gratitude for the inspiration and support provided by Dr. A.S. Faroda, Director, Central Arid Zone Research Institute, Jodhpur to publish this report in its present form. The dedicated technical support for the field works provided by Shri Prahlad singh, Shri Ram Lal Gunrat and Shri Ved Prakash Sharma is thankfully acknowledged.

S.S. Rathore
J. P. Gupta
B. L. Jain

CONTENTS

1. Introduction

Out of the total geographical area of 328.73 million hectares of India, 34.22 million hectares is occupied by Rajasthan. The total area covered by degraded land in Rajasthan is 19.93 million hectares and is mostly spread over North-West parts of the state. The climate of this region is characterised by extremes of temperatures ranging from below zero in winter to above 45°C in summer with low and erratic rainfall varying from 100 to 400 mm annually. Hot winds and dust storms, from south-west and west, are common features. Failure of rains is a regular phenomena. Thus the area is drought prone. Agriculture in the region is mostly unstable and gamble due to hostile agroclimatic conditions. Animal husbandry is therefore one of the main stay of local population. Livestock development has a natural advantage over crop cultivation. Moreover livestock of this region are famous for high production potential and drought hardiness and therefore they are in demand in different parts of the country.

The productivity of common grazing lands has decreased considerably due to over grazing and impairment of ecological balance. It is estimated that the livestock population of arid region in 2000 A.D. would be 11.27 million and the forage requirement would be 28.18 million tonnes. Expected annual forage production in normal rainfall situation would be 11.24 million tonnes, creating there by a fodder deficit of 16.94 million tonnes. This warrants emphasis on grassland management and forage production, particularly for sustaining the livestock population. It is therefore, essential to rehabilitate the degraded pasturelands, increase the productivity of common grazing lands and also to motivate individual farmer to bring his land under grass to meet the fodder requirement.

2. Pasture Development Programme and Objectives

Pasture production technologies developed at Central Arid Zone Research Institute, Jodhpur have shown considerable potential of increasing the productivity of degraded pasturelands. Inspite of this, adoption of such technologies for regeneration of common grazing lands and bringing private ownership land under grass cover has not taken place at village level. Therefore studies were conducted at farmers fields to evaluate the performance of pasture development techniques and also to explore the possibilities of regeneration of common grazing lands for increased fodder production.

The pasture establishment project, sanctioned under National Mission on Wastelands Development by Ministry of Environment and Forests, was undertaken in Tilwara village (situated at 25° 55 'N latitude, 72° 8 'E longitude) near Balotra in Barmer district is shown in Fig. 1. Tilwara is a celebrated name in the geography of western Rajasthan. It is sanctified by the shrine of Rawal Mallinath (Patron God of the Rathores).

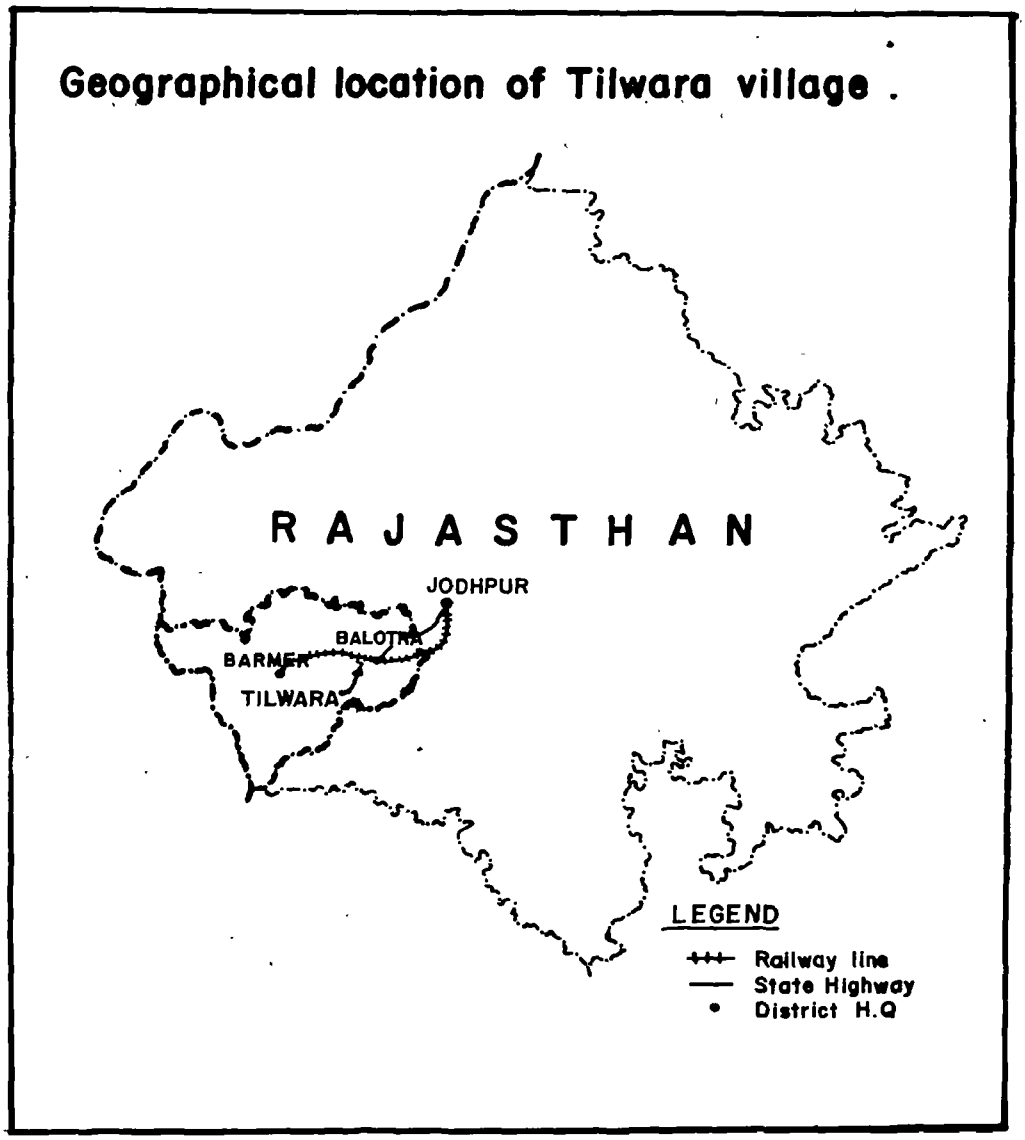

Fig. 1 Geographical location of Tilwara village in Western Rajasthan

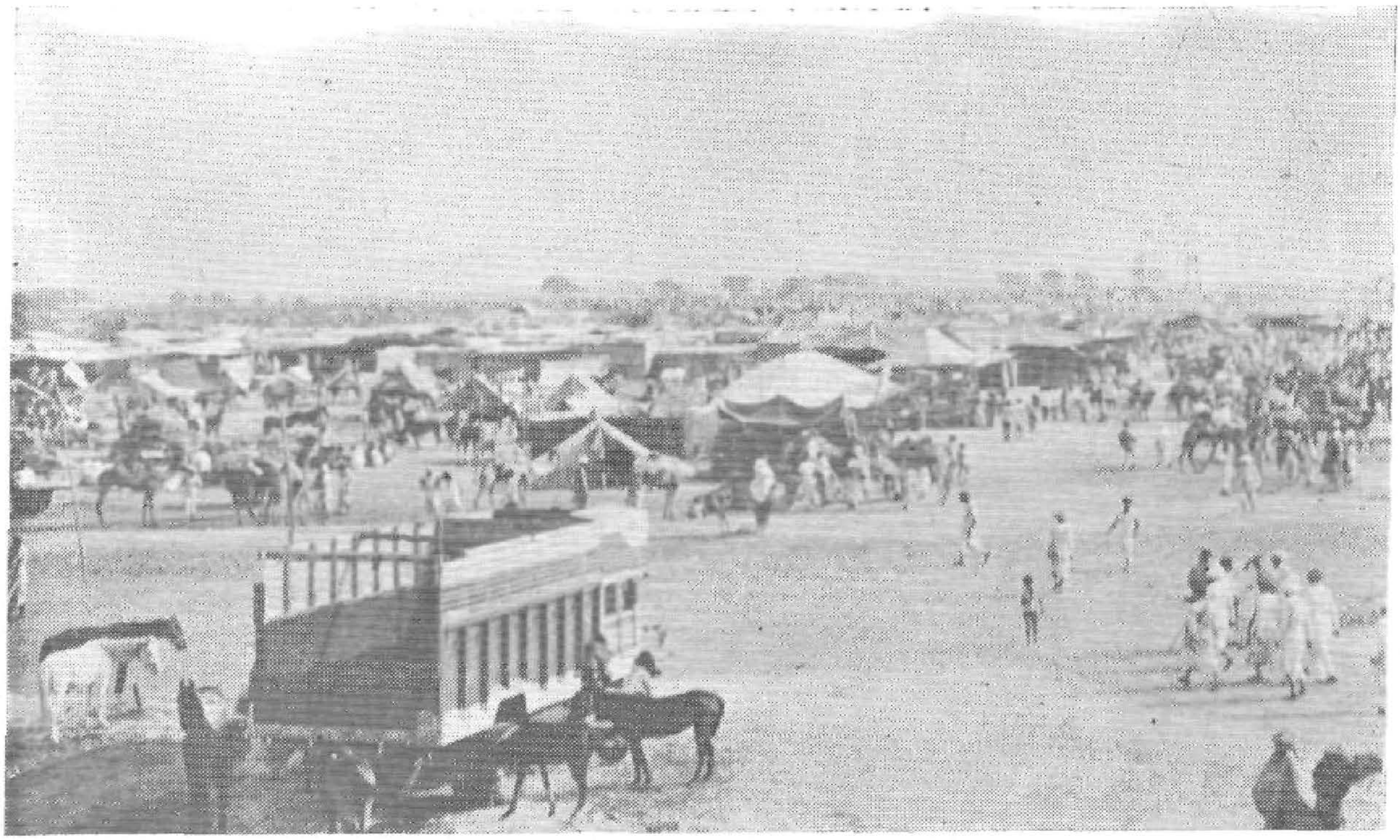

Fig. 2 A view of annual animal fair at Tilwara village

Tilwara is famous for its annual animal fair called 'Chaitri-Mela' (Fig. 2) which is held in the month of March-April for about a fortnight. In the fair bullocks, camels, horses, other animals and goods related to rural life are traded. Traders come from far and wide to purchase and exchange animals and goods. Under the present project 30 farmers were selected with a total area of about 200 hectares privately owned degraded pastureland, shown in Fig. 3.

The project was initiated in July 1990 with the following main objectives-

1. To prevent further degradation of pastureland through the development of appropriate technology for grass establishment and sustainable forage production.
2. To develop and demonstrate alternate land use system for sustainable production on degraded lands.
3. To develop suitable measures for in situ moisture conservation for the establishment of silvopasture.
4. To generate continuous production of good quality forage and grass seed for farmers/development agencies.
5. To study the economic feasibility of the development of pasturelands.

3. The Site Characteristics

Soils of project site are generally sandy loam to sand in texture, having pH 8.8, electrical conductivity 0.76 dSm^{-1} and organic carbon 0.16 per cent before the start of the project. Project site falls in arid climatic conditions with av-

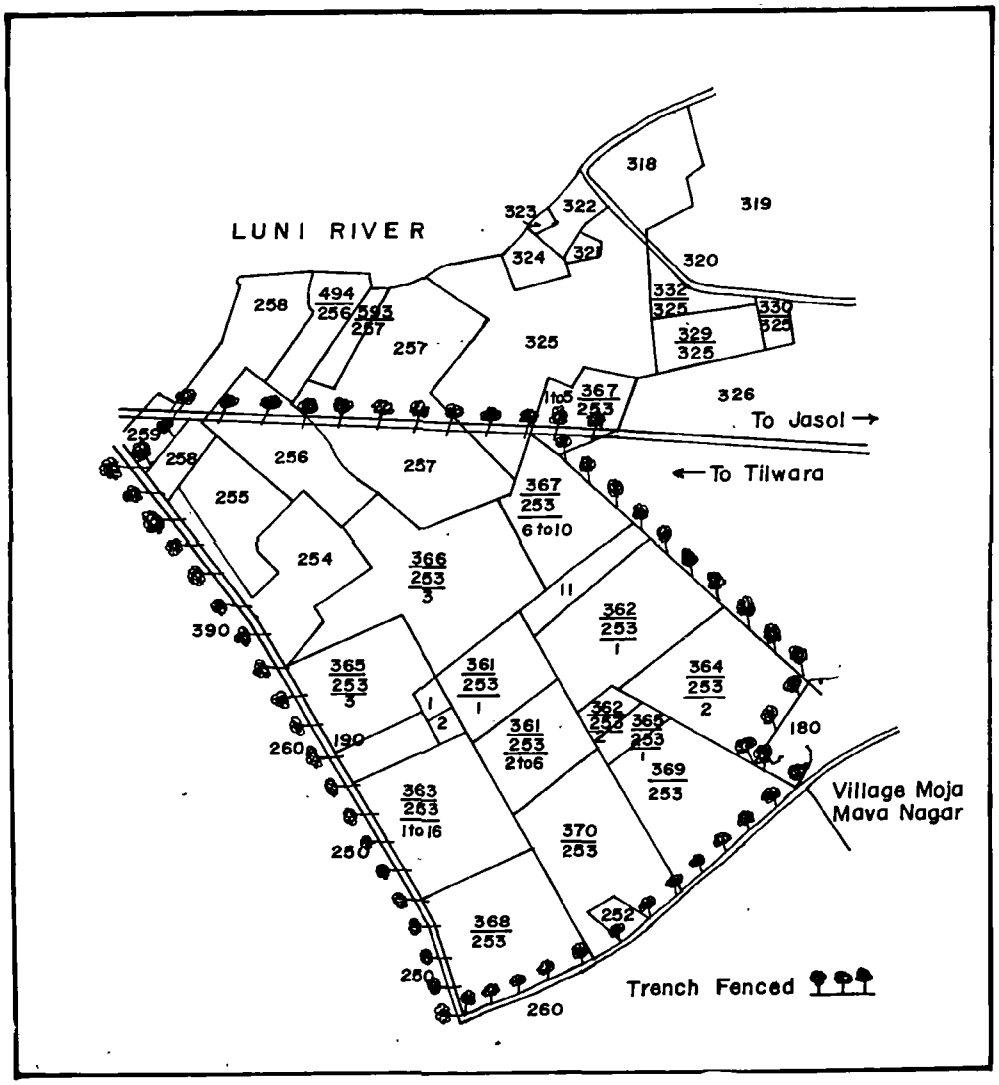

Fig. 3 Detail map of project area

erage annual rainfall of 200 mm. The rainfall is received during the months of June to September. Maximum temperature during summer ranges between 40° to 45° C and minimum during winter is between 2° to 6° C. Wind velocity is quite high during the period March to June resulting in the severe wind erosion. The area is almost devoid of vegetation (having productivity of 300 to 500 kg/ha) and infested with shrubs and bushes (Fig. 4).

4. Fencing Studies

4.1 Trench-cum-mound fencing : No pasture development programme can be successful without proper fencing. For proper protection of the area

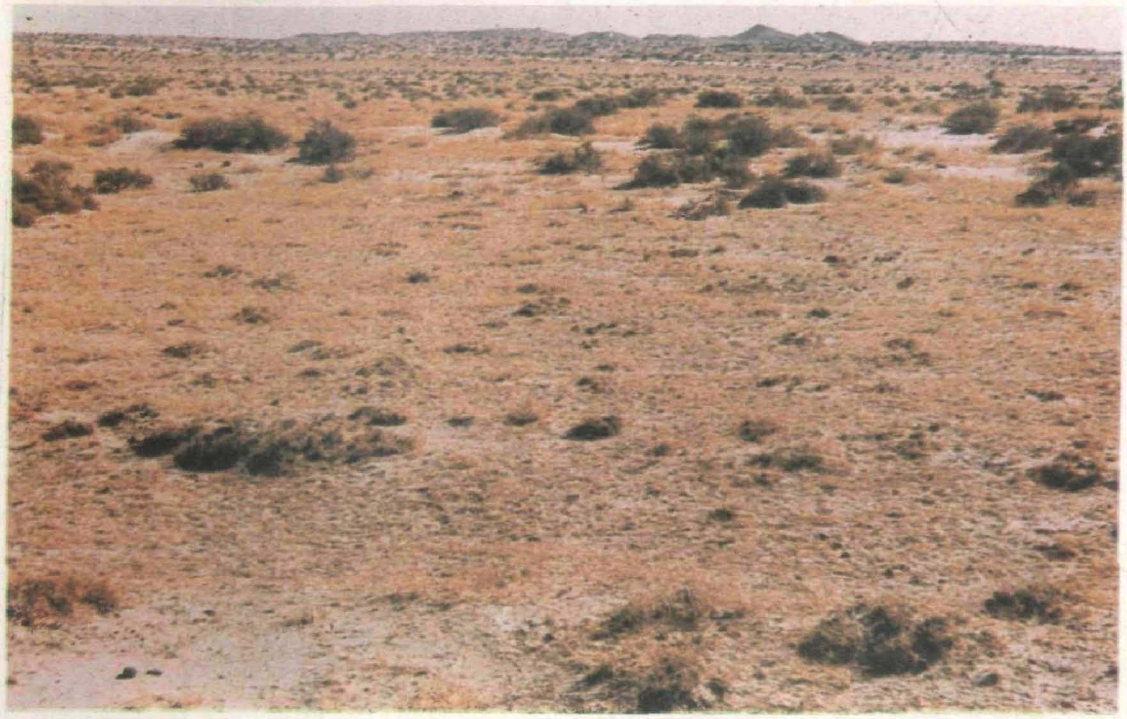

Fig. 4 Project site before start of programme (almost devoid of vegetation and infested with shrubs and bushes)

Fig. 5 A view of trench-cum-mound fencing

from stray animals, trench-cum-mound fencing was tried. It proved very economical and was appreciated by the farmers. This kind of fencing was constructed by digging a 0.9 m deep trench of trapezoidal shape, 1.5 m wide at the top and 0.9 m wide at the bottom. The excavated earth was heaped in a uniform manner on the inner side of the trench also with a trapezoidal cross section of approximate 0.9 m width at the top, 1.5 m width at the bottom and keeping the edge of mound about 0.3 m away from the edge of the trench (Fig. 5). The fencing was constructed in total peripheral area of 7560 running metres length.

4.2 Live fencing : For proper stabilization of mound and to check trespass by animals, live fencing with *Acacia tortilis, Acacia senegal* and *Prosopis cineraria* was established by direct seeding, as well as plantation of saplings on trench-cum-mound fencing during July 1990 (Fig. 6). Direct seeding performed better than sapling plantation. Among different tree species established by direct seeding on trench-cum-mound fencing *Acacia tortilis* performed better as compared to *Acacia senegal* and *Prosopis cineraria* in three years (Table 1).

5. Pasture Establishment / Production Technology

Before establishment of pasture, proper cleaning of the field and soil working are essential. The land should be properly ploughed with disc harrow and cultivator and all unwanted vegetation grubbed out and cleaned. Accordingly in July, 1990 after soil working *Cenchrus ciliaris* grass (strain 358) was established following the standard practice of pasture development. The programme was undertaken in a phased manner (during 1990 work was undertaken in 45 hectares area; 35 hectares in 1991 and 25 hectares in 1992). The average forage yield and grass seed yield for pasture established during 1990 was 2418 kg/ha and 62 kg/ha respectively. Average forage yield of pastures established during 1991 and 1992 were 2402 and 2420 kg/ha respectively, with grass seed yield ranging from 40-60 kg/ha.

Field studies on method of seeding and use of organic polymer for pasture establishment, and fertilizer application and post planting cultivation for improvement of established pasture were conducted on operational scale.

Table 1. Performance of trees after three years as live fence established by direct seeding and sapling plantation on trench-cum-mound fencing.

Species	Direct Seeding		Sapling Plantation	
	Height (cm)	Canopy (m^2)	Height (cm)	Canopy (m^2)
Acacia tortilis	131.0	0.97	123.0	0.93
Acacia senegal	86.0	0.41	79.0	0.39
Prosopis cineraria	64.0	0.13	62.0	0.13

5.1 Seeding method : Different methods of seeding grass were tried during the years 1990,1991 and1992 but major sowing operations were done through normal sowing behind cultivator because it is simple method of establishment of pasture in field conditions.

5.1.1 Sowing behind cultivator

5.1:1.1 Normal Sowing : Immediately after the first effective shower the requisite quantity of grass seeds @ 5 kg seed per hectare mixed with moist sandy soil three to four times the volume of seeds were drilled uniformly behind cultivator in lines 50 cm apart in 8 to 10 cm deep furrows at a depth of not more than 2 to 3 cm under the soil. *Cenchrus ciliaris* pasture was established with this technique (Fig. 7).

5.1.1.2 Pelleted seed sowing : Pellets were prepared by mixing seeds of grass, cow dung, clay and sand in proportion (by volume) 1:1:3:1 using sufficient quantity of water for preparing round pellets(of the size of about 0.5cm diameter).The pellets containing 2 to 3 spikelets were dried and stored. The pellets were sown in lines 50 cm apart and placed 1-2 cm deep below the soil surface. Sowing operations were carried out immediately after first effective monsoon rain and also a couple of days before expected rains.

5.1.2 Hand/spot sowing : Seeds were sown by hand in lines 50 cm apart in spots prepared by spade or pickaxe 2-3 cm deep in the soil.

Comparison of hand sowing, pellet seeding and normal sowing behind cultivator for establishment of pasture was made in the field conditions. Normal grass seed sowing and pelleted seed sowing methods were found superior as compared to hand sowing (Table 2).

Table 2. Effect of different methods of sowing on establishment and performance of *Cenchrus ciliaris* pasture.

Method of Sowing/ Year of observation	Plant population (000/ha)		Basal Cover (%)		Canopy Cover (%)		Seed yield (kg/ha)		Dry fodder yield (kg/ha)	
	1992	1993	1992	1993	1992	1993	1992	1993	1992	1993
Normal sowing with culti	61.0	52.5	27.7	21.2	120.1	61.0	62.5	51.0	2018	1550
Pelleted seed sowing with culti	75.0	50.0	25.2	18.4	102.0	51.9	65.0	47.0	1862	1456
Hand/spot sowing	35.0	41.2	7.5	11.3	31.3	33.9	25.0	23.0	1593	1237

Sowing of grass seed behind cultivator has been observed to be convenient method of grass seeding for pasture establishment in large developmental projects.

Fig. 6 Live fencing established on trench-cum-mound fencing

Fig. 7 *Cenchrus ciliaris* pasture

5.2 Use of organic polymer : Effect of seed treatment with organic polymer Jalshakti on pasture establishment and forage production was assessed for *Cenchrus ciliaris* in field conditions. Mixing of *Cenchrus ciliaris* grass seed with polymer Jalshakti at the rate of 5 to 20 per cent, increased plant population, basal cover and fodder yield (Table 3).

Table 3. Effect of Jalshakti polymer on productivity of *Cenchrus ciliaris*.

Jalshakti kg/100kg seed	Plant population ('000/ha)		Basal Cover (%)		Canopy Cover (%)		Dry fodder yield (kg/ha)	
	1992	1993	1992	1993	1992	1993	1992	1993
0	22.5	21.2	4.5	13.6	7.7	22.1	1490	1262
5	38.7	48.7	15.3	15.8	71.2	52.3	2051	1506
10	47.5	58.7	22.3	23.1	92.5	84.6	2287	1668
20	63.7	61.2	26.6	30.0	126.0	87.6	2418	1762

Use of 0.25 or 0.5 kg Jalshakti with 5 kg *Cenchrus ciliaris* seed per hectare is desirable for pasture establishment.

5.3 Fertilizer use : The average productivity of *Cenchrus ciliaris* grass in arid region is low due to adverse climatic conditions and poor soil fertility. Soils are mostly deficient in nitrogen and phosphorus and application of these nutrients can play a vital role in increasing the forage production. Post planting cultivation once in the season can help in effective weed control and in-situ moisture conservation. Therefore, effect of fertilizer (N&P) application and post planting cultivation on the productivity of two years old established *Cenchrus ciliaris* pasture was studied during 1992. Established pasture responded to both nitrogen and phosphorus application. Better response of fertilizer application was achieved in combination with post planting cultivation after 25-30 days of growth. Forage samples were analyzed for protein content. Application of 40 kg N + 20 kg P_2O_5 along with post planting cultivation resulted in significantly higher forage yield (5400 kg/ha) and crude protein (296.8 kg/ha) as reflected in the other yield attributes like plant height, basal diameter and crown diameter (Table 4).

5.4 Performance of grass strains : A relative performance of five strains of *Cenchrus ciliaris* and *Cenchrus setigerus* (CC Bundel, CC 1106, CC 75 A,CC 75 B and CS 76) established during 1991 in 5 hectares area (one hectare under each strain) was studied for their suitability in this region and compared with production data of the final year,1993 (Table 5).

All the strains of *Cenchrus ciliaris* performed superior as compared to *Cenchrus setigerus* 76. Among different strains of *Cenchrus ciliaris*, strain Bundel gave better performance and the highest yield.

Table 4. Effect of fertilizer and post planting cultivation on yield, growth parameters and crude protein content of *Cenchrus ciliaris* grass.

Treatment	Height (cm)	Basal diameter (cm)	Crown diameter (cm)	Forage yield (kg/ha)	Crude protein (kg/ha)
Control	98.9	19.2	40.7	2929	110.0
20kg N	127.7	21.4	43.5	3283	143.4
20kg N+20kg P_2O_5	134.6	22.6	45.9	3812	179.7
40kg N+20kg P_2O_5	137.8	24.7	51.9	4662	220.5
PPC*	120.2	21.5	42.0	3066	123.7
20kg N + PPC	148.2	22.4	45.6	3641	164.6
20kg N+20kg P_2O_5+PPC	153.0	24.1	49.9	4350	209.6
40kg N+20kg P_2O_5+PPC	156.2	25.4	53.6	5400	296.8

* Post-planting cultivation.

Table 5. Performance of grass strains.

Strain	Height (cm)	Plant population (000/ha)	Canopy (%)	Basal diameter (cm)	Dry fodder yield (kg/ha)
Cenchrus ciliaris Bundel	111.2	69.0	131.1	36.4	2022
Cenchrus ciliaris 1106	111.1	68.5	120.3	34.5	1795
Cenchrus ciliaris 75A	112.3	63.5	116.2	30.5	1640
Cenchrus ciliaris 75B	114.0	62.5	116.4	31.5	1872
Cenchrus setigerus 76	104.0	55.0	85.1	20.8	1490

5.5 Grass seed production : Seed is the most important input for any grassland development programme. Therefore, there is great demand of *Cenchrus ciliaris* seed by development agencies/ departments and farmers. Every year good quality seed (Fig. 8) is collected manually as sown in fig. 9. Approximately 1500 kg grass seed of *Cenchrus ciliaris* was collected from the 45 hectares field during first year of establishment in 1990. During 1991 and 1992 approximately 1000 kg and 540 kg seed were collected, respectively. Less seed collected during 1991 and 1992 was due to the prevalence of drought and labour shortage. The labour cost of seed collection was about Rs. 5.50/kg during these years and seed was sold at the rate of Rs. 35/kg.

6. Pasture Utilization Studies

Forage of the pasture can be utiliged in two ways

(a) harvesting, preserving and then feeding to the livestock,

(b) grazing.

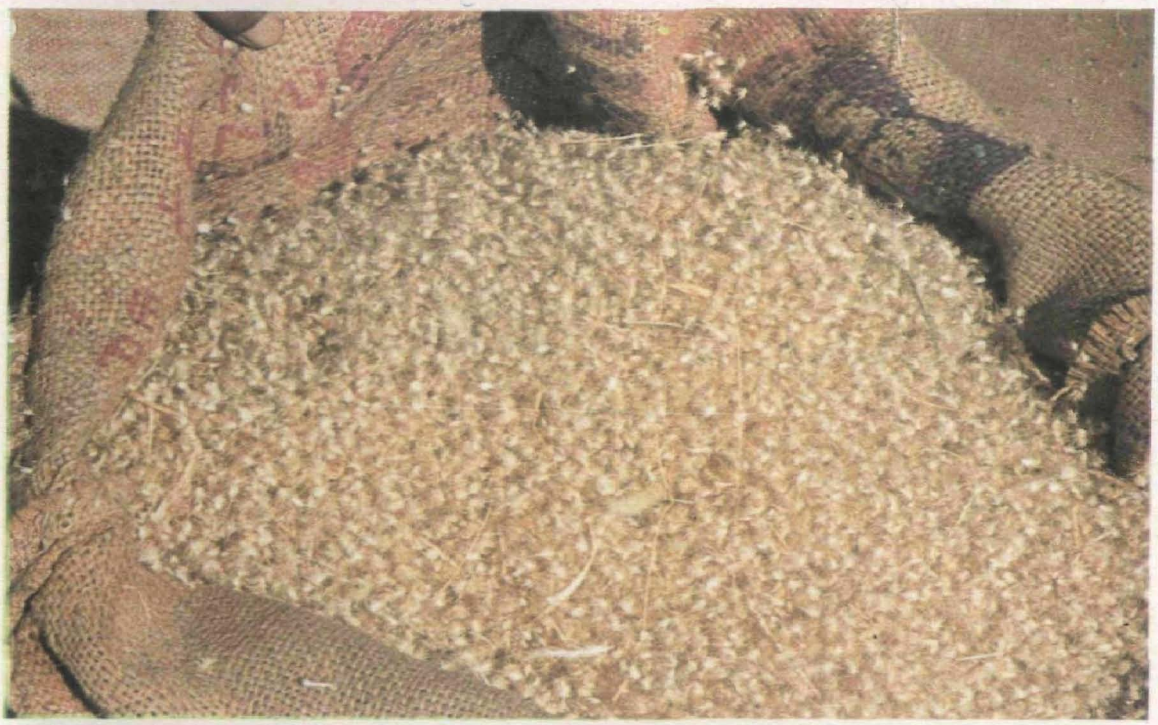

Fig. 8 Good quality seed collected from project site

Fig. 9 Manually collection of grass seeds from pasture

Fig. 10 Bumper harvest of *Cenchrus ciliaris* pasture

Fig. 11 Cattle grazing on *Cenchrus ciliaris* pasture

6.1 Harvesting and preservation : It is advisable not to put the pasture to grazing during first year of its establishment. Therefore, the pasture grass was harvested and stocked in 1990 and 1992. Average dry fodder yield during 1990 and 1992 were 2418 and 2420 kg/ha respectively. A good harvest of grass can be seen in fig. 10.

6.2 Grazing : Best way to utilize the pasture is through controlled grazing which is dependent upon carrying capacity of the grassland. Pastures can be categorized as'excellent', 'Good', 'Fair', 'Poor' and 'Very poor' depending upon the grass productivity of 2000, 1500,1000,750 and 500 kg/ha, respectively, and can safely provide year long grazing to 25-30, 20, 17, 13 and 1-6 adult cattle units per 100 hectares blocks, respectively during the normal years. The excellent condition of pasture in the present case sustained 25-30 adult cattle per 100 hectares per year for grazing. This way after seed collection grazing was allowed during 1991 and 1993 (Fig.11). Approximate revenue of Rs. 2500 per hectare was realised through grazing during these years.

7. Economics of Pasture Production

The degraded lands when rehabilitated through pasture establishment and managed properly are potential source of nutritious forage for livestock feeding and good source of grass seed production. The main expenditure is, however, by way of fencing, soil preparation, cost of inputs, maintenance etc. An economic analysis of the pasture development studies (1990-92) are presented in annexure-1.

On the basis of economic analysis pasture production seems to be more advantageous over crop cultivation in Barmer region because of frequent crop failures due to droughts. Further there is no recurring expenditure in pasture establishment as in crop cultivation.

8. Silvopasture Studies

Introduction of tree species in the pastureland is important from the point of view of continuous supply of quality fodder and fuel wood. Beside this,leguminous trees fix nitrogen, efficiently utilize water stored deep in the soil and also provide better micro environment for grass productivity, animals and human beings. However in the absence of irrigation, enhancing rain water supply and its conservation is important for successful establishment of trees. For this, 30 cm high ridge was constructed by disc plough at 12 to 15 m distance across the slope before grass seeding. Tree seeding was done on the ridge during 1991 and 1992. This system prevented the runoff and increased the profile water storage. Direct seeding of fodder and fuel trees of *Prosopis cineraria, Acacia senegal, Acacia tortilis, Colophospermum mopane, Hardwickia binata* etc. was successful in establishment of trees on the ridge in field conditions (Fig.12). Trees attained the height of 70-150 cm in 2.5 years.

In another study hortipastoral block with budded plants of ber (*Zizyphus mauritiana*) in 5 hectares area was established in 1990. Survival and growth of ber plants in hortipastoral system were poor due to low rainfall, high temperatures and lack of irrigation facilities.

8.1 Raising of shelter belt : Shelterbelt is rows of trees planted for the conservation of soil and moisture and for the protection of forage from hot desiccating winds. Studies were conducted to find out the relative growth of shelterbelts of different types of trees. Trees namely *Prosopis juliflora, Acacia tortilis, Acacia arabica, Acacia senegal* were planted as live shelterbelt along the project field boundary around 15 hectares area. (Fig. 13)

Among the different tree species *Acacia arabica* attained the height of 3.31 m and canopy 6.84 m^2 as compared to *Acacia tortilis* which has attained the height of 2.83 m and canopy 4.36 m^2 only in 2.5 years.

8.2 Tree plantation along field boundary : About 10,000 plants of *Prosopis cineraria, Prosopis juliflora, Acacia tortilis* and *Acacia senegal* were planted along field boundaries and roads (Fig.14) with in the project area under both situations of grass cover and without grass cover (Table 6).

Grass in association with trees retarded the growth of trees. Trees generally performed better in loamy sand than sandy loam soil.

9. Soil Improvement Under Pasture

Establishment of pasture of *Cenchrus ciliaris* in 1990 in degraded pastureland improved the soil characteristics by decreasing pH (from 8.8 to 8.5), salinity level (from 0.76 to 0.13 dSm^{-1}) and increasing the organic carbon content (from 0.16 to 0.20 per cent) in three year period. There was also crust breaking due to the movement of animals. As a result of this there was improvement in the infiltration rate and the grass productivity.

Table 6. Performance of tree species after three years.

Tree species	Without grass		With grass	
	Height (cm)	Canopy (m^2)	Height (cm)	Canopy (m^2)
Sandy loam				
Dichystachys nutans	137.0	1.12	–	–
Acacia tortilis	120.0	0.74	76.0	0.33
Acacia senegal	76.0	0.29	68.0	0.23
Loamy sand				
Acacca tortilis	171.0	1.85	111.0	0.84
Acacia senegal	121.0	0.90	–	–

Fig. 12 Silvopastoral management: *Cenchrus ciliaris* with fodder and fuel trees

Fig. 13 Live shelterbelt of *Prosopis juliflora*

Fig. 14 Plantation of *Acacia tortilis* along field boundary

Fig. 15 Visit of farmers to project Site during field day

10. Technology Extension Programme

Farmer fair/field day was organised at Tilwara on 21st October 1991 to disseminate the technologies for rehabilitation of degraded pasturelands. Large number of farmers, Government Officials, Non-Government Officials, Press and All India Radio representatives participated in the fair. An exhibition was also organised at the farmers field.

Visit of the farmers to the project site was arranged (Fig.15). They were apprised of the new technologies of pasture and silvopasture establishment by efficient management of rain water. They were also told about the harsh agro-ecological condition of the region and the role of silvopasture/Agrihorticulture systems in imparting economic stability. These could therefore, be adapted by the farmers of the region.

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ANNEXURE-1

ECONOMIC ANALYSIS OF PASTURE PRODUCTION

Expenditure (Rs.)		
(i)	Field preparation and grass seeding	
	(a) Three tractor operations (for removal of unwanted vegetation, thorough soil working and grass seeding) required 8 hours @Rs. 60/hr	480
	(b) 12 labours for cleaning of area and sowing of grass seed @ Rs.22/day	264
(ii)	Input cost	
	(a) Grass seed 6 kg @ Rs.35/kg	210
	(b) Jalshakti (0.5 kg/ha)	50
	(c) Fertilizer (40 kg N + 20 kg P_2O_5)	200
	(d) Miscellaneous	40
(iii)	Fencing Cost	
	Fencing was constructed in total peripheral area of 7560 running metres length. The excavation cost was Rs.22/2.7 cubic metres. Thus the total cost of fencing in about 200 hectares were Rs.66528.0 and in one hectare was Rs.330.00	330
(iv)	Maintenance and other recurring expenditure	
	(a) Post planting cultivation once in season	
	Two tractor hour @ Rs.60/hr	120
	Two labours @ Rs.22/day	44
	(b) Other recurring expenditure	100
(v)	Seed collection and forage harvest cost	
	(a) Seed collection cost (Average production 60 kg/ha) 15 labours @ Rs.22/day	330
	(b) Grass harvesting cost (Average production 2000 kg/ha) 10 labours @ Rs.22/day	220
	Total	2388
Returns (Rs.)		
(i)	Grass fodder (2000 kg/ha) sold @ Rs. 1.5/kg	3000
(ii)	Grass seed (60kg/ha) sold @ Rs. 35/kg	2100
	Total	5100

Net profit : 5100-2388 = Rs. 2712/ha