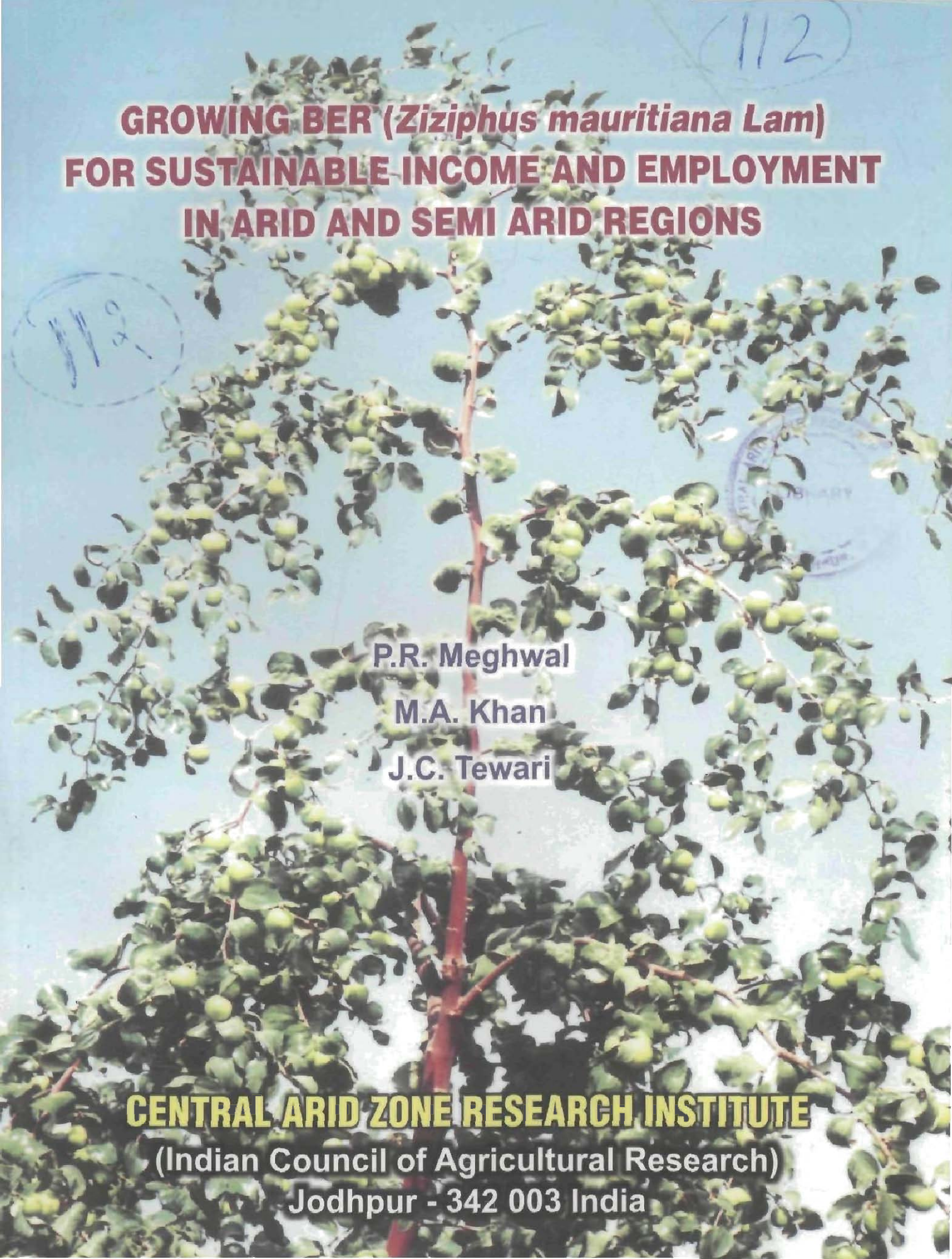

GROWING BER (*Ziziphus mauritiana Lam*) FOR SUSTAINABLE INCOME AND EMPLOYMENT IN ARID AND SEMI ARID REGIONS

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Growing Ber (*Ziziphus mauritiana* Lam) for Sustainable Income and Employment in Arid and Semi Arid Regions

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Front cover: Fruit laden branch of ber var. Gola.

Back cover: Heavy fruiting in plants of var. Illaichi (back ground) and ZG-3

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FOREWORD

Ber has changed scenario of horticulture both in arid and semi arid regions significantly. At present rainfed ber orchards are seen at all the places across the country. Varieties 'Seb' and 'Gola' are household names being equal to apple health wise are providing nutritional security to the rural poor with its availability at lower costs. In this horticultural revolution CAZRI has contributed its own might by standardizing the techniques on budding and nursery management. With mushrooming of nurseries around Jodhpur and in most of the places in Rajasthan, this propagation of ber brought in change in the rural and urban scenario. Popularly the planting material is known as CAZRI variety. It generated additional employment in the rural areas through pruning and budding.

The 'ber' is a solid solution for droughts and famines and offers a sound land use It can fit in any silvi-agri-pastoral systems without any constraint. This plant has not only capacity to butter the economics of poor farmers of our country but also in the deserts of Africa, Israel, West Asia and others. Its potential is being already noticed in these regions. Thus 'ber' can unite the people globally and offers nutritional security throughout the desert region cutting across political boundaries.

The CAZRI once having 74 varieties of ber has scaled down to 25 by continued selection. The work initiated in early seventies on ber at this Institute was never dreamt to expand so much. It was more self-replicated than taught. In this direction the work done of Dr(s). O.P. Pareek, B B. Vashishtha, M.P. Singh and others is always remembered with faith. They have added with time in eighties a few publications for popularizing the technologies These efforts of horticultural and extension scientists are highly appreciated by one and all. We also fondly remember the support and inputs of Shri Nand Kishore Jaisalmeria, a farmer, perfectionist and messiah of this work. Presently Dr. P.R Meghwal, Senior Scientist (Horticulture) and his team has endeavored to record efforts made and improvements thereof. This is a laudable job. This bulletin will be useful not only to the farmers, and extension workers but also to all the other readers who may be new to the crop.

K.P.R. VITTAL
Director, CAZRI, Jodhpur

PREFACE

Fruit trees have a major role in crop diversification and overall livelihood security Their importance is much more in highly vulnerable arid ecosystem where rainfall is scanty and drought is a recurring feature. Under such situations, the diversified production system with fruit trees as a major component reduces the risks, which are inherent in the monoculture of staple food crops. Fruits when processed and with value addition facilitates remunerative prices and ensure economic benefits to stakeholders.

Among arid zone fruits, ber (*Ziziphus mauritiana*) is the most important fruit plant It is a multipurpose fruit crop supplying fruits, fodder, fuelwood and fencing material Wild ber i.e., jhar ber (*Ziziphus nummularia*) and bordi (*Z rotundifolia*) have been growing in different parts of Rajasthan since ages. . In arid zone, where growing of most other fruit crops is difficult due to prevailing climatic conditions, ber offers a promise of success even under rainfed conditions. The production potential of rain fed ber is influenced largely by rainfall amount and its distribution. Ber plants utilize the rainwater most efficiently as their growth and flowering coincides with monsoon rain. Also, the fruit setting and its maturity are completed before the advent of hot and dry summer and depletion of sub- soil moisture after which the plants enter in dormancy, thus avoiding the adverse weather.

This bulletin has been prepared with an objective to create technological awareness on nursery development, production, processing, value addition, marketing and utilization of ber to policy makers, researchers, field workers and farmers We sincerely hope that the available information will be utilized at various levels to boost ber production to achieve livelihood security and for upliftment of socio-economic status of stakeholders.

We express our sincere thanks and gratitude to Dr. Pratap Narain, Ex-Director, CAZRI for his constant encouragement in preparing this bulletin and to Dr. K.P.R. Vittal, Director, CAZRI, for his valuable guidance and help in giving the bulletin to final shape. Thanks are also due to Director General and Deputy Director General (NRM), Indian Council of Agriculture Research for providing financial assistance for the bulletin. The secretarial assistance was given by Shri Narayan Ram Gundi and Mrs Aleyamma Varghese, for which we are thankful to both of them.

P.R. Meghwal
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J.C. Tewari

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1. Introduction

The Indian arid zone is spread over about 31.7 m ha area in the states of Rajasthan, Gujarat, Maharashtra, Andhra Pradesh, Punjab and Haryana. Since the major potential area for growing traditional fruit crops have already been exploited, the emphasis is now shifted for utilization of vast land resources spread in arid areas, where several indigenous fruit crops like ber can successfully be grown.

The Indian ber or jujube (*Ziziphus mauritiana* Lam.) is one of the most ancient cultivated fruit trees grown in north Indian plains. In the arid zone, R&D on ber was started way back in the late fifties with the establishment of CAZRI, Jodhpur in the year 1959. Later the research work on ber got impetus with the start of Cess fund scheme "Research on some selected fruits in the arid and semi arid areas" during 1976 to 1981 In due course, this scheme was merged to cell III of the All India Coordinated Fruit Improvement Project (AICFIP). During seventh plan, the cell III of AICFIP was restructured to form an independent All India Coordinated Research Project on Arid Zone Fruits (AICRPAZF) with 13 centres representing different agro-ecoregions of the country.

The arid regions experience scanty rainfall (100-400m), frequent drought with erratic distribution of rains which often results in complete or partial failure of annual crops. However, ber being perennial hardy fruit tree, gives some income to the resource poor farmers even in the severe drought It can be grown even on marginal land or inferior soil where most other fruit trees either fail to grow or give very poor performance. It is the only fruit crop which can give good production even under rainfed conditions. It can be grown in a variety of soils and climatic conditions ranging from sub tropical to tropical. However, its systematic plantations are sporadic. There are three main species of ber found in north-western India. The *Ziziphus mauritiana* is the main species of commercial importance with its several varieties. Other species, Z. *nummularia* is prized for its leaves (rich in protein) which provide fodder (Pala) for livestock in summer months particularly in fodder deficient areas of Rajasthan. The third species, Z. *rotundifolia* also bears edible fruits but of smaller size. It is used as rootstock for commercial ber (*Z. mauritiana).* It has long upright branches with stipular spines which makes very good fencing materials

2. Composition and Uses of Different Parts of Ber

Fruits and leaves

The ber fruits are rich in vitamin C and sugar with fair amount of mineral constituents (Table 1). Ber is richer than apple in protein, phosphorus, calcium, carotene and vitamin C and excel oranges in phosphorus, iron, vitamin C, calorific values and carbohydrates. According to FAO/WHO recommendation, the daily diet of an adult man should contain 30 mg ascorbic acid. This requirement can be met by including three ber

fruits in daily diet. Besides, the use of fruits as dessert purpose, it can also be processed to prepare preserve, candy, dehydrated ber, jam and ready to serve drink.

The bark is used in diarrhoea, while roots are used as decoction in fever and its powder is applied to ulcers and old wounds. The leaves are used to treat conjunctivitis. The fruits are laxative, invigorating, remove burning sensation, alleviate thirst, control vomiting, and blood disorders. The leaves are anthelintis and good in stomatitis, gum bleeding, asthama and liver complaints. The astringent seed is a tonic for heart and brain, and alleviate thirst

Table 1. Nutritional value of ber fruits

Constituents	Value
Total soluble solids	13-20%
Acidity	0.2-0.8%
Ascorbic acid	70-165 mg/100 g pulp
Vitamin A (ß carotene)	80 IU/100g
Protein	0.9%
Carbohydrate	12.8%
Reducing sugar	3.1 %
Total sugar	10.0%

Source : Jawanda and Bal (1978)

Ber leaves especially those of jhar ber *(Ziziphus nummularia)* are good source of fodder for desert animals such as sheep, goat, camel and cattle. In arid regions, it is more popular because of its ability to grow and regenerate quickly even under environmental stress The leaves are rich in protein and minerals (Table 2)

Table 2. Composition of *Z. nummularia* leaves on dry weight basis

Constituents	Values (%)
Crude protein	12.9-16.9
Ether Extract	1.5-2.7
Crude fibre	13.5-17 5
Nitrogen free extract	55.3-56.7
Total ash	10.2-11.7
Calcium	1.42-3.59
Phosphorus	0.21-0 33

Source : Anonymous (1976)

The palatability of air dried leaves for both sheep and goat is more than khejri leaves, the other prominent top feed species in Thar desert. A jhar ber bush can produce 2.5-3 kg air dry leaves per year (Bohra and Ghosh, 1981). Even under extreme arid condition (100-125 mm annual rainfall), a ber tree (*Z. mauritiana*) can yield 3-5 kg green leaf fodder. For collecting leaves of jhar ber (called pala locally), the bushes are cut at ground level at the end of kharif season. They are allowed to dry under sun for a week which facilitates the leaves to drop off and separate from the branches. The left out underground stump remain dormant till next monsoon season when it resprouts and, thus cycle is repeated.

Branches

After collecting the leaves from jhar ber, the left over highly thorny branched portion form very good fencing material. The use of jhar ber bushes for preparing boundaries around dhanies (rural household) is a well known practice particularly in Barmer, Bikaner, Ajmer, Jodhpur and Jaisalmer districts of Rajasthan state (Fig 1). Such bushes are also used to protect the heaps of grasses (meant for storage) from stray animals. The commercial ber also yield large quantity of fencing material as a result of annual pruning. During pruning some of the thick dried and undesirable branches are removed, which constitute very good fuelwood and can produce good quality charcoal. The quantity of fuelwood/fencing material produced is dependent on severity of pruning, however, on an average 10-20 kg $tree^{-1}year^{-1}$ air dried materials can be obtained.

Timber wood

The wood of cultivated ber trees may not have much value as timber but the wild type *(Z rotundifolia)* is moderately durable and can be used in a variety of purposes such as house post, handles of agricultural implements and other tools, tent pegs, posts of charpai etc.

Lac culture

Ber trees are considered one of the best host for raising of lac insects *(Kerria lacca* and *K. sindica)* (Fig. 2). Lac yield upto 1.5 kg per tree per year was obtained by collecting it during October -November at Ranchi (Anonymous 1996). By using 6-8 and 2-3 m long shoots of 2-3 cm thickness on a stump for inoculation by lac insects, yield of 3-6 kg of raw lac can be obtained in three years. However, in such cases, fruit production has to be foregone.

3. Varietal Collection and Evaluation

Wide range of germplasm consisting 74 varieties were collected and evaluated for their performance under arid zone (Fig. 3-6) The collected germplasm showed variation in vegetative characters, flowering, fruiting and time of maturity. Morphological characteristics of 59 ber cultivars were studied at CAZRI. The cultivars showed different growth forms ranging from erect branching habit to vine like and spreading types. On the

basis of anthesis time, the cultivars were grouped in two groups i.e morning time and afternoon (Desai and Patil, 1978). The fruit maturity time is specific to particular cultivar and depend on agro-climatic conditions (Table 3). Thus, based on time of maturity, the cultivars can be grouped into early, mid season and late season (Table 3). However, the meaning of early, mid season and late season cultivars will have to be understood with respect to agro-climatic location. In Haryana, east Rajasthan, Punjab and Uttar Pradesh, the early cultivars ripen during February, while in west Rajasthan they ripen during January, in Gujarat during December, in Bangalore during September and in Maharashtra during October (Vashishtha, 2001). Umran (Katha/Ajmeri), Gola, Seb, Kaithli, Banarasi Karaka, Maharwali, Meharun and Mundia are important cultivars. The cultivar Gola have good yield potential but poor storage life whereas, Umran and Maharwali have better shelf life

Twenty two cultivars were evaluated at CAZRI, Jodhpur under rainfed condition with respect to mean fruit yield and physico-chemical characteristics during normal, sub normal and drought year (Table 4). The cvs. CAZRI Gola, Gola, Chhuhara, Mundia and Kaithli gave higher yield compared to others. It was interesting to note that even under severe drought of 2002 with a rainfall of merely 39 mm, the cultivar Gola, an early fruit yielding one, gave mean yield of 14.33 kg tree^{-1}, which can well be considered good for growing ber for drought proofing.

Table 3. Classification of ber cultivars on the basis of fruit maturity period at different locations in India

Location	Early	Mid Season	Late
Rajasthan	Gola, Mundia	Jogia, Seb, Banarasi, Karaka, Kaithli, Banarasi Pebandi	Umran, Maharwali Bagwadi, ZG-3 Kali
Harayana	Gola, Safeda selected, Sandhura Narnaul, Chonchal	Kaithli, Sanaur-5, Muria, Mahrara (Mundia) BanarasiKaraka	Umran, Illaichi
Punjab	Nazuk, Gola, Safeda Selected, Sandhura Narnaul	Banarasi, Dandan, Kaithli	Umran, Illaichi, ZG-3
Maharashtra	Shamber, Badami, Gola	Sanaur-2, Maharun, Chuhara	Umran
Tamil Nadu	-	Banarasi, Kaithli	-
Andhra Pradesh	Gola, Mundia	Kaithli, Umran, Seb	Banarasi
Gujarat	Gola, Mundia	Banarasi Karaka, Kaithli	Vikas (Randeri), Umran (Chameli)

Source: Singh *et al.* (1973); Pareek (1983)

Fig. 1. Fencing materials available from ber bushes & their uses

Fig. 2. Lac insect infested ber twigs :
Potential source of lac production

Fig. 3. ZG-3 variety of ber

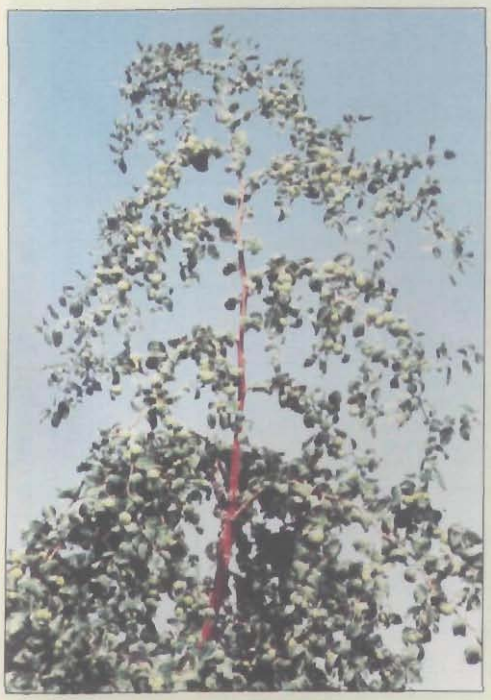

Fig. 4. Gola variety of ber

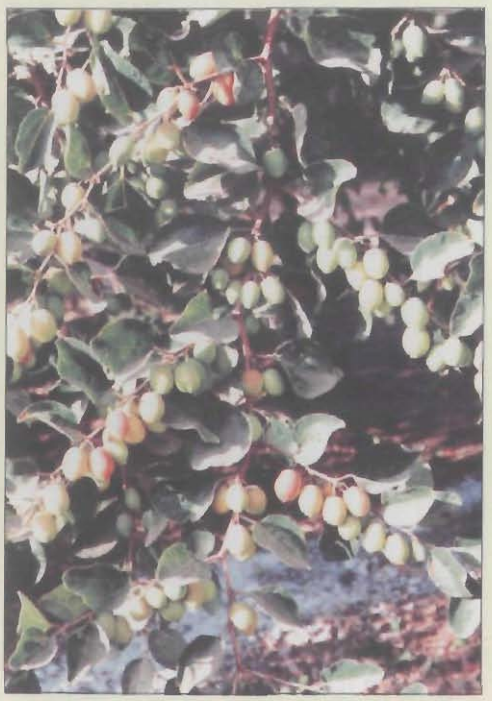

Fig. 5. Tikdi variety of ber

Table 4. Physico-chemical characteristics of fruits of different ber cultivars as influenced by rainfall (normal, subnormal and drought years) at CAZRI, Jodhpur).

Cultivars	Parameters	Fruit weight (g/fruit)			TSS (^{0}Brix)			Acidity (%)			Fruit yield (kg/tree)		
	Year	1995	2000	2002	1995	2000	2002	1995	2000	2002	1995	2000	2002
	Rainfall (mm)	339.6	292	39	339.6	292	39	339.6	292	39	339.6	292	39
1. CAZRI Gola		21.20	19 20	17.68	21.00	19.00	19 00	0.48	0 56	0 58	33.86	15.21	05.51
2. Chhuhara		20.30	16.20	14.12	19 00	23 60	14.12	0 18	0.21	0.22	26 74	13.13	06 26
3 Bagwadi		18.20	17.30	12 74	20.00	21.00	19.00	0.38	0.39	0 46	20.74	11.15	02 48
4 Jogia		24.00	16.30	12.46	18.00	18 80	18.00	0.38	0.41	0.45	18.85	16 70	08 90
5 Mundia		32.20	14.70	13.09	19.00	19 60	16.00	0 44	0 43	0.49	26.06	12 00	05 65
6. Seb		19.80	18.10	16 10	17.00	20 00	18 70	0 30	0 38	0.41	17 03	15 40	08 61
7. Dandan		27 60	17.20	16.18	20 00	23 60	19.00	0.21	0 25	0.31	18.15	14.80	03.85
8. Thornless		16.30	15.30	12.23	15.30	19.00	19.00	0.28	0.31	0 34	16 00	06.20	04.28
9. Banarsi Karaka		26.00	19.20	18 32	17.00	19.00	16 00	0.11	0.17	0.20	19 09	13.86	02.50
10. Kaithli		29 50	19 00	15.01	15.00	22 80	17.00	0.38	0.45	0 44	24.66	14.79	02 43
11. Banarasi Pebandi		33 30	15.40	10 51	20 00	22.40	20 00	0 23	0.38	0.48	18 14	08 26	01 28
12. Aliganj		20 70	16.20	15.28	23 40	23.40	18.00	0 16	0 52	0.50	14.95	07.29	02 85
13 Sanaur-5		18.70	15.50	14 21	14.20	21 00	15 00	0.12	0.42	0.23	15 59	10.26	03.75
14 ZG-3		18.60	15.20	13.94	18.00	23.70	18.00	0.22	0.35	0.38	18 30	12.50	02.50
15. Kali		16 50	14 20	14.88	19.00	24 00	19 00	0.33	0.42	0.42	21 59	13 10	06.20
16 Katha		26 20	22.20	20.78	25.00	26 00	20.00	0.21	0.26	0 27	27 24	17.20	06 86
17. Umran		30 80	24.60	22.31	29.00	27 00	21.00	0.38	0.42	0 41	18.82	15.29	09.46
18. Rashmi		13 80	12.60	10.18	20.00	26 08	22 00	0 38	0 44	0 46	15 75	07 02	01.91
19. Illaichi		11 20	08 00	07 32	23.00	24.00	20 00	0 38	0.39	0.36	15.87	09.86	11.90
20 Gola		21.80	16.90	13 02	17 00	21.00	20.00	0.51	0 60	0 59	29.34	19.32	14 33
21. Maharwali		18.00	15 05	13.09	17 50	19.40	18.00	0.44	0 49	0 55	21 96	13.20	03.26
22. Tikadi		06.20	05 80	05.34	13.00	18.00	15.00	0.16	0 28	0 29	18.22	12.80	11 20

Source:Anonymous(2000)

4. Agro-climatic Requirements

The ber is one of the most hardy trees adapted for growing under varied agro-climatic conditions. It can be grown on marginal lands, where most other crops fail It is an ideal fruit crop for both arid and semi-arid areas. Ber tree can tolerate temperature as high as 49- 50°C though, fruit set is adversely affected if the temperature shoots above 35°C during flowering/fruit setting period. It enters in dormancy during extreme summer by shedding leaves. The emergence of new shoots start with the onset of monsoon during June-July, however, the sprouting may start in summer also and dormancy may not last longer, if the summer temperature is not extreme. Ber trees can also withstand short period of freezing temperature, though, frost can kill the young twigs and developing fruits. To be safe, ber trees should not be grown in areas experiencing temperature lower than 4°C for extended period. Production of ber fruits require average annual rainfall of about 400 mm The performance of ber is adversely affected in humid areas receiving rainfall above 1500 mm Ber grows on wide variety of soils from gravelly, shallow soils to deep aridisols to some extent in entisol (Pareek, 1983) Neutral or slightly alkaline soils are good for growth and production of ber.

5. Plant Propagation

In the past seed propagation was common therefore, seedling trees are still found in many parts of the country. Vegetative propagation of improved varieties is very essential to make ber cultivation commercially viable venture. Only budded plants should therefore, be preferred to for commercial plantation. The ber is commercially propagated by budding on to the seedling rootstock of *Z. rotundifolia* or *Z. mauritiana*. The seed stones are used to obtain seedling rootstock for budding. Each seed stone contains 2-3 seed kernel inside the endocarp of the drupe. Seedlings of bordi (*Z. rotunudifolia*) or commercial ber are generally used as rootstock.

Rootstock

Four rootstocks viz., *Z. nummularia, Z. mauritiana Z spinachristi* and *Z rotundifolia* were tried to find out the best rootstock for commercial ber varieties Seb and Gola at CAZRI. The maximum fruit yield per plant was recorded in both Gola and Seb cultivars budded on *Z. rotundiflia*. Maximum plant height, canopy spread, in east-west and north-south direction as well as stem girth was recorded on *Z. rotundifolia* while least values of these growth parameters were recorded on *Z. nummularia* (Table 5). The rootstock *Z rotundifolia* also performed better in terms of fruit yield (38.3 kg tree^{-1}) as compared to *Z. nummularia* (30.5 kg plant^{-1}). However, the fruit yield was at par on *Z. mauritiana* rootstock.

Table 5. Effect of different rootstocks on performance of ber cv. Gola after 10 years of planting

Rootstock	Plant height (m)	Canopy (m)		Stem girth (cm)	
		E-W	N-S	Below union	Above union
Z. rotundifolia	1.8	4.38	4.57	7.8	5.25
Z. nummularia	1.53	3.37	3.13	4.4	3.24
Z. mauritiana	1.67	4.02	4.06	7.1	4.59
Z. spinachristi	1.77	4.2	4.1	7.13	4.94

Raising of rootstock

Ber seeds require certain period of after ripening for good germination. The germination increases after one or two months of extraction and one year old seeds germinate better. Partial removal of endocarp result in higher seed germination. Complete removal of endocarp gives still higher percentage germination. Although acid scarification with concentrated sulphuric acid for six minutes has been advocated, however, mechanical extraction is still better and practiced commercially. The seeds can be extracted from seed stone by carefully breaking the stone with a small hammer or a piece of stone without damaging the inner seed kernel (Fig 7). The extracted seeds can germinate within a week after sowing. These seeds can be sown directly on the field in prepared pit at 6x6 m spacing for *in-situ* planting. In the nursery, polythene tube or bag (perforated at the bottom) filled with rooting mixture can be used for sowing the seeds. The tubes or bags should be 25 cm long, 10 cm in diameter and of 300 guage. The best media for seed germination is sand, clay and organic manure mixed in 3:1:1 ratios. The powdered goat manure has been found to be the best as organic manure.

After filling the tubes with potting mixture, they are laid in sunken nursery beds. The tubes may be arranged in an upright position on either side leaving a 20 cm space in the center to facilitate better light and air penetration and to avoid over crowding. The extracted seeds of rootstock should be sown @ 2 seeds per tubes at 2 cm depth. The nursery bed needs to be watered on alternate days. Maximum germination takes place at 30^0C. The sowing of the seeds are done during March-April in north-west India for getting buddable rootstock thickness by June-July. The seedlings can be transplanted on the field when they are 90-100 days old for *in situ* budding. Polytube raised seedlings (Fig.8 & 9) develop straight root system and therefore, make vigorous growth comparable to those raised directly on the field In commercial nurseries, seedlings are budded while still in polytube at the age 90-100 days. The polythene tubes remain

protected from disintegration by solar radiation as they remain in sunken beds. The tubes also remain free of algal growth due to absence of light in the sunken beds

Role of bio-inoculants in raising of rootstocks

The use of nitrogen fixing bacteria, AM-Fungi and their combination has significant influence on growth of rootstock seedling in the nursery as well as in the field for *in-situ* budding. These bio-inoculants complement in producing healthy and buddable seedlings 15-20 days earlier than those uninoculated ones (Table 6 & 7).

Budding

The bud wood for budding should be collected during active growth period during June-July. The bud sticks with well-swollen and recently matured buds, which have not opened yet are collected. The bud wood should be collected from juvenile shoots Such shoots can easily be produced by severe pruning of the mother trees. The bud wood retain good viability when kept in ventilated conditions and wrapped in moist jute cloth (Pareek, 2001).

Different methods of budding have been tried with varied degree of success. However, 'I', 'T' and patch budding are most commonly followed. Budding should be done at 10 cm height on seedling with stem diameter of pencil thickness. Lopping and topping of rootstock from 8 days to 15 days after budding in the nursery bed has been found to ensure 90-100% success. However, in practice rootstocks are topped just before budding. All side emerging shoots and leaves are also removed prior to budding.

The success in budding is high during active growth phases of both rootstock and scion During the active growth period the sap flow is more and the bark can be easily separated from the xylem. The bud take is higher at temperature of 30-40^{0}C with relative humidity (RH) above 50% The bud take declines at RH below 36% and when temperature drops to 18-20^{0}C. In northwest India, June to September is the most ideal time for budding.

Transplanting and transport of budded plants

In polytube raised rootstocks budlings become transplantable after 30 days of budding The polytube containing budlings are removed from nursery bed and kept in shade for a week for hardening If the budlings are to be kept in the nursery bed beyond 30 days of budding, they have to be shifted to another bed after every month so that their roots do not penetrate deep in nursery bed. If the roots go deep in the bed then transplanting shock is more and chances of mortality during transplanting or transport increases. Hardened plants in this manner have more than 90% survival in transplanting. The technique has also been standardized for long distance transport of budlings in truck.

Fig. 6. Heavy fruiting in a plant of Ilaichi variety of ber

Fig. 7. Fruits and seeds of *Z. rotundifolio* for use as root stock

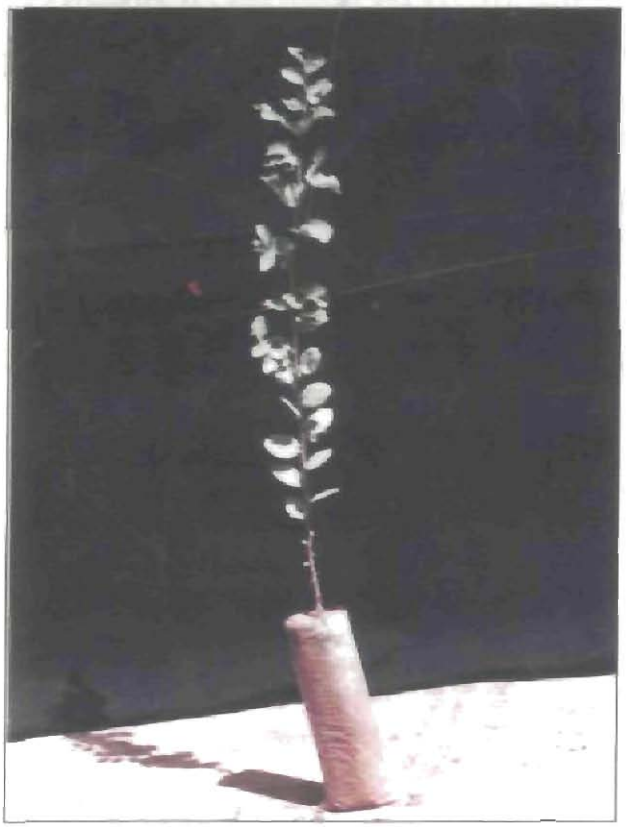

Fig. 8. Rootstock seedling ready for budding

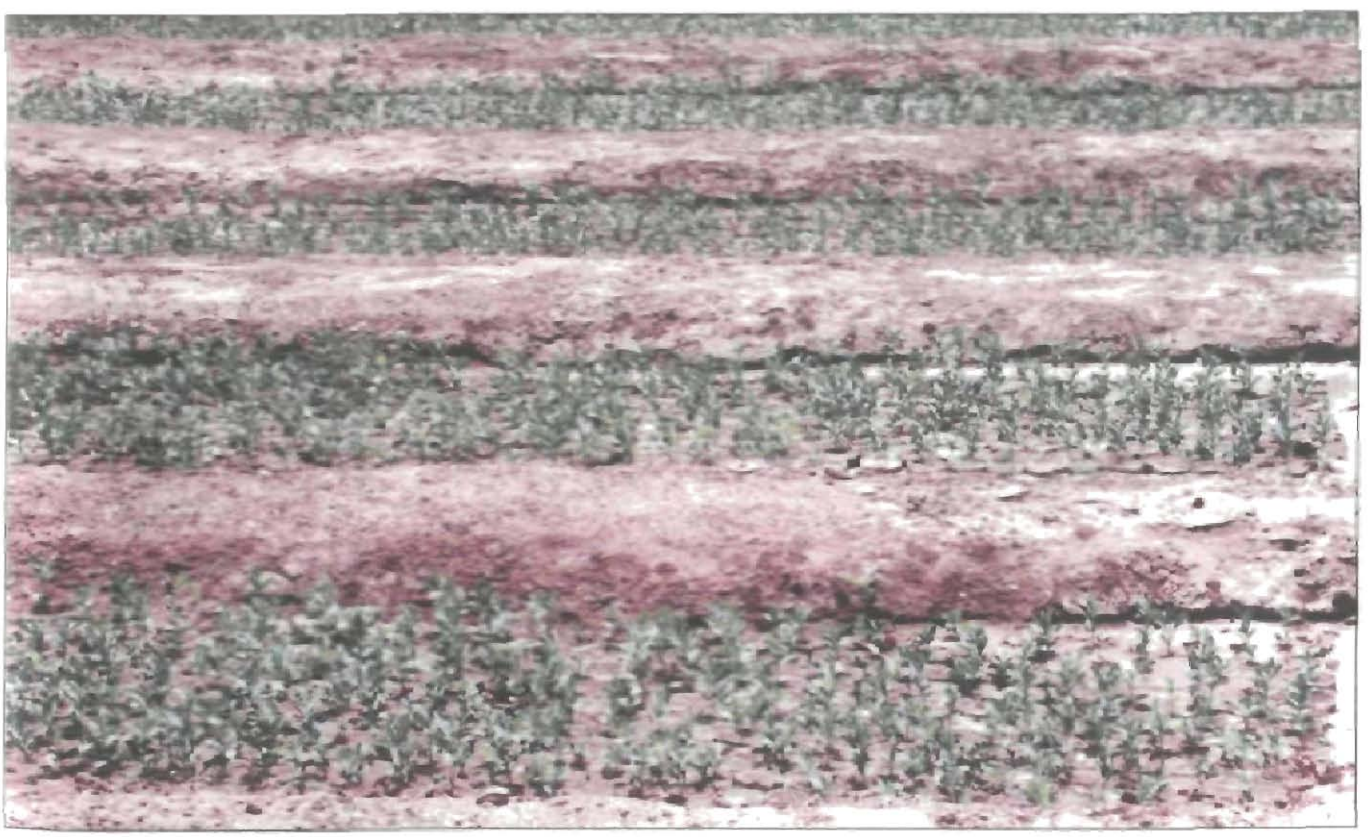

Fig. 9. A view of seedlings raised in nursery beds.

Table 6. Growth of ber seedlings as influenced by bio-inoculants in the nursery).

Organism	Germination (%)	Seedling height (cm)	Leaf area (cm^2 $plant^{-1}$)	Shoot dry weight (g $plant^{-1}$)	Budding success (%)
Control	81	28.1-	265.6	1.29	64
Azospirillum	91	38.0	400.0	1.81	76
Azotobacter	85	40.0	355.8	1.52	75
Glomus mosseae	83	40.0	349.1	1.72	84
G. fasciculatum	82	42.0	305.8	1.60	89
Azotobacter + G. mosseae	94	45.5	419.1	1.98	93
LSD (P=0 05)	NS	34.0	37.4	0.22	9

Source: Meghwal *et al.(2000)*)

Table 7. Effect of bio-inoculants on growth of ber plants in the field.

Biofertilizer	Plant height (cm) *	Fresh weight of pruned wood (rootstock)** (g $plant^{-1}$)	Fresh weight of pruned wood (budded portion) (g $plant^{-1}$)
Control	38.0	345	690
Azospirillum	54.9	580	985
Azotobacter	55 2	475	945
Glomus mosseae	66.7	480	915
G. fasciculatum	67.2	509	971
Azotobacter + G.mosseae	72.1	536	1060
LSD (P=0 05)	4.3	49	72

* 6 months after transplanting

** 10 months after transplanting

Source: Meghwal *et al.*(2006)

The budlings are first packed in wooden cartons, the upper portion of such cartons being kept open and placed in truck,in 4-5 tier system. For very long distance transport through aerial route a polypack method has been devised in which bare rooted budlings are wrapped in sphagnum moss grass soaked in nutrient solution (0.2 g potassium nitrate, 0.8 g calcium nitrate, 0.2 g magnesium sulphate, 0.2% potassium hypo phosphate and 1 ml of 0.5% ferric tartarate along with 0 2% Dithane Z-78) and kept in polythene bags. The leaves and stem are kept out of bag and tied securely to avoid moisture loss (Pareek and Vashishtha, 1980).

6. Orchard Establishment

An improved ber orchard can be established by following methods:

Planting of budded plants

The digging of pits for out planting the budded plants should be done in hot weather during May-June The lay out for planting is generally done on square system. In western Rajasthan, planting distance of 6-7 m has been recommended After lay out, pits of 60x60x60 cm size are dug and filled with a mixture of top soil, FYM (about 10-15 kg) along with 50g endosulfan (4%) powder to guard against risk termites. Planting is done after one or two rainfall when soil is well settled. While planting, the polythene tube is carefully removed by cutting from one side without disturbing the earthen ball and root system. The soil around the budling needs to be pressed from all sides after planting and watered immediately. Subsequently irrigation at 4-5 days interval is required for the first two months.

In situ budding

In situ budding is of great importance to establish orchard under rainfed condition in arid areas (Fig.10). Establishment of orchard by this technique for resource poor farmers has been suggested. In this method seeds of rootstock species are sown right there on the field at the recommended spacing during the months of July with the onset of monsoon The rootstock plants raised in this manner develop deep tap root system and hence they have more drought resistance. The seedlings are protected till next summer (May) when they are headed back at ground level. The rootstock will give out new shoots during monsoon season and budding with suitable scion cultivar is done when the shoots attain pencil size thickness.

Topworking

Old and unproductive ber orchard and other wild *Zizyphus* species can be improved by the technique of topworking. The technique involves replacement of the top by budding or grafting with desired scion cultivars (Fig. 11) The top growth of the old tree is removed by heading back at 60-100 cm height from ground level (Pareek, 1983) or at 2 m height, if high headed trees are to be developed However, in practice, it has been

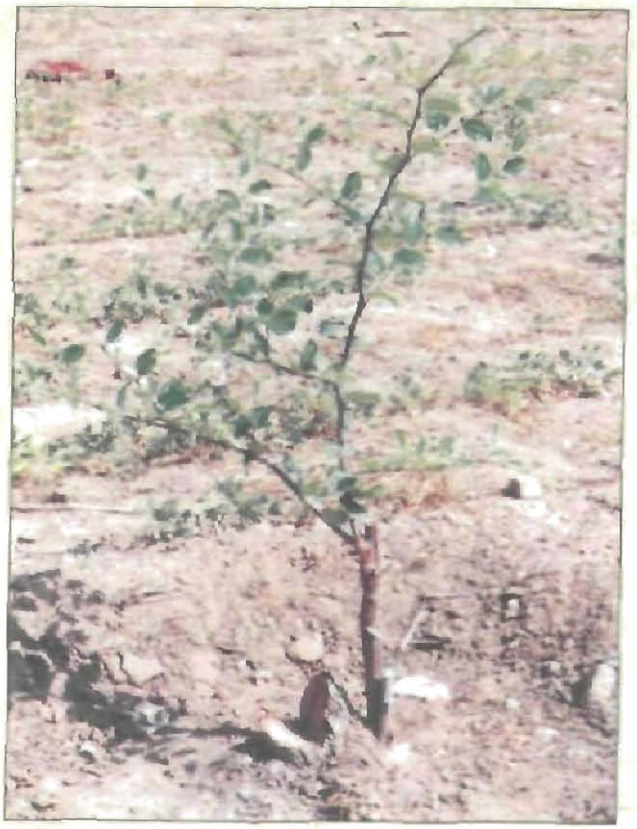

Fig. 10. An *in-situ* budded ber plant

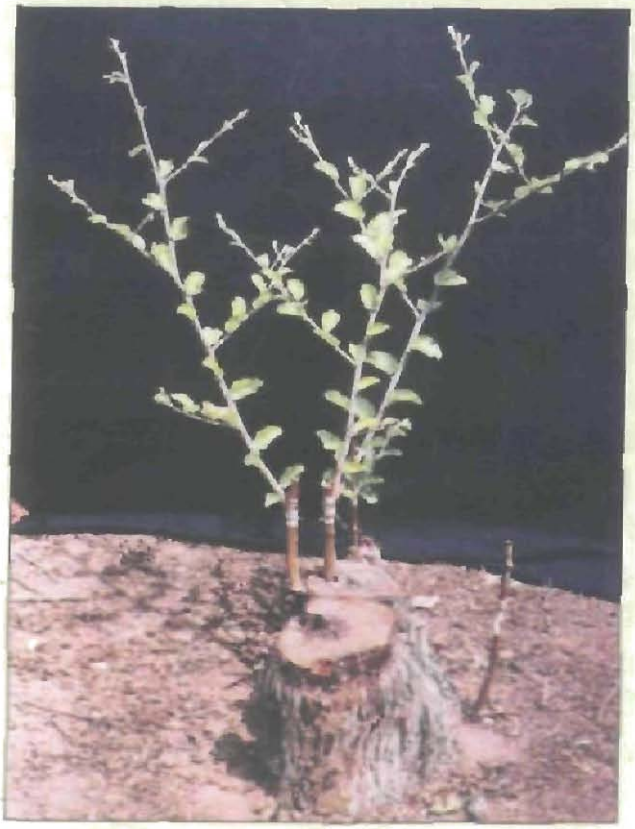

Fig. 11. Top working on an old stump of ber plant

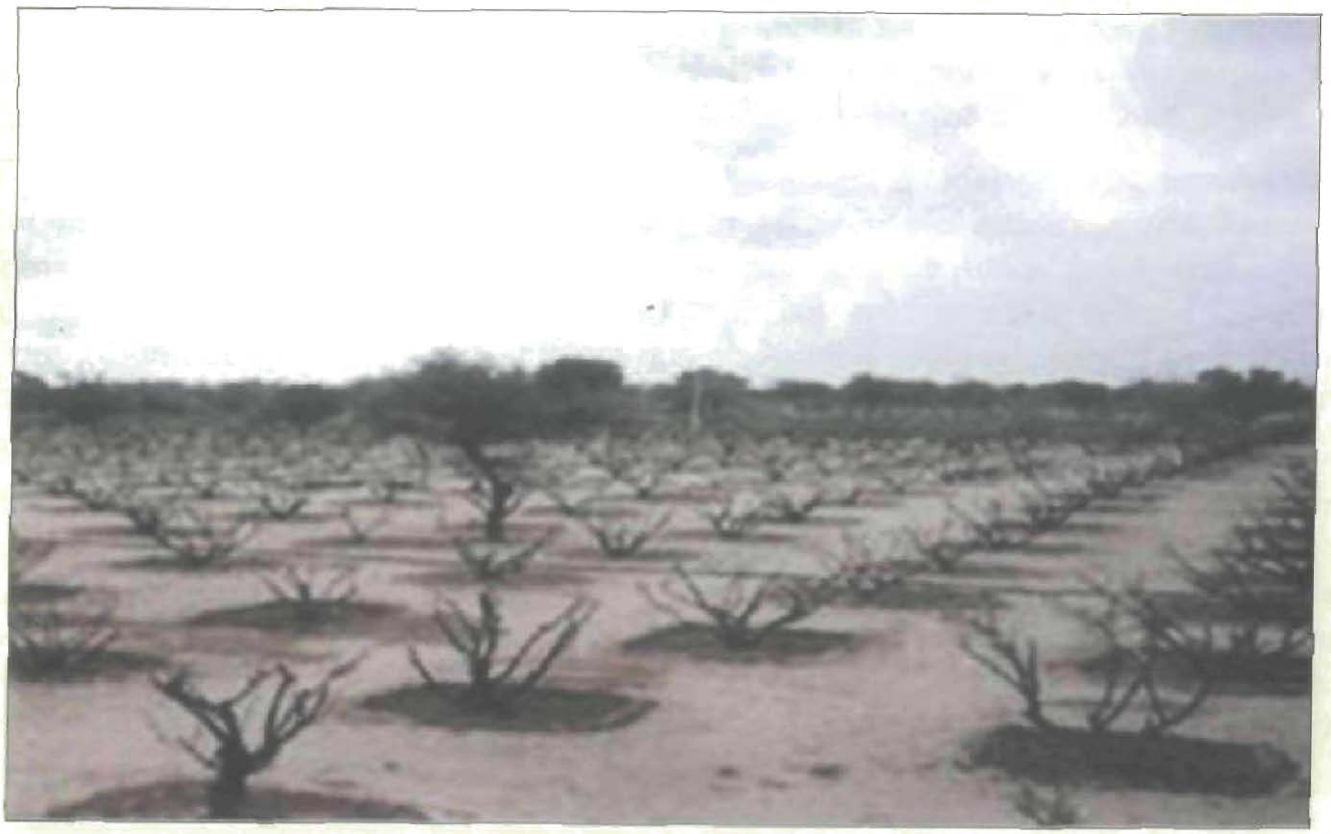

Fig. 12. A Properly pruned ber trees

observed that heading back just above the ground level is better as there is less chances of breakage after budding due to stormy winds. The heading back operation may be carried out during April-May. Several new shoots emerge from the old stumps during monsoon season. Of these, 2-3 shoots can be selected for budding with suitable scion cultivar.

7. Training and Pruning

During the beginning, pruning is required to build strong architecture of branches to bear heavy load of fruits, while subsequently it needs to be done every year to obtain profitable crops. In the first year, the plants are allowed to grow until the next spring (March) when it is headed back keeping 1-2 basal buds on the scion portion just above the graft union to induce development of vigorous shoots. One upright growing vigorous shoot is retained from the scion bud. The trunk is kept clean up to a height of 30 cm from ground level by removing all side shoots. From the main trunk, 3-4 properly spaced and favorably placed branches are allowed to grow. The top of the trunk is again headed back during May to encourage growth of side branches. Ber has characteristic of producing branches usually starting from sixth or ninth node from the base and subsequently at regular intervals of three internodes (Reddy and Chadha, 1993). It is observed that during spring or summer season of the following year, shoots emerge from the basal buds of these secondaries and grow vigorously, but the secondaries themselves either dry out or remain insignificant in growth and vigour (Pareek, 2001). In the spring of the second year, the secondaries are again pruned to basal buds for emergence of vigorous shoots in the next season. One of the shoots emerging from the secondaries is retained, which will form main branches of the tree. On these main branches, 3-4 upright growing and well spaced side shoots are retained and top of such branches are again removed. In the spring of the fourth year, these side shoots are pruned to their basal buds. Vigorous shoots emerge from these buds to form the tertiary branches of the tree architecture.

After building a strong architecture of branches, annual pruning is necessary to maintain the plants in productive state and to produce the quality fruits. During the pruning operation, the unproductive part of the past season's main shoot and its secondaries as well as weak and diseased branches are removed (Fig. 12) to obtain healthy growth at most of the productive nodes. Annual pruning at right time facilitates better development of tree architecture and vigorous growth during the onset of monsoon (Fig.13).

The exact time of pruning is location specific, however, hot and dry summer season, when plant drops off leaves is considered most ideal. In arid regions of north west Rajasthan, early pruning induces early flowering. The fruit yield is higher when pruning is done during the month of May. At Rahuri and Hissar, also early pruning advanced flowering (Anonymus, 1987). Under Haryana condition, maximum fruit retention was observed on trees pruned to 15 buds per primary branch on 30th May (Kundu *et al.*, 1994).

As regards to pruning severity is concerned, pruning at 17-23 nodes on the main axis produce vigorous shoot with maximum fruit production. The main axis of the branches should be pruned keeping 15-25 nodes depending on climatic conditions i e , 20-25 nodes in arid areas and 15 nodes in semi-arid area along with complete removal of secondaries (Pareek and Vishalnath, 1996).

8. Water and Nutrient Management

Although, ber trees once established can give production under rainfed condition, but provision of irrigation water increases the yield significantly Ber cultivation can be taken up under rainfed condition, but the yield varies from year to year depending upon the quantum of rainfall. Work done at CAZRI revealed that fruit yield per tree varied from 10 - 52 kg in rainfed condition with 125 - 800 mm rainfall, respectively. Even during sub-normal rainfall years, *in situ* water harvesting has given encouraging results. Higher run-off yield was obtained from catchment having 5% slopes (Sharma *et al.*, 1982) Circular catchments around each tree (1 5 m radius) with 5% slope towards tree trunk and covering the catchment with black polyethylene sheet has been advocated to concentrate and conserve the moisture. If there is enough rain during July-August months, irrigation is not required during this period. September-October is the period of flowering in arid and semi-arid areas of north-west India and irrigation during this period may cause flower shedding. However, watering may have to be done in light sandy soils low in water holding capacity After fruit set, irrigation at monthly interval from November to February is beneficial for fruit growth and development under north Indian conditions. Application of irrigation at 10 cm depth and 0.2 IW/CPE ratio is better in terms of growth and quality of fruits in cv. Gola

Generally ber orchard is not fertilized in north-western India except the organic manure which is applied at the time of planting. However, regular manuring is required to replenish the nutrient used by the tree in vegetative growth and fruit production A ber tree removes from the soil 142-191 g N, 59-87 g P and 467 - 684 g K during a single growing season (Mehrotra *et al.*, 1987). For knowing the nutrient status of ber trees, fifth or sixth leaf representing the recently matured leaves should be sampled for analysis (Bhargava *et al.*, 1990) The nutritional recommendation based on experience in different states are set in Table 8

Fig. 13. A view ber orchard at the on set of rainy season

Fig. 14. Agrohorticulture system

Fig. 20. A view of Jaisalmeria Ber orchard

Table 8. Nutritional recommendation based on experience in different states

Manurial practice	Punjab	Rajasthan	Haryana
Farm yard manure year 1	10 kg plant^{-1}	10 kg plant^{-1}	10 kg plant^{-1}
Annual increment	10 kg	10 kg	5 kg
Year 5 onwards	-	50 kg	30 kg
Calcium ammonium nitrate (Year 1)	0.5 kg	-	0.5 kg
Annual increment	-	-	0.5 kg
5 year onwards	-	-	0.5 kg
Year 10 onwards	-	-	2 kg
Super phosphate (Year 1)	-	-	0.25 kg
Annual 5 years onwards	-	-	0.25 kg
Year 5 onwards	-	-	1.0 kg
Bonemeal			
Year 1	-	0.25 kg	-
Year 2	-	0.25 kg	-
Year 3	-	0.50 kg	-

Source : Singh *et al.* (1973) (Punjab), Parcek (1978) (Rajasthan), Chundawat and Srivastava (1978) (Haryana).

Table 9. Nutrient uptake in ber as influenced by bio-inoculants

Organism	Nutrient uptake (mg plant^{-1})		
	N	P	K
Control	27.09 (2.10)	3.35 (0 26)	14.45 (1.12)
Azospirillum brasilense	38.91 (2.15)	5.24 (0.29)	21.90 (1 21)
Azotobacter chroococcum	33.28 (2.12)	4.23 (0.27)	17.89 (1.14)
Glomus mosseae	36.63 (2.13)	5.84 (0.39)	19.60 (1.14)
G. fasciculatum	34.24 (2.14)	5.12 (0.32)	18.40 (1.15)
Azotobacter + G.mosseae	42 76 (2.16)	6.13 (0.34)	24.75 (1.25)
LSD (P=0.05)	2.3	0.12	1.21

Note : Figure in parenthesis indicate their per cent concentration.
Source : Aseri (2002)

Generally a full grown tree is applied with 250 g N and 250 g P_2O_5 per plant per year. However, nitrogen application @ 750 g per plant results in significant increase in

relative growth and fruit yield. Exact requirement of nutrients should however, be decided after soil analysis for nutrient availability of a particular location.

Foliar application for supplementing the nutrient requirement of ber appears to be more practical method under rainfed conditions. Foliar sprays of urea (1-2%) increases fruit set, fruit retention, fruit yield and improve fruit quality in different cultivars. The best time for spray application was found to be after fruit set. Foliar application of borax (0.5%) and $ZnSO_4$ (0.5-1%) twice during flowering and fruit setting also increase fruit retention, yield and quality. The work done at CAZRI revealed that application of GA_3 reduced fruit drop and increased fruit retention in cvs. Gola and Jogia. Use of nitrogen fixing bacteria, AM-Fungi and their combination had significantly improved growth and nutrient uptake in ber seedlings (Table 9)

9. Weed Control

Weed growth can be kept under control by a combination of mechanical and manual control measures. Ploughing the inter row spaces immediately after pruning during summer exposes the soil to solar radiation and kills hibernating insect pests. The weed population in the inter row spaces is uprooted by mechanical harrowing, while those growing just around the trunk is removed by manual weeding Herbicide can also be applied to control the weeds. Dalapon followed by paraquat @ 5 kg ha^{-1} each and Glyphosate @ 4 kg ha^{-1} are very effective in killing the weeds.

10. Flowering Pattern and Fruit Setting

Flowering, pollination and fruit set

The flowering in ber takes place mostly on current season's growth. New growth starts in the first fortnight of June in north India while flowering starts in first week of September and continues till middle of November. However, majority of the fruit set occurs in the month of October. Most of the varieties are self unfruitful. The pollination is brought about by honey bees and houseflies, though, several other insects such as yellow wasps may contribute to it. In spite of profuse flowering, fruit set in ber is very low under open pollination. Prevailing temperature and humidity during the blooming period appear to be major hindrance in fruit setting. The period of peak fruit set varies in different regions, mainly depending on the occurrence of favourable temperature conditions. The peak fruit set occurs with the onset of monsoon (July-August) in tropical regions, while it is towards the end of monsoon and during the autumn (September–October) in the sub-tropical regions Spray of growth regulator such as GA_3 and NAA at 10-15 ppm is reported to enhance fruit setting.

Fruit drop

Immediately after fruit set, heavy fruit drop occurs, which is mainly caused by lack of fertilization or degeneration of ovule. Fruit drop also occurs due to soil moisture stress, frost, high atmospheric aridity and high or low temperature during fruit maturity period. The extent of fruit drop varies in different varieties with maximum drop in those varieties which has highest fruit set and vice versa. Fruit drop in ber can be minimized by maintaining good soil moisture and by controlling biotic damage during fruit development In arid climate, high flower and fruit drop takes place between middle of October to middle of November mainly due to high temperature during this period. Creating favourable microclimate by boundary plantation can minimize such drop Spraying of water during evening time lowers the temperature and increases humidity and thus may minimize the drop of flowers and fruits Exogenous application of growth regulators such as 2, 4, 5-T; 2, 4-D and NAA at 10-30 ppm are reported to reduce fruit drop to some extent.

11. Intercropping and Farming Systems

During the initial five years of planting a new orchard, there remains a sufficient space uncovered between the rows which can profitably be utilized for growing intercrops. Intercrops such as mung bean, moth bean, cowpea, cluster bean (Fig 14) and sesame can be grown under rainfed conditions during kharif season. Under irrigated conditions, chilies and cumin can be taken up Total returns from ber fruits and inter-crops is always higher than crops alone. Introduction of *Cenchrus ciliaris* in 18 year old ber orchard at CAZRI farm (Fig. 15) revealed no adverse effect on fruit yield and gave an additional yield of 32.0 q ha^{-1} dry fodder in addition to grass seed yield of 25 kg ha^{-1}.

12. Disease and Inset Pest Management

Powdery mildew causes significant losses in ber, particularly in humid areas. Most of the cultivars are reported to be susceptible under humid condition of south India. In north-west India, 31 out of 61 cultivars were found free from symptoms of powdery mildew (Lodha *et al*, 1984) Epidemiological studies indicate that maximum development of powdery mildew occurs at maximum temperature of 24-35° C, minimum temperature of 4-22° C and RH between 24-91%. The symptoms of the disease appear on leaves, inflorescence as well on newly set fruits. Developing young leaves show whitish powdery mass, which cause them to shrivel and defoliate.

The disease can be controlled by spraying Dinocap (0.2% Karathane W.P. or 0.1% Karathane EC) or 0.2% sulfex. The spray of chemical should be started soon after appearance of the symptoms and repeated at three weeks interval. Where the disease occurs regularly every year one prophylactic spray of fungicide should be applied on new growth after pruning.

Other diseases such as *Alternaria* leaf spot, black leaf spot, *Cercospora* leaf spot, *Cladosporium* leaf spot and rust are also reported but losses due to them are not very significant in adverse conditions.

Among the insect pests, fruitfly (*Carpomyia vesuviana* Costa) is the severe most pest of ber fruits. The infestation starts just after fruit set with the laying of eggs on young fruits when they are tender. This is followed by hatching of eggs and the resulting larvae to feed on developing fruits rendering them unfit for consumption. An integrated approach to control the pest involves, collection and destruction of infested fruits, deep ploughing during summer to expose the hibernating pupa and chemical spray. The chemical spray schedule to control the pest include two sprays of Endosulfan (0 05%) or Methyl Demeton (0 03% a.i.) or Quinolphos (0.05% a.i.) or Monocrotophos (0.03% a.i.) once in October or when majority of the fruits attain pea size and second spray after 15-20 days of the first spray. A third spray with 0 1% Melathion during December ensures complete freedom from the infestation

The bark eating caterpillar (*Inderbela quadrinotata* Walke) is the second most serious pest of ber trees in arid zone. The appearance of frassy deposits on forks and angles of the branches is indicative of pest attack. It makes holes for shelter at the forks and angles of young branches rendering them weak, which also impede the food supply to branches Such branches get detached due to heavy weight of fruit and ultimately dry. There is direct loss of fruits borne on such infested branches The simplest means of getting rid off the caterpillar is to insert an iron spike or thick wire into the holes where the larvae rest and thereby by killing it. The holes may also be plugged with a cotton swab dipped in kerosine oil or dichlorvos insecticide. The other insect pests of minor importance are chafer beetle, hairy caterpillar; lac insects etc. may inflict some damage occasionally However, they are not severe to cause economic losses and can be kept under control by physical means.

13. Varietal Improvement

Majority of the present day ber varieties are selections made at different places from seedling population apart from few clonal selections Very little attempts have been made to develop superior varieties by hybridization. Reciprocal crosses involving cultivars Seb, Gola, Sanaur-2, Katha and Umran were tried at CAZRI, Jodhpur The result indicated that maximum fruit set was recorded in Umran x Katha (Fig. 16) and minimum in Gola x Sanaur-2. The cultivar Umran had best combining ability with other cultivar as either parent. To improve shelf life of Seb, it was crossed with Umran The resultant hybrid had three days longer shelf life than Seb besides other economic traits.

Fruitfly is a serious pest of ber and, therefore, attempts were made to develop resistant varieties against this pest A local cultivar Tikadi was found to possess

Fig. 15. Hortipasture System

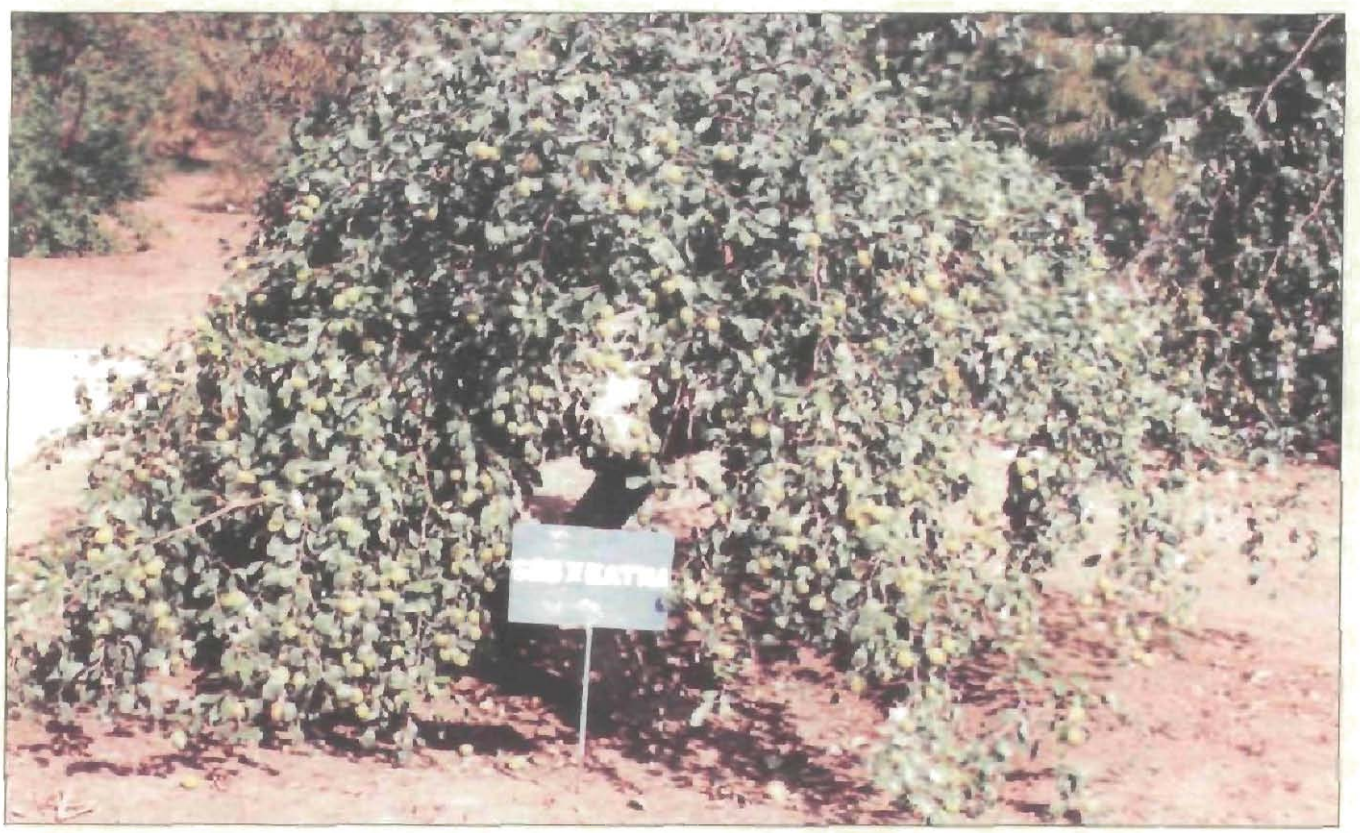

Fig. 16. Hybrid ber variety developed at CAZRI, Jodhpur

resistance to fruitfly but with undesirable fruit quality (Singh and Vashishtha, 1984). The F_1 of Seb x Tikadi was found to be resistant to fruitfly, but did not have acceptable fruit quality due to dominance of the characters of Tikadi. Therefore, F_1 was back crossed with Seb and the BC_1 generation possessed resistance to fruitfly along with desired fruit characteristics.

The cultivars were also screened for resistance to powdery mildew at Hisar and Rahuri (Pareek and Vishalnath, 1996). The field reaction under varying agroclimatic conditions revealed that the disease occurred with increased virulence during high rainfall years The local collection Manuki and Glory showed medium susceptible reaction under Rahuri condition Five local cvs. (Dharakhi-1, Dharakhi-2, Guli, Villaiti and Seedless) identified at Rahuri were found completely free from the disease under artificial ephiphytotic conditions both at Rahuri and Sardar Krushi Nagar. The cultivar Gola was found to be the most tolerant to salinity and alkalinity and could be grown in soils having pH 8 0 and ESP 26.3-33.7% (Pareek 1998). An early maturing variant was selected from a population of Umran cultivar at Godhara and named Goma Kirti (Anonymous, 1994).

14. Fruit Harvesting and Yield

Harvesting of the fruits at right stage of maturity is essential for obtaining desired organoleptic quality in fruits and for extending the shelf life. The immature fruits remain green in colour, which turn greenish yellow to golden yellow on maturity in different varieties. The best index for judging the maturity of cv. Umran is at specific gravity just less than one with golden yellow skin colour. Both immature and over mature fruits are not good for market value. The immature fruits do not have desired sweetness and are acrid in taste, while over ripe fruit loose their natural colour, crisp and juicy texture. Such fruits become red or dark brown in colour and slimy in texture.

In north India, the peak season of harvesting is from December to March for different varieties. However, in south India, harvesting is done during October-November. The fruit harvest is performed by 4-5 manual pickings, since all the fruits do not ripe at a time during the fruiting season. The number of hand pickings can be reduced to 2-3 by pre harvest application of Ethephon @ 500-750 ppm (Pareek and Vishalnath, 1996). Harvesting of fruits should be done early in the morning. Immediately after harvest, the fruit should be precooled and graded according to size.

Budded ber plants can flower and set fruits even in first year of planting, though, during the first two years in tropics and three years in sub-tropics, the young plants are trained to develop strong frame work. Fruiting should, therefore, be allowed from third and fourth year onwards in tropics and sub-tropics respectively. The peak fruit production is reached at 8-10 years of planting, which may continue up to 40 years depending upon care and management. Fruit yield varies at different agro-climatic location In semi-arid sub-tropics of north India under irrigated condition, fruit yield per tree ranges from 80-200 kg depending upon varieties and management practices during prime bearing age of

10-20 years. Under rainfed condition in arid zones, the yield obtained is 40-50 kg tree^{-1} in good rainfall years

15. Post Harvest Management

Packaging

The fruits have to be packed properly for storage and safe transport (Fig.17) The harvested ber fruits should be sorted to discard the damaged, over ripe, unripe, and misshapen fruits. The fruits should also be graded into large, medium and small sized groups. For local markets, fruits are generally packed in cloth sheets or in gunny bags but for long distance transport, packing should be done according to grade While 'A' grade fruits can be packed in perforated cardboard cartons of six kg capacity with paper cuttings as cushioning material, the lower grades can be packed in baskets or gunny bags.

Storage

In general ber fruits are stored at room temperature (25-35°C) after harvest. Fruits can be kept for 4-15 days at ambient condition without loss of quality depending upon the cultivars. The varieties like Sanauar-5, Ponda, Rashmi and Umran have better shelf life The ideal temperature for cool storage is 10°C and 79% RH. During storage, enzyme activity, sugar and carotenoid content increase with corresponding decrease in acidity, pectin and tannin content.

Several pre-harvest treatments can be helpful for extending the shelf life of the fruits Spraying of $CaCl_2$ (0.17%) with 1% Teepol 10 days before harvest improves shelf life of Umran ber. Similarly spray of calcium nitrate (1%) at colour turning stage (10 days before harvest) can also be used. Post harvest treatment such as pre-cooling, dipping the fruits in 1-2% $CaCl_2$ containing surfactant prolongs shelf life of fruits Storage life could be extended up to 10 days in cv. Umran and 12 days in Sanaur-2 at room temperature by treating the fruits with wax emulsion and packing in perforated polythene bags (Jawanda *et al.*, 1980)

Drying/dehydration

Traditionally, the fruits are sun dried. The product quality in such cases is very poor as the fruits become very hard after drying and also dust particles get deposited on the fruits during the process. Not all the varieties are suitable for drying purpose. The fruits of the cvs Katha or Umran, Chhuhara, Bagwadi, Mehrun, Sanaur-2 and Sanaur-3, of give good dehydrated product (Khurdia, 1980). Golden yellow to reddish brown fruits give the best quality of dehydrated products. Blanching (dipping the fruits in boiling water for 2-6 minutes) and sulphuring before dehydration improves the quality of the end

Fig. 17. Packaging and transportation of ber fruits

Fig. 18. Dehydrated ber fruits

Fig. 19. Processed products from ber fruits

product (Fig. 18). Sulphuring involves exposing the fruits to SO_2 fumes for 3 hours by burning the sulphur powder @ of 3.5-10 g/kg fruits. The dehydration can be accomplished under bright Sun (7-10 days) or in solar drier (for 4-5 days) or in tray drier at 60-65°C for 20-35 hours.

Products from fruit pulp

Ber fruits especially, the juicy varieties can be used for preparing unfermented beverages Fruits are first peeled and destoned followed by heating with water for few minutes and then strained through muslin cloth. The juice so prepared can be preserved by pasteurization or by adding chemical preservatives. The juice can be used for preparing squash, jam and nectar (Fig.19). Studies at CAZRI have shown that ber juice lacks in colour and flavour, and therefore by blending it selectively with pomegranate and karonda juice in equal quantities, comparatively better quality squash can be prepared.

Preserve and candy

Preserve and candy can be made from the fruits of selected ber varieties such as Umran, Banarasi Karaka and Kaithli. Fully mature fruits while still hard are selected for preserve or candy making. The fruits are first pricked and softend for uniform sugar impregnation. Softening can be achieved by blanching the fruits for 2-3 miinutes in boiling water followed by dipping in cold water. The sugar impregnation is achieved by dipping the fruits in sugar syrup starting with 30^0 Brix and gradually increasing the syrup strength to about $65\text{-}70^0$ Brix by adding more sugar. For preparing candy sugar concentration is further increased to $70\text{-}75^0$ Brix and the fruits are submerged for another 10-15 days in concentrated sugar syrup. At the end, the syrup is drained off and fruits are air dried and packed in air tight jars or polypacks.

16. Impact Assessment

The contribution of CAZRI in the field of arid horticulture has been recognized in arid and semi-arid regions of the country. The polytube method of raising rootstocks and producing transplantable budlings within a period of four months have given the much needed impetus to the ber expansion programme not only in Rajasthan but also in other states having suitable dry land areas for ber growing. The research and extension efforts made in past 28 years have resulted in increased area and production of ber fruits through out India. Based on nursery technique standardized by CAZRI, approximately 50 private nurseries are operating in and around Jodhpur. About one million grafted plants are supplied to different states every year. The rural unemployed youth are getting employment both in the nurseries and in the field for various types of operations necessary from field establishment to marketing and post harvest management. These efforts have resulted in increased area and production of ber from just few thousand hectare in 1979 to about 88000 hectare in 1994-95 with a production of 8.95 lakh tones of fruit.

In fact, about 28 years back few innovative farmers first adopted CAZRI standardized technology of ber cultivation in rainfed areas of hot arid region of Rajasthan. The success of these farmers opened the gate for improved ber cultivation in rainfed arid and semi-arid areas from Haryana in north to down south upto Tamil Nadu. The innovative farmers acted as catalyst between technology and extension agents, which resulted in rapid expansion of this time tested technology.

Landuse issues

Ber can be successfully grown on a variety of wastelands, not only to provide ecological stability to such lands but also to make them economically productive and useful. The implementation of ber cultivation technology successfully demonstrated how very low productive desert lands can be transformed into an efficient production system, which infact is a sustainable landuse for hot arid and semi-arid tracts Besides fruit production, ber cultivation also leads to soil conservation and improvement in the fertility level in fragile ecosystem of arid and semi-arid regions. More over, substantial amount of fuel and fodder is also generated as a result of regular annual pruning.

Social and economic issues

Raising of ber orchard ensures nutritious fruits at low cost. It yields fruits under extremely adverse agro-climatic condition on marginal lands and at low cost of cultivation. Fruits are available at cheaper rate than many other fruits and thus it remains accessible to the poor masses. In arid region of north-west India, ber was found to have higher annuity value per hectare than other fruit tree species over a felling cycle of 15-20 years. Analysis of records of ber cultivators, it was observed that six hundred mandays are required to maintain one hectare ber plantation. At the moment 10,000 ha land is under ber cultivation in arid western Rajasthan and about 80,000 ha in rest of the country. Thus ber cultivation is generating 6 million mandays employment in arid western Rajasthan and 48 million mandays in rest of the country. The technological package is very simple and acceptable to the farmers with various levels of family economies i.e. poor to rich ones. In the country like India, especially in rural sector of arid and semi-arid areas, where huge labour force is facing acute un-employment problem, the employment generation through ber cultivation could play a vital role in improving rural economy. More over, this also helped in checking migration of rural youth to urban areas in search of employment.

Social capital

A very high degree of adoption of ber cultivation package in hot arid and semi-arid areas of the country has improved the income of many poor farmers. Due to adoption of ber cultivation, the lands which have previously no commercial value are now being

considered worth lacs of rupees. This has direct impact on social status of the farmers in traditionally complex socio-economic-cultural web of rural societies in arid and semi-arid regions, who have successfully adopted the technological package. More over, a high rate of employment generation in environmentally inhospitable hot arid and semi-arid tracts, especially for rural women folk, as they are considered most efficient in harvesting and grading the ber fruits is playing significant role in women empowerment.

Policy related issues

Successful development and large scale adoption of CAZRI technological package of ber cultivation attracted the attention of farmers, subject matter specialists, policy makers, planners, NGOs, horticulture department/agencies of various state governments, especially those having arid and semi-arid areas, etc. started giving serious thoughts to ber crop. In due course of time ber has been recognized as a fruit crop and to promote ber plantation, provisions of subsidies and loans have been made by various state governments through National Horticulture Mission and other financing institutions like National Horticulture Board, NABARD, Gramin (village) Banks, Co-operative banks, etc.

Drought proofing

Droughts are common phenomenon in hot arid regions, thus sole arable cropping is gamble. Ber cultivation acts as an insurance against recurring droughts. In one hand it is capable of conserving resources from wind erosion, the most dreaded problems of hot arid regions, on the other it is capable of providing sustainable production from un-productive arid lands. The carbon sequestration potential of ber plantations in arid and semi-arid part is immense. Thus, CAZRI'S developed ber cultivation package of practices, if adopted successfully by rural people can provide a win-win situation in all respects as far as stressed environmental conditions of hot arid and semi-arid tracts are concerned.

Nutritional issues

The rural masses in hot arid and semi-arid areas cannot afford fruits in their daily diet. With large scale production of ber fruits, the rural folk at large will get some nutritious fruits. This is a latent impact of ber cultivation.

Ber-First experience in transfer of technology

Most of the farmers of arid regions were reluctant to take up ber cultivation, since there was severe shortage of water even for drinking purpose. However, with the efforts of CAZRI out reach programme in 1975, a literate farmer like Shri N.K. Jaisalmeria was identified. He had a parental land of about 4.3 hactare undulating land in Manaklaw village situated about 25 km north west of Jodhpur on Jodhpur-Osian road. He was growing traditional rainfed crops such as pearl millet, greem gram, clusterbean etc. On an average he was getting 4-6 quintals of cereal and pulses besides 8-10 quintal of dry forage depending on quantum of rainfall However, there was hardly any production during drought years. Till 1975, Shri Jaisalmeria had no alternative but to grow traditional cereals and pulses in the event of good monsoon rains At that time he was young and was thinking of some alternate land use to this risky farming practice The extension wing of CAZRI was also looking for some farmer who could take the technology from research field to farmers field Dr. O.P Pareek was instrumental in identifying Shri Jaisalmeria who introduced him to Dr. H S. Mann the then Director CAZRI.

As advised by CAZRI scientists, he got the land cleared off wild bushes and other vegetation. The undulalting land was levelled. He sowed the seeds of wild ber (*Ziziphus rotundifolia*) at 6x6 m spacing in central 3 ha area during July 1976. About 800 rootstock seedlings were well established in the monsoon season of 1976. These seedlings were provided with some life saving irrigation with tractor tanker during post monsoon period. The seedlings were headed back during April 1977. In July 1977, the buddable shoots grew up on the headed back rootstock seedlings. All the rootstock seedlings were budded *in situ* in the month of July itself with three varieties namely, Gola, Seb and Umran which represented early, medium and late repining cultivars, respectively. The idea behind taking all the three varieties was to continue supply of ber fruit in the market from January to March. Besides these three varieties he also got the budding done with some other varieties like Jogia, Kaithli, Mundia and Illaichi so as to enrich the germplasm for further multiplication The budded ber plants started giving some fruits during third year (1978-79), however, production could not reach to commercial scale. The fruit yield rose to 10-15 kg per tree in the fourth year (1979-80) and the farmer started getting the benefit of the technology.

After establishing a successful ber orchard (Fig.20), shri Jaisalmeria continued to be in touch with CAZRI scientists and many times he invited multidisciplinary teams to his orchard to suggest further improvement in ber cultivation. Besides ber growing, shri Jaisalmeria also started nursery business under the guidance of CAZRI scientists in early eighties. Since he had already established large number of trees of different varieties which also served the purpose of mother plant for collecting bud wood in multiplication of plants. He trained large number of unemployed youth specially from rural areas in ber budding and supplied large number of ber budlings in different parts of

the country. Later on, the trained youth also established their own nursery business. During the course of time his farm became a center of attraction amongst nearby farmers. To protect the orchard from wild animals, shri Jaisalmeria dug a trench 1.5 meter deep and 2 m wide all around the orchard and planted *Acacia tortilis, Prosopis juliflora* and neem outside the trench. Due to quick growth habit, these trees covered the boundary from all sides within 5-6 years. This acted as an effective wind break and shelterbelt besides creating the congenial microclimate in the orchard. The said farmer also continued to grow rainfed cereals and pulses in the remaining area for his own consumption.

During 1997, he got a tubewell dug at farm with a total cost of Rs. 1.5 lakh. However, tubewell water came out to be saline (EC=6dSm^{-1}). With the digging of tubewell he started giving 2-3 supplementary irrigation to ber plants besides taking some salt tolerant rabi season crops such as wheat (cv. Kharachia 65).

He also gets a production of 6-7 quintals of local grass (*Cenchrus biflorus*), which grew naturally between ber trees during kharif season. Thus, a system which developed between Shri Jaisalmeria and CAZRI, proved the worth and remained sustainable even under the condition of frequent droughts. It provides security cover to fight drought, hunger and malnutrition besides generating employment through out the year.

Production potential

Average yield data of Jaisalmeria ber orchard under rjainfed and irrigated condition is given in Table 10 After boring of tubewell also he could give only limited supplementary irrigation since water was bit saline. The number and timing of irrigation were decided in consultation with CAZRI scientists. Under normal rainfall year, three irrigations from November to January at monthly interval was sufficient while, in drought year it increased to 5 or 6 depending upon the rainfall situation. He was advised to add about 10 kg gypsum per plant after every three years to correct the salinity. The average productivity was 44 32 quintal ha^{-1} under rainfed, while it was 99.72 q ha^{-1} with supplementary irrigation Besides the above, certain by-products were also produced In addition to ber some income was also obtained from forestry trees in the form of fuel wood and forage. About 6-8 quintals of leafy forage was produced every year which could to sustain 6-10 goats

General economic analysis

Mean gross income (Table 11) was calculated by taking into account, the prevailing whole sale price of fruits and other products. The production of different products got doubled with supplementary irrigation. Under normal rainfall condition, a gross return of Rs.29694 ha^{-1} was obtained. Even, after deducting 40% of total income as inputs and over all maintenance cost, a net income of about Rs.18000 ha^{-1} was obtained.

Under irrigated condition, the gross as well net income was more than double as compared to rainfed condition.

In recognition of his efforts in extending ber technology, Mr. Jaisalmeria has been rewarded nationally and internationally. On December 22nd, 2002 he was given Krishi Shiromani award on the occasion of "Kishan Divas" by Ministry of Agriculture, Govt. of India. He was also invited to address the meeting of Asia Workshop on resource mobilization of UNCCD Implementation in Asia and the Pacific, Bangkok, Thailand on November 9-11, 2000 He further continued the efforts on ber based diversified farming system which rewarded him with prestigious N G. Ranga Award for Diversified Agriculture for the year 2004.

Table 10. Average productivity of fruits and other products in Jaisalmeria ber orchard under rainfed condition.

Products	Yield (kg)			
	Rainfed condition		Irrigated condition	
	kg plant^{-1}	kg ha^{-1}	kg plant^{-1}	kg ha^{-1}
Fruits	16	4432	36	9972
Fuel wood (air dry)	3.5	969 5	5	1385
Leaves (air dry)	2	554.0	3	831
Fencing material (air dry)	4	1108	8	2216

Table 11. Gross income in Jaisalmeria ber orchard under rainfed and irrigated condition.

Products	Wholesale price (Rs. kg^{-1})	Gross Income			
		Rainfed condition		Irrigated condition	
		Rs. plant^{-1}	Rs. ha^{-1}	Rs. plant^{-1}	Rs. ha^{-1}
Fruits	6.0	96	26592	216	59832
Fuel wood	0.8	2.8	775.6	4.0	1108
Leaves	3.0	6.0	1662	8.27	2293
Fencing material	0 6	2 4	664.8	4.8	1330
Total	-	107.2	29694.4	233	64563

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