OUTLINES OF THE TECHNOLOGIES FOR RECONSTRUCTION OF THE ARID ZONE

CENTRAL ARID ZONE RESEARCH INSTITUTE
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Contents

Preface

Realising the importance of the arid region in the national economy, its potentials and characteristic problems, the Government of India established a Desert Afforestation Research Station at Jodhpur in 1952. The scope of the station was enlarged in 1957 when it was re-named as the Desert Afforestation and Soil Conservation Station. Again, in 1959 the Government of India decided to intensify the research programme of this Station and on the basis of the recommendations of Mr. C.S.Christian of CSIRO, Australia, the station was designated as the Central Arid Zone Research Institute (CAZRI), Jodhpur, to couduct research in the physical, biological and social sciences on an inter-disciplinary basis. CAZRI has by now achieved considerable insights into the haunting problems of arid regions, generated scientific knowledge for their solution and has developed number of technologies for the reconstruction of the Indian arid regions.

CAZRI, in collaboration with the State Development Departments, is engaged in transferring technologies to the farmers specially through its Operational Research Projects and the Lab-to-Land Programme. One of the felt needs of the extension functionaries involved in these programmes was the availability of the outlines of the technologies recommended by CAZRI at one place. To meet this need, CAZRI had published a technical bulletin (No. 7) on "Outlines of the Technologies for Reconstruction of the Arid Zone" in 1980 compiled by Shri Gian Chand, Technical Officer, CAZRI. In the present bulletin, the material has been updated and reorganised in the form of "Package of Practices". Also, a small note on the economics is added at the end of each technology.

CAZRI is indebted to various officers in the Ministries of Food and Agriculture & Rural Reconstruction, the Department of Science and Technology and the Indian Council of Agricultural Research and also of the State Governments of the arid and semi-arid regions, particularly to the Government of Rajasthan, for their continued support to its research and extension activites. A special mention must be made of the personal interest of Shri G. K. Bahnot for his interest and guidance in various capacities in the Government of Rajasthan.

Mention must also be made of Desert Development Commissioners of the Government of Rajasthan, and particularly of Shri R. K. Aggarwal on whose suggestions the information contained in the original bulletin was compiled.

Grateful thanks are due to Dr. H.S. Mann, Ex Director, CAZRI for his keen interest in arid zone research in general and publication of this bulletin in particular.

Our special thanks are also due to Shri Vijay Verma, the present Desert Development Commissioner for his continued support and valuable suggestions from time to time.

Thanks are due to my colleagues in CAZRI for their willing co-operation to spare the material included in this publication. Dr. Mruthyunjaya, Scientist S-2 (Agricultural Economics) has done an excellent job of revising and updating this bulletin.

The information contained in this publication is applicable to average situations and hence need to be adjusted to local conditions.

I hope this bulletin will be of use to all research, extension and development workers involved in the development of arid regions of India. Suggestions and criticisms for improvement of this publication will be welcome.

Dated : 11.6. 1982

S. P. MALHOTRA
Officiating Director

Dry Farming Technology

Crop production in Western Rajasthan is a big gamble in monsoons. However, the arid districts contribute 1.7 and 4.8 per cent, respectively, to India's total cereals and pulse production, their contribution to the total foodgrain production of country being about 2 per cent. The average yields of the crops in Western Rajasthan are very low as compared to either Rajasthan State or India as a whole. Even a small increment in the productivity of these crops, because of larger area under these crops, can contribute substantially to the cereal and pulse production in the country. A sound dry farming technology is now available for improving the crop production in these areas.

BAJRA *(Pennisetum typhoides)*

Bajra is an important staple food grain crop in Western Rajasthan. It was grown on 3380 thousand hectares, contributing nearly 70 per cent of the total bajra production in Rajasthan State during 1977-78. It is a short season, drought resistant crop.

Variety : BJ - 104

Land preparation and soil conservation measures : A clean and mellow seed bed should be prepared by sweep cultivator or cross disc harrowing or cultivation. Keep the field well-bunded and levelled for better spread of rain water. If possible, prepare deep furrows alternated by raised micro-catchments for effecting inter-row water harvesting.

Seed rate : 4 to 5 kg per hectare.

Sowing time : 4th week of June to 2nd week of July. Grain yields decline if sown after 2nd week of July.

Sowing : Sow seeds in paired rows (30/60 cm) with plant to plant distance maintained at 15-20 cm apart. Use improved seed drill having fluted roller metering device. Do not sow the seeds deeper than 5 cm.

Fertility management : Apply 40 kg of nitrogen per hectare. Alternatively, if FYM is available, apply 10 tonnes of FYM and top dress 10 kg of N per hectare. Use phosphorus if needed as per soil test values. Use

full dose of phosphorus and one half of nitrogen (20 kg of N/ha) 10 cm deep before sowing. Top dress the remaining 20 kg of N 3 to 4 weeks after sowing, only if rains are received. If the rainfall received at the time of sowing is inadequate, sow the crop without applying any N fertiliser. If the season progresses normally, then top dress full dose of N in 2 to 3 equal splits with subsequent rains. A saving of 20 kg N/ha is also possible by following mung-bajra rotation.

Disease and pest management : Soil borne pests like termites and white grubs can be effectively controlled by incorporating 10% BHC dust at 20 kg/ha while field crickets, leaf cutter and blister bettle can be controlled by dusting the crop with 5% BHC at 5 to 10 kg/ha.

Interculture : Make the crop weed free by 1 to 2 hand weedings.

Mid season corrections :
i) In the event of early seedling mortality due to drought, fill in gaps through transplanting 20-25 days old seedlings.
ii) Under unusual delayed onset of monsoon, a successful bajra crop can be raised through transplanting technique.
iii) Under conditions of prolonged drought at active growth stage, thin out the crop within rows or even remove alternate rows when moisture stress becomes too severe.

Transplanting technique : Raise a nursery on a plot of size 100 m^2 which caters seedlings to an area of one hectare. Preferably raise the nursery near a water source. The seedlings should be kept well watered for a period of 20-25 days when they will be ready for transplanting. Transplant on a drizzling day in the evening hours or on a cloudy/clear day. Transplant two seedlings per hill, 25-30 cm, apart in furrows spaced at 45 cm apart.

Harvesting : The crop comes to harvest in ahout 80 to 85 days.

Yield : In normal rainfall years, 15-20 quintals grains can be expected per ha. If there is late onset of rains, about 8 quintals of grains can be expected. Under these situations, 0.4, 0.3 and 0.2 tonnes of dry fodder per ha can also be expected. The long run average yield is 2 quintal grains and 0.1 tonnes fodder per ha in this region.

Storage : Damage in store can be avoided by treatment of empty storage structures and containers using malathion. Grains should be fumigated when placed in storage.

Economics : At 1981 prices on per hectare basis, the estimated total cost of cultivation comes to Rs. 110/- under traditional practices. Additional costs on modern inputs (HYV seed, fertilisers and

plant protection chemicals) come to Rs. 315. Average gross income from main and byproducts comes to Rs. 278/- under traditional technology. If modern inputs are used, an additional income of Rs. 1,772/- under normal rainfall conditions, Rs. 824/- under late onset of rains and Rs. 412/- under occurrence of drought in the late season can be expected.

About 84 mandays of labour is required per hectare which has not been accounted for working out economics as it is assumed to be contributed by family labour which has no opportunity costs at present in these arid areas.

GUAR [*Cyamopsis tetragonoloba* (L.) TAUB]

During the year 1977-78, more than 2682 thousand hectares were under guar cultivation in Western Rajasthan contributing to about 60 per cent of production in the Rajasthan State. It is used for human consumption as vegetable, for animals as feed and fodder. It has also medicinal values and also can enrich the soil fertility. Endospermic gum from guar is of industrial significance. Guar meal that is left as byproduct after gum extraction is a high protein (42%) source as cattle feed.

Varieties : D-Saffed, 2470/12, HFG-75, HFG-182, B-19-1-55.

Land preparation and soil conservation measures : Prepare the seed bed by one or two ploughings by sweep cultivator. In a highly weed infested field, two to three ploughings, the first by mould board plough followed by a desi plough is required.

Seed rate : 12 to 15 kg/ha.

Sowing time : From the onset of monsoon to third week of July.

Sowing : Drill seeds at a depth of 5-7 cm in rows spaced at 45 cm. Thinning should be done 10-15 days after sowing and maintain plant to plant distance of 10-15 cm.

Interculture : Intercultural operations like weeding should be done within 25-30 days of sowing.

Fertility Management : Apply 15-20 kg N/ha to give the crop a good start. On soils low in phosphorus application of 40 kg P_2O_5/ha is beneficial. Inoculation of seeds with appropriate rhizobium culture, at 10 gm for each kg seed, should be done for ensuring good nodulation and efficient nitrogen fixation.

Disease and pest management : Guar crop does not suffer from any major insect pests. However, because of other legume crops in the vicinity, pests of these also attack guar crop. Termites, white grubs, red hairy caterpillars and *Cyrtosemia cognata*, aphids, white fly and Jassids

cause damage to the crop in some areas. For effective control of termites and grubs, application of 25 kg/ha of 5% aldrin dust and its thorough incorporation into the soil at the time of last ploughing is necessary. Bacterial blight and alternaria blight are the major diseases, which can be controlled effectively by the seed treatment with streptomycin (1000 ppm) for the former and with two sprays of dithane Z-78 (0.2%) at 15 days interval for the latter.

Harvesting : The crop is harvested in 100-10 days after sowing depending on the variety and rainfall distribution.

Yield : In normal rainfall years, 12 quintals of grain can be expected per ha. If there is occurrence of drought in the late season, only about 4 quintals can be expected per ha. The long run average yield in the region is about 1.5 quintals per hectare.

Economics : At 1981 prices, on per hectare basis, the estimated total cost of cultivation under traditional practices comes to Rs. 165. Additional costs on modern inputs (fertilisers and plant protection chemicals) comes to Rs. 644. Average gross income comes to Rs. 141 under traditional technology. Additional income from use of modern inputs comes to Rs. 987/- under normal rainfall situations. If late season drought occurs, investment in morden inputs is not profitable.

About 85 mandays of labour is required per hectare which has not been accounted for working out economics as it is assumed to be contributed by family labour which has no opportunity costs at present in these arid areas.

MOTH [*Vigna aconitifolia* (JACQ.) MARECHAL]

Rajasthan is the major producer of this crop in India, producing 0.16 m tonnes of grain in an area of about 1.23 m ha. In the year 1977-78, 1410 thousand hectares were under this crop in Western Rajasthan contributing to more than 95 per cent of the state production.

Varieties : T-18, T-2, IPCMO-926 (Jwala), JMM 259 and Jadia.

Land preparation and soil conservation measures : Seed bed preparation by one or two ploughings by sheep cultivator.

Seed rate : 10 to 12 kg/ha.

Sowing time : First fortnight of July.

Sowing : Drill the seeds at a depth of 5 cm. in rows spaced at 45 cm. Thinning should be done 10-15 days after sowing and maintain plant to plant distance of 5-10 cm.

Interculture : The weeding of the crop should be done within 30 days of sowing.

Fertility Management : Apply 30-40 kg $P_2 O_5$/ha below the seeds at the time of sowing. However in new area, where the crop has not been grown before the seeds should be inoculated before planting with a suitable culture of rhizobium.

Disease and pest management : Yellow mosaic virus is the most important disease. The disease vector can be controlled by applying Rogar (0.03%) @ 1 litre per hectare. Termites and white grubs can be controlled by applying aldrin dust (5%) at the rate, 25 kg/ha.

Harvesting : The crop is harvested in 90 to 115 days after sowing depending upon the variety and rainfall distribution.

Yield : Under normal rainfall conditions, 8 quintals grain and 0.4 tonne dry fodder can be expected which reduces to only 2 quintals and 0.4 tonne, if there is occurrence of drought in the late season. The long run average yield is about 1.5 quintals and 0.1 tonne per ha in this region.

Storage : All empty storage structures and containers should be treated with malathion or another equally effective insecticide before filling. Moth grains should be fumigated before placement in store.

Economics : At 1981 prices, on per hectare, basis the estimated total cost of cultivation under traditional practices comes to Rs 168. Additional cost on modern inputs (fertilisers and plant protection chemicals) comes to Rs. 631. Average gross income from both main and byproduct comes to Rs. 405/- under traditional technology. If modern inputs are used, an additional income of Rs. 1759 can be expected under normal rainfall situations. Investments in modern inputs is not profitable if droughts occur in the late season.

About 70 mandays of labour is required per hectare which has not been accounted for working out economics as it is assumed to be contributed by family labour which has no opportunity costs at present in arid areas.

MOONG *(Vigna radiata)*

In Rajasthan moog is cultivated on an area of 203 thousand hectares producing about 31 thousand tonnes of grains.

Varieties : S-8, S-9, T-44 and PS-16.

Land preparation and soil conservation : Prepare a clean and smooth seed bed using sweep cultivator. Keep the field well bunded and levelled for better inter-row water harvesting.

Seed rate : 12 to 15 kg/ha.

Sowing time : Third or fourth week of July.

Sowing : Drill the seeds at a depth of 5 cm in rows spaced 30-45 cm apart. Thinning should be done 8-10 days after sowing and maintain plant to plant distance of 5-10 cm.

Interculture : Intercultural operations should be done within 20-25 days of sowing.

Fertility management : Apply 30-40 kg P_2O_5/ha. In new areas of cultivation, the seeds should be treated with appropriate rhizobium culture.

Disease and pest management : For control of most of the soil borne insects like white ants and white grubs, incorporate 20 kg BHC 10% dust/ha at sowing time. The other pests are shoot fly, plant hoppers, pod worms, aphids, leaf rollers, blister beetels, stink bug and seed weevil for which field rotation and application of systemic insecticides is beneficial. Yellow mosaic virus is an important disease. The other less important diseases are powdery mildew and cercospora spot.

Harvesting : The crop is harvested in 60 to 70 days after sowing depending upon the variety and rainfall distribution.

Yield : Under normal rainfal conditions, 12 quintals grain and 0.6 tonne fodder per ha can be expected. If drought occurs in the late season, yield may go down to 4 quintals and 0.2 tonne per ha. The long run average yield is about 2 quintals and 0.1 tonne per ha.

Storage : All empty storage structures and containers should be treated with malathion or another equally effective insecticide before filling. However, moog grains should be fumigated before placement in storage.

Economics : At 1981 prices, on per hectare basis, the estimated total cost of cultivation under traditional technology comes to Rs. 215. Additional cost on modern inputs (fertilisers and plant prot-

ectionc hemicals) comes to Rs. 362. Average gross income from both main and byproducts comes to Rs. 801/- under traditional technology. If modern inputs are used an additional income of Rs. 4005/- can be obtained under normal rainfall conditions and Rs. 801 under conditions of drought late in the season.

About 70 mandays of labour is required per hectare which has not been accounted for working out economics as it is assumed to be contributed by family labour which has no opportunity costs at present in arid areas.

RAYA (MUSTARD) *(Brassica juncea)*

In Rajasthan, mustard occupies an area of 0.2 million ha and produces 0.06 million tonnes of grains. Area under raya and mustard in Western Rajasthan in 1977-78 was 84 thousand hectares contributing nearly 28 per cent of the State production.

Varieties : T-59, Durgamani.

Land preparation and soil conservation practices : After the recession of monsoon, conserve moisture by repeated cultivations and keep the field free of weeds. It requires a clean, trash free but firm seed bed with adequate moisture in the seeding zone.

Seed rate : 4 to 6 kg/ha.

Sowing time : First fortnight of November.

Sowing : Drill the seeds at a depth of 3-5 cm in rows spaced 30 to 60 cm apart. Thinning should be done 10-15 days after sowing and maintain plant to plant distance of 0-15 cm.

Interculture : Intercultural operations should be done within 30-40 days of sowing.

Irrigation : If possible, give 1 to 3 supplemental irrigations for higher yields.

Fertility management : Apply 30-40 kgN/ha. Apply phosphorus as per soil test values. In case the crop is raised under only rainfed conditions, the nitrogen may be placed below the seed at the time of planting.

Disease and pest management : In dry climate, diseases do not become a serious problem to raya crop. However, some of the diseases which can infest raya are white rust, downy mildew and white blight. *Bagrada picta,* leaf miners and aphids can cause a serious damage to the crop. *Bagrada picta* attacks the crop immediately after germination and can be controlled by dusting the crop with BHC 5%, 15 kg/ha. Infestation of leaf miners generally occurs in the early growth stages and aphids are serious pests-

during flowering and pod formation stages. Both these insects can be effectively controlled by spraying the crop with any systematic insecticide like Dimecron or Rogor or Nuvacron (1 litre/ha).

Harvesting : The crop is harvested in about 130-140 days after sowing.

Yield : Under conserved moisture and 1 to 2 supplemental irrigation conditions, about 10 quintals can be expected per ha. Under conserved moisture conditions, only 4 quintals can be expected. The long run average yield in the region is about 1.5 quintals per ha.

Storage : If the seed is not to be processed promptly for oil extraction, it may be stored under cool dry storage conditions. Pre-treatment of storage structures and containers with malathion, and fumigation of incoming seeds is essential to control insect pests in store.

Economics : At 1981 prices, on per hectare basis, the estimated total cost of cultivation for traditional practices comes to Rs. 313. Additional cost on modern inputs (fertilisers and plant protection chemicals) comes to Rs. 348. Average gross income comes to Rs. 900/- under traditional technology. If modern inputs are used, an additional income of Rs. 3833/- per hectare can be obtained under conserved moistnre and 1 to 2 supplementary irrigated conditions and Rs. 1127/- only under conserved moisture conditions.

About 70 mandays of labour is required per hectare which has not been accounted for working out economics as it is assumed to be cotributed by family labour which has no opportunity costs at present in arid areas.

TIL (SESAME) *(Sesamum indicum)*

Til is one of the important oilseed crops growing in Rajasthan. It is grown on an area of 0.64 million ha producing 56 thousand tonnes of grains. In 1977-78, area under til was about 290 thousand ha contributing to nearly 90 per cent of the State production.

Varieties : T-13, TC.-25.

Land preparation and soil conservation measures : Prepare clean, mellow and firm seed bed by cross disc harrowing.

Seed rate : 4 to 5 kg/ha.

Sowing time : With the onset of monsoon in the end of June or 1st week of July.

Sowing : Sow seeds at a depth of 2 cm in moist soil in rows spaced at 40-45 cm. Thinning should be done 10-15 days after sowing and maintain plant to plant distance of 10-15 cm.

Interculture : Intercultural operations should be done 25-30 days after sowing.

Fertility management : Apply 20 kg N/ha at sowing and 20 kg N/ha be top dressed 30-35 days after sowing on the receipt of rains. In soils deficient in mineral nutrients, apply calcium and sulphur rich phosphates as per the soil test values.

Diseases and pest managament : Frequent rains and high humidity may cause diseases like phyllody, leaf spots, blights, etc. Disease prevention is feasible using disease resistant varieties and field sanitation through rotation of crops and disposal of all residues of harvested crops. Sphinx caterpillar *Adcherentia styx* and leaf web are the important pests. These can be controlled with application of 0.03% quinophos (0.750 ml/ha) or 0.05% methyl parathion. Prompt planting at the very beginning of the rains after a dry period, will evade many or most of the insect problems.

Harvesting : The crop is harvested in about 85 to 100 days after sowing depending upon the variety and rainfall distribution.

Yield : Under normal rainfall conditions, about 6 quintals per ha can be expected which may reduce to 3 quintals under late onset of rains. If drought occurs late in the season, only 2 quintals can be obtained. The long run average yield in the region is only 0.7 to 1.0 quintal per hectare.

Storage : Treat all empty containers before filling with Malathion. Fumigate the seeds in storage.

Economics : At 1981 prices, on per hectare basis, the estimated total cost of cultivation for traditional practices comes to Rs. 310. Additional cost on modern inputs (fertilisers and plant protection chemicals) comes to Rs. 318. Average gross income comes to Rs. 673/- under traditional technology. If modern imputs are used, an additional income of Rs. 2363/- can be obtained under normal rainfall conditions, Rs. 845/- under late onset of rains and Rs. 339/- under occurrence of droughts late in the season.

About 70 mandays of labour is required per hectare which has not been accounted for working out economics as it is assumed to be contributed by family labour which has no opportunity costs at present in arid areas.

CASTOR (CASTOR BEANS) *(Ricinus communis)*

Rajasthan grows castor in about 2,400 ha with a total production of 500 tonnes.

Varieties : Aruna, Bhagya (R-63) and GAUCH-1.

Land preparation and soil conservation measures : The seed bed should be clean, mellow and friable and manage the fields to conserve rainfall by reducing runoff and storing rainfall in the soil profile.

Seed rate : 12 to 15 kg/ha.

Sowing time : In the second half of July after the onset of monsoon.

Sowing : Drill the seeds at a depth of 7-10 cm in rows spaced 60-90 cm with plant to plant distance maintained at 30-40 cm. Soak the seeds in water for 24 hours before sowing.

Interculture : Interculture operation should be done within 30-40 days of sowing.

Fertility management : Apply 40-60 kg N/ha in bands below the seed.

Diseases and pest management : A mold disease often destroy flower clusters in humid regions but diseases are not serious problem in drier climates of the region. Castor semilooper is the serious pest of this crop. Ekalux (0.05%), 1 litre/ha is very effective for the control of this pest.

Harvesting : The crop is harvested in about 120 to 170 days after sowing, depending upon the variety and rainfall distribution.

Yield : Under normal rainfall conditions, about 12 quintals of seeds can be expected. If there is occurrence of drought in the late season, only 6 quintals of seeds per ha can be expected. The long run average yield is 2.96 quintals of seeds per ha.

Storage : If the seed is not to be processed for oil extraction precaution should be taken to prevent rapid insect damage in storage.

Economics : At 1981 prices on per hectare basis, the estimated total cost of cultivation for traditional practices comes to Rs. 337. Additional costs on modern inputs (fertiliser and plant protection chemicals) comes to Rs. 404. Average gross income comes to

Rs. 829/- under traditional technology. If modern inputs are used, an additional income of Rs. 2543 per ha under normal rainfall conditions and Rs. 857/- under occurrence of drought in the late season can be expected.

About 85 mandays of labour is required per hectare which has not been accounted for working out economics as it is assumed to be contributed by family labour which has no opportunity costs at present in arid areas.

Sheep and Goat Husbandry

In Western Rajasthan, it is reported that about two thirds of the earning members of households follow animal husbandry as their main occupation. Shortage of fodder, high ambient temperature, low humidity, meagre water availability and salinity hazard have all made this refractory region particularly suitable for sheep and goat rearing. The total livestock population in Western Rajasthan during the livestock census in 1977 was estimated at 1,90,36,651 out of which goats and sheep constituted 32 and 35 per cent, respectively. In the arid region, where pressure on the grazing land is very high, sheep and goat predominate. The soil-climate conditions of the desert is considered more suitable for livestock farming than crop farming. It has been estimated that during the drought years, while agricultural production falls to less than 10 per cent of the production of a favourable year, the production of milk and wool is still over 50 per cent of that of a good year. Besides being capable of withstanding extremes of climatic and nutritional stresses, the desert livestock also benefit from seasonal migration. Hence the major programmes of desert development should aim at dairy development and sheep and goat development for wool and mutton.

GOAT

The goat's potential for extracting nutrients from areas which are unable to support larger livestock is well recognised. The desert goat's usually long sleek coat of hair provides insulation against penetration of thermal energy into the body. The goat of this desert is also a very thrifty animal in respect of water expenditure. In the livestock census of 1977, there were 6,16,90,92 goats which constitutc 32 per cent of the livestock population in the desert. In the desert during that census goats formed 50 per cent of the total goat population in Rjasthan state.

Breeds : Parbatsar and Marwari.

Feeding schedule : Browsing on shrub pastures comprising *Zizyphus nummularia* bushes and *Khejri (Prosopis cineraria)* leaves, etc. The average

dry matter intake of adult goats weighing about 45 kg is about 1.5 kg/day. During lean periods and drought years *Acacia arabica* pods and *Khejri* loppings can be fed. About 200 gm *bajra* or *guar* per animal during late pregnancy (about 30 days) is recommendad as supplementary feed.

Mineral mixture (Nuvimin forte) at the rate of 15 gm per animal per week may be given especially to young ones (for 2 months) and for the animals in advanced stage or pregnancy (for 1 month) at the rate of 30 gm per week.

Watering schedule : Thrice a week at the rate of 2 to 3 litres per animal each time for optimum meat production.

Common diseases : Mastitis, Pneumonia, Scabies, Foot-infection, diseases caused by internal parasities like intestinal worms, liverflukes etc.

Control measures : A. Drenching : (i) Thrice in a year in April, August and November with Nilverm.

(ii) In early monsoon season it is necessary to drench with hexachrorethane or distodin tablets.

B. Vaccination : i) Foot and mouth disease vaccination in early monsoon.

ii) Goat pox vaccination in the spring season.

C. Dipping : Aleast once in a year in Mareh before clipping, wirh Lindane liquid BHD. In case of skin diseases, the frequency of dippings can be increased.

Treatment : Due to warm climate, the chances of severe attacks of various diseases are comparatively lower than in other parts of the country. However,if outbreak occurs, nearby veterinarians have to be immediately contacted for diagnosis and treatment.

Management : i) Overgrazing of pastures has to be regulated.

ii) As far as possible, perennial grasses should be cultivated.

iii) Pastures should have legumes, grasses as well as fodder trees.

iv) Sown pastures of improved grass varieties should be propagated.

v) Rotational and deferred grazing systems are beneficial.

vi) The animals should have access to the shade of some trees during the hottest part of the day.

vii) Also it should be ensured that they are not required to walk very long distances for water.

viii) A few milch goats should be kept in sheep flocks to provide sufficient nourishment to the new born lambs. Mixed farming of sheep and goats is beneficial.

ix) Supplementary concentrate feeds should be given particularly during lean periods or drought years.

Labour : 2 men are required daily to look after a herd of 100 goats for attending to various works.

Clipping : Twice in a year in March and September.

Yield : About 70-80 kids are expected to be born every year out of 100 does. The goat kids thrice in two years under the farm conditions. The average milk yield of a desert goat is about 100 kg in a lactation of 6 months. A goat will yield about 0.5 kg of hair per year. A flock of 100 goats can produce about 20 tonnes of manure in a year.

Economics : At 1981 price, for a flock of 100 goats, the fixed cost comes to Rs. 1454/- per year. The total variable cost comes to Rs. 25,771. This consists of Rs. 17,500/- towards acquisition of animals and the rest towards feeding, animal health and care, clipping charges and interest on these items. The total cost comes to Rs. 27, 225. From sale of animals, milk, hair and manure a gross income of Rs. 50,325/- can be obtained from 100 goats per year. Thus a net income of Rs. 23, 100/- can be expected per year from 100 goats. Goat husbandry with scientific practices on protected marginal and submarginal lands would be much more profitable than sheep raising in arid areas.

About 2 men are daily required to look after the various works in a herd of 100 goats. Economics has been worked out assuming this labour being contributed by the family which at present has meagre alternative employment opportunities.

To start goat husbandry with 100 goats, more than Rs. 25, 000/- initial capital is required which is beyond the financial ability of many of the desert farmers. Protection through fencing of natural vegetation in about 45 hectares of marginal and sub-marginal lands for browsing by 100 goats needs additional capital of about Rs. 3, 000 per year. Thus adequate credit, feed, water, health and market facilities are required, if goat husbandry, which is eminently suitable for these areas, is to be promotcd.

SHEEP

In the 1977 census, there were 66,76,050 sheep constituting about 35 per cent of the total livestock population of Western Rajasthan constituted about 67 per cent of that in Rajasthan State. The Sheep concentration is high in the areas having less than 300 mm annual rainfall and in the tehsils lying along the foothills of the Aravallis. About 60 per cent of the total wool production in the State comes from Western Rajasthan. The wool produced is of medium quality.

Breeds : Magra and Marwari.

Feeding schedule : Allow the animals to graze on sown pastures of *Cenchrus ciliaris* and *Lasiurus sindicus* for about 8 hours a day. On an average, a sheep will eat about a kg of dry matter and hay per day. Utilise harvested fields for grazing during winter. About 200 gm *bajra* or *guar* per animal during late pregnancy (about 30 days) and in early lactation period (about 30 days) is recommended. Mineral mixture (Nuvimin forte) at the rate of 15 gm per animal per day may be given especially to young ones (2 months) and 30 gm per week for the animals in advanced stage of pregnancy (1 month).

Watering schedule : Twice a week at the rate of 14 litres per animal per week.

Common diseases : Sheep pox, Enterotoxaemia, Foot rot, Pneumonia, Scabies, Liverfluke, Intestinal worms, etc.

Control measures : (A) Drenching : Thrice in a year in April, August and November with Nilverm. In early monsoon season, it is necessary to drench with hexachlorethane or distodin tablets.
(B) Vaccination : Against sheep pox in spring season and enterotoxaemia in summer season.

(C) Dipping : Atleast two dippings, one in March and the second in September before shearing with lindane liquid BHC. In case of skin diseases, the frequency of dippings can be increased.

Treatment : Due to warm climate, the chances of severe attacks of various diseases in the desert are comparatively lower than in other parts of the country. However, if any outbreak occurs nearby veterinarians should be immediately contacted for diagnosis/ treatment.

Shearing : Twice in a year in March and September.

Management : Same as in the case of Goat husbandry.

Labour requirement : 2 men are daily required to look after a herd of 100 sheep for attending to various works.

Yield : About 70-80 lambs are expected to be born every year from a flock of 100 sheep. The sheep lamb thrice in two years uuder the farm conditions. A sheep will produce about 1.0 to 1.5 kg wool per year. A flock of 100 sheep can produce about 20 tonnes of manure in a year.

Economics : At 1981 prices, for a flock of 100 sheep, the fixed cost comes to Rs. 1454 per year. The total variable cost comes to Rs. 17,500 towards acquisition of animals and the rest towards feeding, animal health and care, shearing charges and interest on these items. The total cost (fixed and variable) comes to Rs. 31,879. From the sale of animals, wool, and manure a gross income of Rs. 38,025/- can be expected per year from 100 sheep. Thus, a net income of Rs. 6146/- can be expected per year from 100 sheep.

About 2 men are daily required to look after the various works in the herd. Economics has been worked out assuming this labour being contributed by the family which at present has meagre alternative employment opportunities.

To start sheep husbandry more than Rs. 25,000/- initial capital is required which is beyond the financial ability of many of the desert farmers. Since sheep have to be raised on sown pastures, establishment of about 15 ha of pasture for 100 sheep need additional capital. Thus adequate financial support and feed, water, health, and market facilities are required to promote sheep husbandry on commercial lines in the arid areas.

Grassland and Pasture Development

Livestock industry dominates the economy of Western Rajasthan. Between 1951 and 1971, the livestock nearly doubled here and hence the densiby of livestock per 100 hectare of grazing land increased from 72 in 1951 to 175 in 1971. Animal productivity is reported to be declining with every passing year. The total annual forage deficit in the arid areas of Western Rajasthan is reported to be around 47 lakh tonnes.

Improved strains of grasses and legumes are now available for increasing the productivity and fodder availability in arid areas.

GRASSES

Species/Strains/Cultivars

a) *Cenchrus ciliaris*—358, Molopo, 277, 392, 357 & 362.
b) *Cenchrus setigerus*—412, 415, 175, 76 and 413.
c) *Panicum antidotale*—331, 333 and 379.
d) *Lasiurus sindicus*—318, 319, 321, 352 and 353.
e) *Dicanthium annulatum*—490 and 491.

Propagation : Direct sowing of seeds or transplanting of seedlings and root slips.

Land preparation and soil working : Clean the field from abnoxious species and shrubs. One harrowing and levelling for sandy soils. For heavy soils, one ploughing followed by harrowing and levelling is to be done.

Time of sowing : Best sowing time is last week of June or first fortnight of July.

Transplanting : After receiving good showers, sow the grass seeds. Transplanting has to be done during rainy days.

Sowing/ Tranplanting ; Under normal rainfall conditions, use low seed rate and if rainfall coditions are not favourable, go for little higher seed rate. The seed rate per hectare varies with the species and it is as follows :

a) *C. ciliaris* — 6 to 8 kg
b) *C. setigerus* — 5 to 6 kg
c) *P. antidotale* — 2 to 3 kg
d) *L. sindicus* — 8 to 10 kg
e) *D. annulatum* — 2.5 to 3.5 kg

Two to three seedlings of 45 days old and 2 to 3 rooted slips from old plants per hill may be used if transplanted.

Method of sowing : Sow the seeds in lines. These lines are to be drawn at 50 to 75 cm spacing with desi plough or tractor. Seed should be mixed with wet soil and BHC 10% and stirred in furrows. Proper distribution of seeds in the furrows should be ensured.

Fertility management : Apply FYM at the rate of 5 to 10 tonnes/ha before sowing. In second, third and fourth year drill nitrogenous and phosphatic fertilisers at the rate of 20-30 kg per hectare each after receiving effective rains.

Weeding and interculture : One or two weedings after the seedling emergence in the first year. Interculture with tractor or desi plough after receiving effective rains in the subsequent years.

Seed collection : In absence of any mechanical method of seed collection, pick the seeds preferably from second cutting when the spikes ripen to half by stripping/rubbing the spikes gently with hands. Seeds fallen on the ground can also be collected, cleaned and stored.

Intercropping : Drill one line of legume (*mung/guar/moth*) in the inter row spaces using 6-8 kg seed rate per hectare after the receipt of rains enough to saturate the soil profile upto 90-100 cm.

After the germination of crops, cut the grass once. A second cutting of grass is needed if the competition is observed.

Harvesting : Harvest when flowers emerge or at 50 per cent flowering.

Yield : In case of *C. ciliaris, C. setigerus, L. sindicus* and *P. antidotale* under favourable rainfall conditions, 3 to 5 tonnes of dry fodder per hectare can be expected. Under unfavourable precipitation conditions, 1 to 2 tonnes of dry fodder per hectare can be expected.

Under normal conditions, the above grasses can give about 250 kg seed per ha. Under subnormal conditions, about 150 kg seed can be expected.

If intercropped with legumes, in good rainfall years, 6 to 8 quintals of grain from the legumes can also be obtained. In

normal years, 3 to 5 quintals of grain per hectare can be obtained. Besides 0.1 to 0.2 tonnes of dry fodder per hectare is also possible.

Carrying capacity : It differs from place to place depending upon the climatic conditions. On an average, these grasses sustain 3 to 8 sheep per hectare round the year.

Economics : At 1978-81 prices, considering four years as the duration of the crop, net benefits per hectare per year for important grass species are presented below :

1	*C. ciliaris*	Rs 1342.22
2	*C. setigerus*	Rs 5559.86
3	*P. antidotale*	Rs 81.14
4	*L. sindicus*	Rs 1289.22

The higher net benefits in case of *C. setigerus* is largely due to income from seed production of 11 to 13 quintals/ha.

LEGUMES

Some forage legumes classified as annuals and perennials have been identified for higher production and qualitative fodder.

Annuals : a) *Phaseolus aconitifolius* (*Moth*)—T3, TI, T16 and T24

b) *Cyamopsis tetragonoloba* (*Guar*)—B19—1—35 Durgapura Safed, 2470/12, HFG 182

c) *Vigna ungiculata* (Cowpea)—HFC 42—1 and FOS-1, Charodi—1

ii) Perennials : a) *Dolichos lablab* (Sew)—CAZRI—144 (biennial)

b) *Clitoria ternatea* (Aparajita)

c) *Atylosia scaraboides* (Vankulthi)

Land preparation and working : Clean the field from wild bushes and shrubs. One harrowing followed by levelling is needed for sandy soils. For heavy soils, one ploughing followed by harrowing and levelling is required.

Seed rate per hectare : *Moth* : 20 kg; *Guar* : 30 kg; Cowpea : 30 kg; Sew : 20 kg; Aparajita 10 : 15 kg; Vankulthi : 8—10 kg.

Sowing : Sow the annual legumes in lines with 25 cm apart while a spacing of 50 to 75 cm is needed for perennial legumes. Soak the seeds of Aparajita and Vankulthi before sowing.

Fertility management : FYM at the rate of 5 tonnes/ha alongwith 40 kg P_2O_5 per hectare should be mixed with the soil at the time of soil working.

Weeding and interculture : One or two weedings when the plants are 3 to 6 weeks old. For perennial legumes, after the establishment of the crops, interculture operation between the rows at the first effective rains is needed.

Diseases and pest management : Grasshoppers and aphids are the common pests. Grasshoppers can be controlled by dusting with 10% BHC. Aphids can be controlled by spraying metacystox 0.03%.

Harvesting : Annual legumes are generally harvested between September-October. Harvest the perennial legumes during the establishment year at the end of the period when they have put up growth. In subsequent years, two cuttings can be obtained under favourable rainfall conditions. Under favourable rainfall conditions, 'sew' can be maintained up to 5 years. 'Aparajta' upto 5 years and 'Vankulthi' up to 3 years.

Yield : Under favourable rainfall conditions 3 to 4 tonnes of dry matter can be obtained per hectare from annual legumes while it will be upto even 5 tonnes per hectare in case of perennial legumes. Under unfavourable rainfall conditions, 0.3 to 1 tonne of dry matter/ha can be obtained in case of annual legumes while it will be 1 to 1.5 tonnes per ha in case of perennial legumes.

Economics : At 1981 prices, on per hectare basis, the estimated total cost of cultivation of an annual legume fodder corp of moth under traditional practices comes to Rs. 168. Additional cost on modern inputs (fertilisers and plant protection chemicals) comes to Rs. 631. Average gross income from both main and by product comes to Rs. 405/- under traditional technology. Additional income from use of modern inputs comes to Rs. 1759/- under normal conditions. Under subnormal conditions investment in modern inputs is not profitable.

About 70 mandays of labour is required per hectare which has not been accounted for working out economics as it is assumed to be contributed by family labour which has no opportunity costs at present in arid areas.

Arid Zone Forestry

In India 22 per cent of geographical area is under forests whereas it is around 12 per cent in Rajasthan State and hardly 1 per cent in Western Rajasthan. It is estimated that our forest will all disappear within 20 to 30 years if our trees continue to be massacred at the present rate of one million hectare of forests a year. It is estimated that about 25% of India's soil is subject to erosion resulting from decimation of forests.

1. Nursery Technique :

   a) Use a well balanced potting mixture of sand, FYM and clay in equal proportion.
   b) Use cylindrical metallic, bottomless cotainers/polythene bags.
   c) Water at the rate of 9 litres at a time per set of 50 containers.
   d) Provide overhead shelter, during hot season.
   e) Raise live wind breaks around the nursery.
   f) Sow the seeds in nursery beds and in containers/polythene bags in August-September.

2. Afforestation technique :

   Species : a) Sandy plain sites : *Acacia tortilis*, (Israeli babool), *Prosopis juliflora* (Vilayathi babool), *Prosopis cineraria* (Khejri), *Azadirachta indica* (Neem), *Albizzia lebbek* (Siris), etc.
   b) Shallow sandy loam sites : *Acacia tortilis*, *Prosopis juliflora*, *Azadirachta indica*, *Albizzia lebbek*, *Zizyphus nummularia* (Bordi), etc.
   c) Sand stone rocky sites : *Acacia tortilis*, *Prosopis juliflora*, *Acacia senegal*, *Albizzia lebbek*, *Azadirachta indica*, etc.
   d) Saline sites : *Prosopis juliflora*, *Tamarix articulata* (Farash), *Salvadora oleoides* (Jal), *Salvadora persica* (Kharajal), etc.
   e) Shifting sand dunes : *Acacia tortilis*, *Prosopis juliflora*, *Prosopis cineraria*, *Acacia senegal*, *Albizzia lebbek*, *Tamarix articulata*, *etc.*

Soil working : a) Dig 60 cubic cm pits and fill to half with loose weathered soil before planting with the onset of rains in the month of July.

d) Shallow sandy loam sites : Perforate the pan to a depth of 90 to 100 cm by using a post hole digger. After ripping open the pan, loose weathered soil should be filled in the pits before planting.

c) Sand stone rocky sites : Select spots having pockets of deeper soil depositions. Adopt effective soil conservation measures such as contour trenches, check dams, etc., on slopes and foot hills. Do not consider sites receiving less than 250 mm rainfall for afforestation. Dig pits of 45 cubic cm or 60 cubic cm and half fill before planting the seedlings. Make crescent shaped ridge of 15 to 20 cm high across the local slope with the remaining dugout soil.

d) Saline sites : Rip open the pan to a depth of a metre by a tractor (D.C.8—Crawler type) followed by cross harrowing. Open up ridges of 1 metre wide at the base and 1 metre high with the help of dosers. Keep the interridge space of about 1.5 to 2m. Plant on the crest of ridges in pits.

e) Shifting sand dunes : Erect microwind-breaks or small barriers across the wind direction 2 to 5 meters apart along the contours on the slope and also as per the wind velocity. Erect barriers by burying vertically brush wood, grass, etc. with crown downwards in lines. Suitable brushwoods locally available near the site are *Leptademia pyrotechnica* (Khimp), *Zizyphus nummularia* (Ber), *Cratolaria burhia* (Samia) and *Panicum tuugidum* (Murat)

Spacing : Adopt 5m x 5m spacing for arid zone afforestation. For energy plantation, 2m x 2m spacing is suggested.

Planting : Plant sturdy seedlings of 9 to 10 months old during middle of July to first fortnight of August with the onset of monsoon. Seedlings should be planted in the pits provided with saucer like depression around the plants in plains or crescent shaped ridges of 15 cm height formed across the local slope in sloppy lands. In case of sand dunes, plant trees in strips of 20 m to 30m wide at 40m to 50m apart across the wind direction for planting grasses in between these wider tree canopies.

Cultural operations : Give 2 weedings and soil working a year round the plants for the first 3 years depending on the intensity of weed growth. Cross harrowing is also found to be beneficial.

Maintenance and after care : Protect the plantation from biotic interferences by wire fencing or thorn fencing round the plantation. If rainfall distribution is unsatisfactory or rain fails completely, water the seedlings at 9 litres per plant fortnightly till the end of March and weekly from April till a good shower is received in the month of July during the establishment year. Arrange for watch and ward to check illicit entry of livestock and tress-passers. Replace the casualties within the same year.

Felling for fuel wood : The rotation for felling trees for fuel wood may be fixed at 10 years under coppice with standard systems. After the end of the rotation a tree would yield about 80 to 100 kg of fuel wood in addition to top feed for livestock and thorns for fencing. These trees also provide seeds, shade, leaves as fodder, pods as concentrate for livestock and timber for small agricultural implements.

Economics : The economics in case of trees depends on the species, sites, spacing, intercrops taken, etc. At 1981 prices, and 14 per cent discounting, the generalised net income from raising important tree species of arid areas over one hectare is given below. The intangible benefits from growing these trees is not considered for economic analysis.

Tree species	Felling cycle (years)	Net income per year (Rs.)	Remarks
1. *Acacia tortilis* (5m x 5m)	8	2979	Grass production in interrow space, normal grass output.
—do—	8	479	Grass production in interrow space, subnormal grass output.
2. *Albizzia lebbek* (5m x 5m)	11	2977	Grass production in interrow space, normal grass output.
—do—	,,	512	Grass production in interrow space, subnormal grass output.
3. *Prosopis cineraria* (5m x 5m)	30	4056	Grass production interrow space, and normal output.
—do—	,,	1558	Grass production in interrow space, subnormal grass output.
4. *Eucalyptus sp.* (3m x 3m)	10	3215	—
5. *Prosopis juliflora* (3m x 3m)	6	880	—

The benefit cost ratios are estimated under different assumptions of cost-return changes. They are as follows :

	Assumptions	Tree species							
		Acacia tortilis		*Albizzia lebbek*		*Prosopis cineraria*		*Eucalyptus sp.*	*Prosopis juliflora*
		(i)	(ii)	(i)	(ii)	(i)	(ii)		
(i)	Estimated costs and returns	1.94	1.15	2.19	1.19	2.64	1.87	8.93	2.36
(ii)	Costs increase by 10% and returns as estimated	1.76	1.04	1.99	1.08	2.39	1.70	8.11	2.15
(iii)	Costs increase by 20% and returns remain as estimated	1.61	0.95	1.82	0.99	2.19	1.56	7.44	1.97
(iv)	Returns reduce by 10% and costs remain as estimated	1.74	1.03	1.97	1.07	2.37	1.68	8.03	2.12
(v)	Returns reduce by 10% and costs increased by 5%	1.66	0.98	1.87	1.02	2.25	1.60	7.65	2.02

Thus it can be seen that even under adverse conditions, raising these tree species seem to be profitable. Benefit cost ratio indicated in column (i) under each tree species denotes estimates under normal grass output and that in column (ii) under subnormal grass output.

It should be noted that estimated cost will be higher by around Rs. 200-300 per ha for soil working in sand stone rocky sites and shifting sand dunes. Similarly around Rs. 100/- per ha are additionally required for soil working in case of shallow sandy loam sites and saline sites.

Ber Plantation

In Rajasthan, the most common *ber* species is *Zizyphus nummularia* (Jharberi) which forms a predominant vegetation in the desert due to its extremely drought hardy nature. These bushes are lopped every year during winter from near the ground. After drying, the leaves are separated which provide nutritious fodder (*Pala*). The twigs are used as fuel and fencing material. The other most common type found in this region is *bordi* (*Z. rotundifolia*) which is upright in growth habit. Its wood is of a marginal timber value and is used for making farm implements and household articles. Both these types give small round fruits which are edible but have very little pulp. High yielding varieties of *ber* (*Z. mauritiana*) giving delicious fruits of large size can however be grafted on the seedlings of these species. Old planatations of these wild *Zizyphus* types can also be top worked with good varieties. *Ber* can be grown even on marginal lands.

Varieties : *Gola, Seb* and *Mundia.*

Propagation : Budding can be done on both bordi and jharberi root stocks. Raise root stock seedlings by sowing seeds in early April in 300 gauge polythene tubes, open on both ends, of 25cm length and 10cm diameter (300 guage) filled with sand, clay and FYM (1 : 1 : 1) mixture. 90 days old seedlings should be budded in July. Budded plants become ready for transplanting during August.

Land preparation : Dig pits of 60 cm depth and 60 cm diameter at 6m spacing in square system. Just before filling, a basal dressing with about 100 g. Aldrex or BHC dust in each pit must be given to control termites. Fill the pits with 0.5 cft of FYM during early July so that they settle with rain water. Plant the budded plants during rainy season. One or two irrigations must be given immediately after planting, if rain fails.

Training and pruning : Remove the shoots arising from the root stock below the graft union. Allow well spaced 3-4 main branches from about 30 cm.

height from ground level. This can be done by pruning during March. A second pruning for this purpose should be done in May. This process should be repeated in the second year. Keep the trees upright by training. See that no crotches should form upto the tertiary branching level. Allow not more than one upright growing side shoot from a node.

Prune the trees every year during May after the leaf fall. Smear the cut ends with a fungicidal paste.

Fertility management : With the onset of rains in July, apply two cft FYM per tree in the first year which should be raised to 4,9 and 12 cft per tree during second third and later years, respectively. Also apply 250 g bone meal to each tree during first and second year and 500 g bone meal per tree from third year onwards.

Diseases and pest management : Fruit flies damage the ber fruits. Apply either phosphomidon (Dimecron) 100-2½ ml. (half tea spoonfull) or Dimithoate (Rogor) 30 E-C-10ml. (2 tea spoonful) in 10 litres of water for 3 trees, first when about 70 per cent fruit set has taken place and next after 3 weeks. A third spray with malathion (Cythion) 50 EC (3 tea spoon in 10 liters of water) may be given after one month of the second spray, if needed. Powdery mildew is a serious disease of ber. Leaves, twigs and fruits are covered by white powdery mass of the fungus. As soon as initial symptoms appear, spray karathane 10 g in 10 litres of water for 3 trees. Repeat the spray after 3 weeks and whenever necessary.

Weeding and interculture : In the rainy season, one or two weedings may be needed. During summer months, before the onset of monsoon, one ploughing is beneficial.

Top working or Rejuvenation of old plantation : Behead the old trees of bordi or jharberi retaining a clean trunk, 1-2 m in height. Also retain 2-3 main branches above 1 to 1.5 m height on the tree trunk. Behead the branch leaving basal 30 cm of each during March to June. Buddable roots come in about 15-30 days after cutting back. Bud on these new shoots during April to July. Adjust beheading time in such a way that the buddable shoots develop during period when the bud sticks of the improved ber cultivars are likely to be available. On each branch, only one shoot should be budded with the scion from improved cultivars and others

should be removed. Sprouting and growth of the scion buds will start 10-15 days after budding. All the other shoots from the wild root stock must be removed.

Harvesting : Under rainfed conditions, fruit bearing starts from the second year.

Yield : During the second year, the yield may be around 10 kg/tree which increases to 20 kg in third year and 30 kg in fourth year. From 5th year onwards, over 50 kg fruits/tree can be expected.

Under irrigated conditions, however, the fruit yelid may be as much as 2-3 quintals/tree. Trees will remain productive till 30-35 years. The fruits can be sold fresh or after processing.

Post harvest processing technology : i) *Ber* squash

receipe : Fruit— 1 kg.
Water— 1 lit.
Sugar—800 g.
Citric acid— 10 g.
Potassium meta—350 ppm.
—bisulphite

Method : Destone the fruits, peel and make small pieces. Mix the fruit pieces in 1 lit water with 800 g sugar and 10 g citric acid and make pulp in a mixie. Strain through a muslin cloth and keep the strained juice in a glass bottle, preferably in the refrigerator. Sediments will settle dowu in the bottle within a week. Decant the juice, leaving the pulp. Add the preservative, potassium metabisulphite.

ii) *Ber* jam

recipe : Fruit— 1 kg.
Sugar—600 g.
Water— 1 lit
citrict acid— 7 g.

Method : Destone the fruits, peel and make small pieces. Mix with water in a mixie to make pulp. Transfer the plup to a steel utensil, add sugar and start heating. After 20 minutes, add citric acid. Cook until end point comes. When ready, pour it into a glass bottle and wax it.

iii) *Ber* preserve : Destone the fruit, peel and blanch in boiling water for 2-3 minutes. Prepare 30 per cent sugar solution and transfer the fruits in it. Next day, again raise the sugar concentration to 30 per cent either by adding sugar or by boiling the syrup. Keep the fruits in syrup for 2-3 days. Raise the sugar concentration to 35 per cent. In this way the sugar concentration has to be slowly raised to 66 per cent in 40-45 days.

iv) Dehydrated *ber* : Blanch the fruits in boiling water for 5 minutes and keep them in a dehydrator initially 45° C temperature. Raise the temperature slowly to 55° C and dehydration will be complete in about 3 days. They can also be dried in solar driers or in the open sun retaining about 10-20 per cent moisture in the plup and can be sold as Chinese dates.

Economics : At 1981 prices and 14 per cent discounting, the annuity value per ha from raising *ber* (seedlings) comes to Rs. 10933. This implies that one can except to receive a net income of Rs. 10,933/- per ha per year from raising *ber* (seedlings) in these areas. If the trees are topworked, the net income comes to Rs. 11,000/- per ha per year. Wage bill of one labourer who has to attend to miscellaneous works round the year has not been considered while working out annuity value. This is assumed to be contributed by family labour which has no opportunity cost at present in these arid areas. The annuity value is thus returns to this labour, land and management.

The capital cost per ha comes to nearly Rs. 3,000/- each in the first and the second year, around Rs. 6,500/- in the third year and 8 to 9 thousand rupees each year afterwards. More than 75 per cent of capital costs is towards fertility management. Costs exceed income upto the 3rd year. From the 4th to 8th year, a net income of more than Rs. 17,000/- per ha per year can be expected. From the 9th year onwards, the net income will be more than Rs. 19000/- per ha per year. The benefit cost ratio under estimated costs and returns comes to 2.58 : 1. This ratio reduces to 2.15 : 1 if costs increase by 20 per cent and returns remain as they are. The situation is more or less the same in the case of topworked plantations also.

Trickle of Drip Irrigation

In arid regions, where water is limited and of poor quality, drip system offers an efficient alternative to other systems of irrigation. Drip system is not affected by winds. It confines the irrigation water in close proximity to the root zone. Besides water economy, the other advantages of the system are use of saline water, fertiliser economy, restriction of weed growth, avoidance of land levelling and higher yields. Since the cost of installation is rather high, drip system seems to have potentials in growing only high value crops particularly fruits and vegetables around towns and cities.

Materials/ facilities required : Perennial source of water, with water conductivity upto 3000 μ mhos/cm. Pumpset and power to lift water. Drip system consisting of mainline (GI or PVC), submain (PVC), laterals (PVC), emitters, filter, fertiliser applicator, nipples (PVC), gate valves, and pipe fitting materials.

Layout : After land preparation and levelling, layout the drip system as required by the crop to be grown. The planting zone of the plots should be moistened before the seedlings are planted.

Crops suggested for drip system : This system is particularly useful for spaced row crops and plantation crops. In the experiments undertaken in the Division of Soil-Water-Plant Relationship of the CAZRI, Jodhpur, diverse crops such as Tomato, Cauliflower, Capsicum, Cabbage, Turnip, Long-gourd (loki), Round gourd (tinda), Ridge-gourd (tori), Watermelon, Muskmelon (Kharbuj), Potato and also maize, have been grown successfully.

Water use efficiency and water economy : Water use efficiency is twice as high with other methods of water application. A 50 per cent saving in water is observed by putting one lateral in between two rows.

Frequency of water application : In loamy sandy soils in hot arid regions, daily irrigation is suggested.

Rate of water application : In amounts equal to 68 per cent of the evaporation from a class A pan. In other words daily irrigate at a rate equal to the daily ET demand. Approximately irrigate for 2 to 3 hours for winter crops and 4 to 6 hours for summer crops.

Salinity rate allowed : Up to 3000 μ mhos/cm. However, tomato can tolerate salinity upto 10,000 μ mhos/cm.

Planting geometry : Double row planting reduced cost and water use by 50 per cent. Hexagonal planting for tomato is beneficial.

Nutrient application : Apply P and K with a drill at the time of planting. Nitrogen can be delivered with irrigation water in 9 to 10 equal applications every four days beginning 12 days after planting.

Yield potential : Upto 47 per cent increase in yield over furrow and sprinkler has been recorded in some vegetables.

Advantages and disadvantages of trickle system : (A) The advantages of the trickle system are as follows :

(a) Economy in the use of irrigation water arise from moistening only the root zone. Water thus is not unnecessarily wasted in the irrigation of inter-row areas.

(b) Transmission and evaporation losses (which may be substantial in dry regions) are avoided.

(c) Economy of fertiliser use is brought about through application only in the wet zone.

(d) Weed growth is restricted.

(e) Saline water may be used.

(f) Land levelling may not be often necessary.

(g) Assured good yields of various crops.

(h) Ensures improvement of quality of life of residents of deep deserts.

(B) The disadvantages are :

(a) Initial installation cost is high and has been estimated to be about Rs. 26,180 per hectare. But high returns from suitable crops is more or less certain, where other agronomic practices of management are normally adopted.

(b) Drippers are to be cleaned from time to time to avoid their choking.

Economics : At 1981 prices the estimated cost of installation of drip system on one hectare comes to Rs. 26, 108. If the GI pipes

are used for main line, another five thousand rupees are required. Assuming different life periods for various components of the system, 14 per cent rate of interest and 5 per cent of the initial investment towards annual repair and maintenance, the annual cost on drip irrigation comes to Rs. 8767/- per ha. If two crops, one in kharif and another either in rabi or summer is taken, the cost of drip system reduces to Rs. 4384 per crop per ha. If one do not have water resource, pumpset and power connections, development of these requires an additional investment of Rs. 24,360. The total annual cost on these comes to Rs. 1,843/- per ha per crop. This cost, of course, can be reduced since the use of these resources can easily be extended to areas more than a hectare.

The estimated net income (return to land and management) per hectare from growing crops under drip irrigation on research farm varied with crops. Considering costs towards drip system as well as water resource development the net income was higher in case of long gourd Rs. 48,699/- while it was Rs. 48,700/- and 41,515/- in case of watermelon and tomato, respectively. It was more than Rs. 12,000/- in case of cauliflower and potato while it was Rs. 5319/- in case of ridge gourd. The net incomes were negative (loss, in otherwords) in case of cabbage (Rs. 3,133), round gourd (Rs. 1,655), turnip Rs. (232) and Maize (Rs. 429),

The economics indicated above highlight the necessity of selection of sites (ready market), season (watching prices), and crops (higher yields) for sinking funds in highly capital intensive activities such as vegetable production under drip irrigation,

Rodent Pest Management

Rodents constitute one of the largest mammalian groups in the desert. It has been estimated that on an average, there will be about 100 rodents per hectare in Western Rajasthan while they will be around 20 on all-India basis. Rodents are responsible for causing serious damage to food grains, grasses and pastures, stored materials, orchards natural vegetation and plantations. Rodent control in desert is thus very important.

Pest status : 8 species *(Meriones hurrianae, Tatera indica, Rattus meltada, Gerbillus gleadowi, Funambulus pennanti, Bandicota bengalensis, Rattus rattus* and *Mus musculus)* have been identified as most harmful to the crops and stored foodgrains in Rajasthan.

Species composition : Delineation of relatively abundant rodent species in Western Rajasthan based on ecological distribution has been done.

Rainfall zone	Species
Upto 250 mm	*G. gleadowi, M. hurrianae*
250-400 mm	*M. hurrianae, T. indica*
400-500 mm	*R. meltada, T. indica.*
	G. ellioti

Population dynamices and time of control : To minimise the operation cost and to maximise the efficacy, large scale operation should be taken up during May and June (Population density and breeding rate of rodents being minimal during summer months).

Bait base : Bajra+3% groundnut oil is the most effective bait for mixing poison for rodent control.

Pre-baiting Pre-baiting should be carried out before poison-baiting for 2-3 days to minimise the effect of neophobic behaviour of rodents.

Toxicology of rodenticides : 2% concentration of zinc phosphide has been found to be equally effective dose for the control of rodents. The acute rodenticide vacor (RH-787) and anticoagulants

Brodifacoum and Chlorophacinone have also been found to be effective for field rodent control.

Bait shyness : Poisoning with Zinc phosphide should be carried out only on a single day during one operation. This poison should be used only after 3 months in the same area. If a repeat operation is needed, both bait and the poison should be changed.

Bait placement : The baits should be placed at a 10-15m interval for an optimal coverage of bait to all the rodents.

The control strategies

(a) Field

i) Poison baits: In crop fields, the rodent control operation should be taken up before the sowing of the crop. The active burrows be surveyed and pre-baiting (cereal floor or cracked grains 97 parts and vegetable oil 3 parts in the form of 1g ball or lump. 6g per active burrow opening) should be carried out on the first and the third day. On the fifth day, 2 per cent Zinc phosphide be added and the baits distributed. On the sixth or the seventh day all the burrow openings be closed. On the eighth day, in those burrows which open, aluminium phosphide tablets be placed at the rate of 1.5 g per burrow opening.

ii) One-shot baiting : The dry fruits of ber *(Zizyphus nummularia)* be soaked in 3mg kg sloution of 1080 (Sodium monofluroacetate) compound for 24 hours. One soaked ber along with unpoisoned ones be inserted in the live burrows.

(b) Residential premises : After assessing requirement of bait, poison and manpower, the crushed cereals (bait material) be mixed with 5% muster mix (0.5%) of anticoagulant (warfarin) poison. The bait be distributed in suitable containers on the second day and placed at 2-4 points with about 300 g bait per house and this baiting should be continued upto three weeks. The dead rodents should be buried deep in the ground.

The operation schedule :

(a) Crop fields and threshing floors

Day 0 : Survery of rodent burrow openings
Estimation of manpower and other requirement

Formation of operational squads
Distribution of work

Day 1 : Start pre-baiting

Day 3 : Pre-baiting

Day 5 : Mix poison, poison-baiting

Day 7 : Close burrow openings

Day 8 : Fumigation of burrows

Day 9 and 10 : Harbourage removal and sanitation

(b) Residential premises and godowns

Day 0 : Study of map of operational area Survey houses, back yards, etc. Estimation of manpower and other requirements. Formation of operational squads. Distribution and allotment of work.

Day 1 : Mix poison in cracked foodgrains. Distribution of bait stations, 2 to 3 per house.

Day 2 : Assess consumption, replenish for 5-6 days.

Day 7, 10, 13, 16, 20 : Collect and disposal of dead rodents. Replenish bait station for 5-6 days.

Day 21-22 Harbourage removal, sanitation and rodent proofing, storing of food grains in rodent proof structures.

Sustenance of operations : Long term control operations have indicated that for minimising losses inflicted by rodents, in some general area, the operation should be undertaken twice (before sowing of kharif and rabi crops) during a year for two years and then as and when required.

Economics of field rodent control : In Daijar, an ORP village of CAZRI, the cost of rodent control came to Rs. 1.80 per hectare. The returns from saving of bajra of both local and high yielding varieties under rainfed and irrigated conditions came to Rs. 400/- per hectare. Thus, a benefit-cost ratio of 220:1 is possible for rodent control under these conditions.

Since voluntary participation of farmers is emphasized in the progamme, labour costs (0.3 mandays per hectare) has not been accounted for working out costs.

Solar Energy and Wind Power Utilization

With the sharp increase in the price of petroleum products, the search for alternative sources of energy began. Energy from sun and wind are renewable, and pollution free. Moreover they are available at the place of use and as such the cost of transportation of them is minimum.

Many of the places in Western Rajasthan receive more than 3000 hours of sunshine a year and they are also favourably placed as far as wind velocity is concerned. Lot of scope thus exists for exploitation of these two alternative sources of energy in western Rajasthan.

A big obstacle in the extension of technologies in utilising these energy sources in villages has been reported to be technological complications. CAZRI has come up with certain devices which can be fabricated with minimum workshop facilities and technical skill.

SOLAR OVEN

In India, it is estimated that cooking fuel amounts for about 95 per cent of the total fuel consumption and major part of this energy (59 percent) comes from burning firewood. Hence cooking is the most potential applications of solar energy.

Model : SC : 2.

Materials required for fabrication : GI sheet, place glass mirrors, MS and aluminium angles, glass, sheet, wood, hard board, nails, bolts, screws, rivets, fibre glass, aluminium sheet, black board, enamel paint, castor wheels, etc.

Facilities required for fabrication : A skilled technican and facilities for gas welding.

Number of mandays required for fabrication by a skilled technician : 5

Life period : 8 years.

Practical utility : It can be used for (i) cooking rice, dal and vegetables at medium temperatures (ii) boiling of milk, tea, and (iii) baking of cakes on clear sunny days from 8.00 AM to 5.00 PM for a small family of 4 to 5 members. By using solar oven, about 30 to 35 per cent of the fuel consumption in cooking can be reduced on annual basis.

Limitations :

i) It cannot be used for baking of chapatis, rotis, etc.
ii) It cannot be used for deep frying in oil.
iii) It cannot be used on cloudy days.
iv) Cooking operations have to be carried out in open.
v) Needs adjustment facing towards sun.
vi) Glass sheets and mirrors used may break and need replacement.
vii) It is not a complete substitute to the existing practices followed for cooking food.

Economics

i)	Installation	: Rs. 600
ii)	Fixed costs/year	: Rs. 127
iii)	Variable costs/year	: Rs. 25
	Total cost per year	: Rs. 152

Benefits : Rs 150 (if charcoal is used) per year and Rs. 41 (if firewood is used)B-C ratio : 0.98 : 1 (if charcoal is used) 0.36 :1 (if firewood is used).

COLECTOR - CUM - STORAGE TYPE OF SOLAR WATER HEATER

Hot water is required for taking bath especially during winter season. Hot water is also used in several industries. Considerable qnantity of fire wood, charcoal, kerosene and electricity are being used for heating water throughout the country. These traditional sources of energy can be saved by adoption of solar water heaters.

Model : Collector-cum-storge type of water heater

Capacity : 90 litre

Materials required for fabricarion: GI sheet, M.S. sheet, m.s. and aluminium angles, glass sheet, wood, hard board, nets, bolts, rivets, screws, fibre glass, aluminium sheet, black board, enamel paint.

Facilities required for fabrication : A skilled technician and facilities for gas welding.

Number of mandays required for fabrication : 3

Life period : 12 years if used seasonally and 8 years if used round the year.

Practical utility : It can provide 100 litres of hot water at a temperature of about 40°C to 45°C early in the morning even during winter season or 100 litres of hot water at about 60°C to 70°C temperature in the afternoons or evenings.

Limitations : i) Glass glazings need replacement when they break.

ii) It can be used under intermittent cloudy weather conditions but on days with overcast skies.

Economics :

i)	Cost of installation.	: Rs. 600
ii)	Fixed cost per year (seasonal use).	: Rs. 92
iii)	Variable cost per year (seasonal use).	: Rs. 10
	Total cost/year	: Rs. 102
	Fixed cost per year (round the year use)	: Rs. 117
	Variable cost per year (round the year use)	: Rs. 10
	Total cost/year	: Rs. 127

Benefits Rs. 208 (if seasonal) and Rs. 433 (if round the year)
B-C ratio : 2.03:1 (if seasonal) 3. 41:1 (if round the year).

SOLAR CABINET DRYER

The traditional method of drying agricultural produce in open courtyard sundrying not only takes longer time but also is unhygienic practice. Further, about 10 to 15 per cent of the produce will be lost due to spoilage by birds and animals. Faster and hygienic methods of drying agricultural produce utilizing solar energy are now available for drying agricultural products.

Model : Solar cabinet dryer with chimney for regulation of temperature.

Capacity : 20 Kg.

Materials required for fabrication : MS sheet, M.S. angle, fibre glass, wire mesh, glass sheet, wood, nails, screws, hinges, black board, enamel paint, hard board.

Facilities required for fabrication : A skilled technician can fabricate using traditional tools.

Number of man-days required for fabrication : 5

Life period : 15 years

Practical utility : It can be used for dehydration of 15 to 20 kg chillies, fruits, and vegetables in about 3 to 5 days. The dried product can be preserved and stored for a long time and will be free from contamination by dust. By drying in solar cabinet dryers, the losses due to birds, animals, etc., which will occur under court-yard drying can be avoided.

Limitations : i) It can not be used for drying when persistent cloudy conditions prevail.

ii) The glass sheets need replacement whenever they break.

Economice : i) Cost of installation : Rs. 550

ii) Fixed cost/year : Rs. 76

iii) Variable cost/year : Rs. 33

Total cost/year : Rs 109

iv) Benefits : Limited if used for only drying chillies.

SOLAR STILLS

The ground water in most of the arid areas is saline with impurities content ranging from 5000 to 10,000 ppm. Difficulties in supplying drinking water to villages are felt due to their remoteness, long distances between the sources of ground water and the village, nonavailability of power, etc. Hence, utilization of solar energy for supplying potable water has lot of scope in these areas.

Model : Step basin type solar still.

Material required for fabrication : Aluminium sheet, wood, hard board, fiber glass insulation, glass sheet MS and aluminium angle, nipple, black board and enamel paint, nails, screws, etc.

Facilities required for fabrication : A skilled technician can fabricate it with traditional tools.

Number of mandays required for fabrication : 4

Life period : 10 years

Practical utility : It can be used for converting brackish water into distilled water. It provides about 6-8 litres of distilled water throughout the year on clear sunny days. The distilled water can be used i) for charging the batteries for tractors and Jeeps and ii) in laboratories of educational institutions. By mixing the distilled water, potable water can be obtained.

Limitations : i) The glass needs replacement as and when it breaks.

ii) On cloudy days the distilled water output will be less.

Economics : i) Cost of installation Rs. 800 per $1M^2$ area

ii) Fixed cost per year Rs. 136

iii) Variable cost per year Rs. 33

Total cost/year Rs. 169

iv) Output : 1000 litres of distilled water per year
Benefits : Rs. 350

v) B-C ratio : 2.07:1

WIND MILL

Places where wind velocity is sufficient, wind mills can be installed to lift the water. This can solve the problem of non availability or shortage of electricity for such purposes.

Model : Auto direct sail wing wind mill for pumping water.

Material required for fabrication : Dhawaral poles, Iron plates, angle iron, Nut and Bolts, steel bolts. Canvas cloth, Bamboos, M. S. shaft, Disposed brake drum, Clamps Springs, Iron flat Cement, Sand Gravel Bigend Bearing, ball bearing, packing felt, courter weight, GI pipe and pump, (reciprocating type) and other items.

Facilities required for fabrication : A skilled technician can make it, except for crank shaft and turn table which need to be done in a small workshop with facilities of lathe, shaper, etc.

No. of mandays required for fabrication : Technician : 30
Helper : 20

Life period : 10 years

Practical utlity : Can be used for pumping water from shallow wells and *tankas* when the wind speed is 8 kmph or more. A cluster of wind

mills can be utilised for irrigation purposes or it can be installled for taking only water for human or animal drinking.

Limitations : i) Can only be used from mid March to Sept. of every year efficiently for 20-25 days in a month.

ii) Minimum wind speed required is 8 kmph. It does not work below 8 kmph.

iii) Maximum efficient depth is 10 metres beyond that it works upto 25 metres depth but the discharge of water is very low.

iv) Minor damages have been noticed when the wind speed increases above 50 kmph.

Economics : Cost of installation : Rs. 3000. The Benefit-cost ratio of wind mill varies from place to place depending upon wind regime.