BORDI *(Zizyphus nummularia)*

A SHRUB OF THE INDIAN ARID ZONE — ITS ROLE IN SILVIPASTURE

Edited by
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Foreword

This publication on *Bordi* (*Zizyphus nummularia*) appears in monograph series by scientists of the Central Arid Zone Research Institute, Jodhpur. Like *Khejri* (*P. cineraria*), *Bordi* is an important top feed species of the arid and semi-arid regions of north-west India. *Bordi* plays a very important role in sustaining the rural economy of these areas particularly in western Rajasthan, where natural scrublands still abound. This ubiquitous, drought hardy, perennial, fodder yielding shrub is often the desert stock owners' last line of defence against the total annihilation of their herds in drought years.

Bordi is also an important source of fruit in the desert. Out of six species of *Zizyphus* only two species, viz. *Z. mauritiana* and *Z. nummularia* are economically important being a major source of fruits for the desert dwellers. *Z. mauritiana* provides comparatively larger edible fruits, while *Z. nummularia* fruit size is small with low pulp content. But this has been found as the best and readily available root-stock material and is being utilised for mass scale budding of superior quality (*Ber*) fruit.

This monograph, which presents the results of research carried out at the Central Arid Zone Research Institute, Jodhpur, is a welcome addition to the knowledge on arid zone plants. The United Nations Environmental programme, in most of its periodical conferences like UNCOD held at Nairobi in 1977, has been emphasizing the need for revegetating the arid areas of the world with suitable species. Similarly, the National Commission on Agriculture of India has suggested, in the report published in 1976, the implementation of several afforestation schemes like Social Forestry, Agro-Forestry and Silvi-Pastoral Systems for developing the much needed energy resources base for the rural areas.

Besides, such plantations should also improve the quality of the environment by conserving soil and other natural resources. It is in the light of these that I commend the efforts made by CAZRI scientists in acquiring new knowledge on different species of useful desert plants and in contributing chapters to this monograph which has been compiled and edited by Dr. H. S. Mann and Shri S. K. Saxena.

I would hope that this monograph will prove to be a valuable source of information to scientists, planners and development agencies dealing with problems

of the arid and semi-arid regions of the country, in their efforts to combat desertification. Some of the suggestions made by the editors in respect of this shrub warrant detailed future studies.

I am sure CAZRI scientists will continue in their endeavours to compile the available information on other useful shrub, tree and grass species of our arid and semi-arid regions.

O P. GAUTAM
Director General
Indian Council of Agricultural Research

26.12.1981
New Delhi - 1.
Krishi Bhavan,

Preface

Bordi (*Zizyphus nummularia* Burm. f.) Wt is an important component of most of the plant communities of arid and semi-arid regions of India. Like *Khejri* (*Prosopis cineraria*), it plays a major role in the economy of the arid regions. Nearly 80 per cent of the people in the arid districts of Barmer, Bikaner and Jaisalmer in Western Rajasthan are dependent on animal husbandry as their main source of livelihood. In the adjoining arid areas also animal husbandry plays a very important role in ensuring atleast some income to the farmers in years of crop failure. Since animal pressure far exceeds the carrying capacity of the land, feed scarcity is a permanent feature of these areas. Recurring droughts further aggravate the situation. The desert top feeds like *Khejri* leaves (*Loong*) and *Bordi* leaves (*Pala*) provide a sustenance when the ground cover is depleted. It is for this reason that palatable and nutritious top feed species have such importance in the desert ecosystem. The *Bordi* plant is particularly valuable in this respect. It can grow on almost all types of habitats. On flat alluvial plains, its natural regeneration is encouraged by the farmers in their own fields as well as in the village common grazing lands (*Orans*). *Pala* is palatable to most species of livestock and is reasonably nutritious. These qualities of the *Bordi* plant have been known to the farmers in the dry areas for centuries. However, there does not seem to have been any effort to obtain hardier, fast growing or high yielding varieties of *Z. nummularia*.

Information on the *Bordi* plant is scantly available in the published literature. Scientists at CAZRI have been doing some work on certain ecological, nutritional and sociological aspects of this plant for the last two decades. A few other agencies also have gathered certain amount of information on this plant. In view of the economic importance of this plant for the arid and semi-arid areas, readily available information has been compiled and is being presented in the form of this monograph. The immediate objective of this monograph is to create an awareness among scientists to study this plant on an interdisciplinary basis with the ultimate aim of increasing the productivity of this plant per unit of land. Another objective is to emphasise the role of this plant in agro-forestry and silvi-pastoral systems.

While we hope that the information contained in this monograph will be of use to scientists and planners in the drier

regions of India and in other countries, we will be grateful for any information on this plant which will be incorporated, with due credit, in revised edition of this monograph.

In the preparation of this monograph many of our colleagues at CAZRI have contributed chapter for which we thank them all. The credit for illustrating the monograph goes to the cartography laboratory of this Institute. We are especially thankful to Shri B. L. Tak, Photographer, for supplying many of the photographs appearing in this monograph. Finally we are most grateful to Dr. O. P. Gautam, Director General, ICAR, New Delhi, for kindly writing a foreword to this monograph.

H. S. MANN
S. K. SAXENA

BORDI (Zizyphus nummularia)

Contents

In the Indian Scriptures

VINOD SHANKAR

The scriptural reference on *Jharber* (*Z. nummularia*) is diffused and often mixed up with *Ber* or *Jujube* (*Z. mauritiana*) and other *Zizyphus* species, e.g. *Z. oenoplia* and *Z. xylopyrus*. The Sanskrit name *Badari* or *Badar* seems to have been given to *Zizyphus* in general. In Sanskrit *Badar* is treated as masculine and *Badari* is feminine and both the words have been ascribed to relate to the tree of *Jujube* (*Z. mauritiana*) but the word *Badarika* has been referred to the fruit or berry of the *Jujube* (Monier-Williams, 1899). It can, perhaps, be conjectured that the word *Badar* refers to the *Jujube* (*Z. mauritiana*) and *Badari* to the *Jharber* (*Z. nummularia*) because at the places where the word *Badari* has been used (Tatak Van[1], Neel Van[2] and Chitrakoot[3] of the Valmiki Ramayana, for example) even now there is preponderance of *Jharber* (*Z. nummularia*) in those *Sal* (*Shorea robusta*) forests [North India Tropical Dry Deciduous (Type 5A) forests—Champion and Seth, 1963]. At another place the glory of The Goddess has been sung[4] as "the universe for *Her* is like *Badar* fruit on the palm of the hand". Here, it is most likely that the *Badar* refers to the *Jujube* (*Z. mauritiana*) because of the resemblance of its fruit to the shape of the earth.

The great Indian sage Maharshi Veda Vyasa who authored a great many scriptural treatise like Mahabharata and Bhagwat Geeta is also named as *Badarayan*, i.e. a person who made his abode amidst dense stands of *Badar* trees at

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१. संकीर्ण बदरी मिश्र किन्विदं दारुणं वनम् ।
तमुवाच महातेजा विश्वामित्रो महामुनिः ।। वा. रा०./वा. का /२४/१६

२. क्रोशमात्रं ततो गत्वा नीलं प्रेक्ष्य च काननम् ।
सल्लकी बदरी मिश्रं रम्यं वंशैश्च यामुनैः ।। वा. रा./बा. का./५५/८

३. ऐङ्गदं बदरै मिश्र पिण्याकं दर्भ संस्तरे ।
न्यस्य रामः सुदुः वार्तो रुदन वचनमब्रवीत ।। वा. रा./बा. का.१०३/२६

४. कर बदर सदृशम् भुवनतलं यस्याः

Badarinath or *Badarikashrama*[1] or *Nardiya Kshetra* (Munshi and Aiyar, 1953) which is one of the four sacred *Hindu Dhams* (main shrines). It is conjectured that it was a forest of *Badar* or *Zizyphus* spp. wherein the *ashram* (abode) of Maharshi Veda Vyas—the *Badarayan* was established and the place thus came to be known as *Badarika-khand* and the presiding deity was *Badarinath.* Apart from being related to *Jujube* (*Z. mauritiana*) the Sanskrit word *Badar* is also reported (Monier-Williams, 1899) to connote several other plants and also to one of the sources of the Ganga and the neighbouring hermitage of *Nara* and *Narayana* (c. f. *Harivan, Katha Saritsagar*). Thus looking to the location[1] of the *Badarikashrama* in the west Himalayas at 2000 to 2500 m, it seems unlikely that the word *Badar* refers to the Jujube or other *Zizyphus* spp. The word *Badar,* therefore, should refer to some other plant. The Silver Fir (*Abies pindrow*) naturally occurs at this altitude in the West Himalayas and at present it is also named as *Badar* by the local hill people. This assumption will also meet the present day description (Champion and Seth, 1964) of the forest type (Type 12/c 2 b *Abies-Quercus* type) at this altitude in the west Himalayas. It will, however, be very difficult to find answer to Deb (1829) who said that the sages around *Badarinath* lived upon the fruits of *Badari* or the *Jujube.*

Pareek (1978) in the introductory part of his book on *'Ber'* (*Z. mauritiana*) quoted a number of scriptural references on the history and use of *Zizyphus* spp. specially *Z. mauritiana* (*Ber*), which reflects the antiquity and popular usage of *Ber* (*Z. mauritiana*) and interalia *Jharber* too. The popularity of *Zizyphus* spp. including *Jharber* (*Z. nummularia*) can be gauged from several *Niti Shlokas* of the *Panchtantra*[2] and of the *Ayurveda*[3].

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१. ब (व) दारिकाश्रम पुनः बदरी स्वार्थे क तस्याः समीपे तच्चिनिहतोवाश्रमः बदरिकावनमप्यत्र तच्च हिमालय पर्वतैक देशे श्री नगराण्य देश समीपे अलक नन्दा नदी पश्चिम भागे स्थितम् ।
गच्छोन्द्रव मयादिष्वे बदरिण्यं ममाश्रमम् ।

२. नारिकेल समाकारा दृश्यन्ते भुवि सज्जनाः ।
अन्येव तु बदरिकाकारा वहिरेव मनोहरा ।।
— पंचतंत्र

३. वृन्ताकं कोमलम पत्थ्यम् कुपत्थ्यम् बदरी फलम् ।
— भाव प्रकाश

Morphology and Ecology

S. K. SAXENA

INTRODUCTION

Bordi (*Zizyphus nummularia*), is the most commonly occurring shrub species in the arid and semi-arid tract of Indian desert. It has assumed much significance in Thar desert as it produces a minor edible fruit "*Ber*". The animal rearing, especially the goat, largely depend on the leaf fodder of this shrub. It is both drought and frost hardy and disease resistant shrub. Most of the "*orans*" and "*Bir*" (common village grazing lands) are dominated by this shrub. It can grow on almost all types of soils showing thereby the wide ecological amplitude. High adaptability of this shrub, therefore, enables it to occupy vast stretches of arid areas in Indian desert, especially in 150-250 mm rainfall zone covering the districts of Bikaner, Barmer, Jaisalmer and part of Jodhpur.

Genus Zizyphus

Zizyphus (Mill) belongs to the family Rhamnaceae. In Indian desert this genus is represented by five or six species, (Bhandari, 1978; Puri *et al.*, 1963) mostly shrub and trees. Distinguishing characters of each species are as under:

Zizyphus xylopyrus: Fruit hard, inedible, finely puberlous, style distinct.

Z. rugosus: Style distinct, petals o.

Z. mauritiana: Fruits with edible pulp, style connate upto middle, armed trees and shrub. Leaves glabrous on one side.

Z. glabra: Fruit edible, style connate upto middle, unarmed tree, leaves glabrous on both surface.

Z. truncata: Much branched shrub, leaves truncate at apex and glabrous on upper surface.

Z. nummularia: Much branched shrub, leaves rounded at apex and tomentose on both sides.

Amongst above mentioned species *Z. mauritiana* and *Z. nummularia* are more common. The former is generally cultivated for its large sized edible fruits whereas the latter grows abundantly as wild.

Vernacular name: *Beri, Jharberi* (Hindi); *Kantan-ber* (*Bundelkhund*); *Malla, ber, birar, Jhari, Kanta, Jharber* (Punjab and *Haryana*); *Ber, Bhor, Borti, Bordi, Jhalpher* (Rajasthan); *Jangra, Jangri, ber, Nandojangro* (Sindi); *Pali* (Madhya Pradesh) *Parpalligidda* (Karnataka).

Botanic name

Zizyphus nummularia (Burm. f.) wt. & Arn. Syn. *Rhamnus nummularia* Burm. f. and *Zizyphus rotundifolia* Lamk.

Plant characteristics: A thorny shrub of 1-2 m height. Branches zig-zag, covered with white coating. Stem and branches purplish to ashy. Bark light brown. Multi-stemmed from the base. Leaves shortly stalked, ovate to orbicular, serrate, 12-18 mm long, 8-10 mm broad, round at apex and base, more or less tomentose above but densely wooly beneath. Stipular spines in pair, one slender and straight whereas other short and recurved. Flowers cream colour, in axillary short and compact cymes. Calyx pubescent outside, cleft about half way down, lobes triangular ovate; petals cuneate or rounded at apex. Filaments deflexed . Disc ten lobes with a pit opposite each lobe, Style two, united more than midway, ovary 2-celled, fruits (Drupe) globose, ovoid, oblong or obovate. 8-10 mm long, glabrous, orange, brown to blackish red with several intermediate shades on ripening. It has little edible pulp. The shrub flowers during July-August and the ripe fruits are available in November-December.

Distribution in various habitats: In Western Rajasthan *Bordi* (*Zizyphus nummularia*) is one of the common shrub which occupies almost all the habitats except the saline patch or rann and the sand dunes.

Flat alluvial plains with fairly deep (80-120 cm) sandy loam soils and with a hard *kankar* pan below, support *Prosopis cineraria-Zizyphus nummularia-Capparis decidua* as the most prevalent community. Generally there is moderate to high (230-500 shrubs/ha) shrub density of *Bordi*. But due to yearly cutting of this shrub for its leaves "*Pala*", it does not seem to impart any visual impact of its density. Flat alluvial plains with sandy clay loam to clayey soils and a *kankar* pan at 45-60 cm below the soil also show high shrub density of *Bordi* (14% cover) in semi-arid regions.

Common village grazing lands with shallow soils and *kankar* pan below (30-45 cm) are generally dominated by *Bordi* shrubs. There are some big *Bordi orans* dedicated to some deity, e. g. Deshnokh (Bikaner), Bhaduria (Jaisalmer), Pabuji (Jodhpur), Lohawat (Jodhpur). These *orans* have 75-90% relative dominance of *Bordi* (*Zizyphus nummularia*) plants only. The rest 25-10% is generally shared by *Khejri* (*P. cineraria*), *Hingota* (*Balanites aegyptiaca*) and *Kair* (*Capparis decidua*). Here the shrub density, with clear bole and crown, ranges from 90-120 plants/ha.

The gravelly plains, where sheet wash has resulted in exposing the *kankar* pan, i.e. Gajner, Nal to Kolayat in Bikaner district, are dominated by a community of *Zizyphus nummularia* (*Bordi*). Here its chief associate is *Capparis decidua* (*Kair*). The long tract has fairly good shrub density (120-150/ha). The plants are generally 1.5-3.0 m high and contribute 8.0% crown cover. On older alluvial flats, *Bordi* (*Z. nummularia*) is associated with several plant communities like i) *Salvadora oleoides-C. decidua-Z. nummularia,* ii) *P. cineraria, S. oleoides-Z. nummularia,* iii) *P. cineraria, Z. nummularia* etc. Saxena (1977) has shown its occurrence in several plant communities. *Bordi* represent as an intermediate stage of succession in most of the plant communities.

Bordi (*Z. nummularia*) is one of the co-dominant in the community of *C. decidua-Z. nummularia* occurring on the eroded rocky surface, piedmont plains and pediment plains. These lands mostly serve as a common grazing grounds. Here soil cover is very shallow and the soil deposition takes place in few pockets and in rock folds which gets vegetated by this shrub. Most of the shrubs assume bushy nature with several branches and form cushion shaped structure due to continuous grazing.

Sandy undulating hummocky plains and interdunal plains have few scattered shrubs of *Bordi* (*Z. nummularia*) where most of the vegetation is psammophytic. Arid districts of Western Rajasthan (Bikaner etc.) in its undulating terrain have *Calligonum polygonoides-Z. nummularia* community. Both species act as good soil binder. Moderate to high density (60-302 plants/ha) have been recorded there. Protected forest on low hills and piedmont zones is also an important habitat of this species where it assume as an important associate to *Acacia senegal* community. The shrub density ranges from 80-350 plants/ha, but with small crown cover (5-7%). In unprotected hilly areas, with a community of (*Thor*) *Euphorbia caducifolia,* this shrub has negligible contribution (10-50/ha) due to severe exploitation.

Position in succession: Saxena (1977), while describing the successional pattern on all the desert habitats of western Rajasthan, has demonstrated that undershrub and perennial grasses create suitable habitat for the take over of shrubby vegetation. Earlier process of development gain upperhand in providing quick development. If favourable conditions continue pioneer shrubs like *Z. nummularia, Mimosa hamata, Capparis decidua* etc. start getting foothold. In some cases *Zizyphus nummularia* start dominating. This stage continue for a long period and finally culminate into woodland of *Prosopis* on light soils and *Salvadora* on heavy soils. Thus *Zizyphus* acts as immediate disclimax to penultimate stage of *Prosopis or Salvadora.* On younger alluvial plains the stages of early development are different but they also lead to *Zizyphus-Capparis* stage which finally give way to *Acacia-Prosopis* community. *Bordi* enjoys same status in case of hilly terrain as well and finally turn into *Anogeissus-Acacia* climax. Thus on majority of habitat it is the essential component of higher successional ladder.

Coppicing and growth pattern: This shrub has remarkable power of regeneration through its root suckers. The cut stumps start coppicing by February-March. The sprouting continues through April to June. Unfolding of buds during summer months indicates that the plant growth is independent of soil moisture. Each plant throws 5-7 shoots which cover approximately 1.0-2.0 sqm area on the ground in a good rainfall year. The spring sprouts, followed by a drought are heavily grazed during summer months (April-June). The plant initiates flowering by the end of July or middle of August depending upon the pattern of rainfall. In rocky habitat where the soils are skeletal, the plant do not sprout but the buds swell up with the increase in humidity. The leaves appear either with premonsoonic showers or with the onset of monsoon. The growth seems quite fast on rocky habitat. The unfolding of leaves marks the beginning of flowering which attains its peak by the end of July and complete it by the end

of August. Thus the fruits on the plains and rocky habitat are simultaneously ready for harvest by middle or late of November.

Shedding of leaves: Plant starts shedding its leaves as soon as all the fruits are dispersed from the plant. In sandy plains, the leaf shedding is gradual beginning by the end of November and continue till April end, but the plant hardly become leafless as the deep root system is capable of utilizing some available moisture from the lower strata (*kankar pan*). In case of plants growing on rocky piedmont or pediments plains the shedding of leaves starts by middle of November and continues till March. Generally the plant remains leafless from April to June. In rocky habitat the soil depth and moisture are limited and hence the same is reflected in plant growth.

In the *'oran'* and *'Birs'* (common village grazing lands), where this shrub assumes its life form, shedding of leaves begin from last week of November and gradually continue till May when plants become almost leafless. The gradual fall of leaf provide continuous supply of nutritious top feed, having 14% crude protein contents though small in quantity, to the grazing animals. Thus this shrub is at par with any leguminous crop as far as protein content is concerned.

Harvesting 'Pala': The harvesting of *Bordi* (*Zizyphus*) shrubs coincides with the season of its leaf fall. High density of *Bordi* shrubs mainly in their growth form (Plate 1) are maintained on flat alluvial plains by the farmers. Its harvesting is taken up after the *kharif* crops are harvested. In a good or normal year the farmer gets double harvest, i.e. the crop as well as *Bordi* (*Zizyphus*) leaves. While in drought years, when the crop fails, the cultivator is able to get leaves, locally called as *'Pala'*. Studies conducted on older alluvial flats have indicated that harvesting of plants should be completed latest by December as moisture percentage of the soil profiles fall during winter and becomes minimum (1.91%) during summer months (Nanda, 1969). The plant exhibits the moisture stress by shedding its leaves.

The plants are cut to the ground level by a sharp implement and four to five plants are heaped together in one bundle. For a week, all such bundles are put at one place for drying in the sun. Subsequently, upon drying, simple beating by a stick, the leaves are easily separated from the twigs. These leaves or *"Pala"* are collected and stored for feeding to the cattle during lean period. Small branches and twigs are used for field fencing.

Variability: *Bordi* (*Z. nummularia*) shrub perpetuate both through vegetatative and sexual means. The natural regeneration by seeds is quite high. The cross pollination of this shrub is brought about by the insects and bees and this results in high variability through segregation. In western Rajasthan a good amount of variability has been noticed. In order to study the extent of variation plants were studied from three bioclimatic zones (Fig. 1), i.e. 150-250; 250-350; and 350-500 mm rainfall areas. There are small to very big *orans* (village grazing lands) with high density of *Bordi* in 150-350 mm rainfall zone while in high rainfall tract (350-500 mm) this shrub occurs in small numbers either in *orans* or wastelands.

Method of study: Morphological variation of leaf, branch, thorn, fruit colour and size etc. were studied. Nearly sixty

Plate 1. Life form and growth form of *Bordi*.

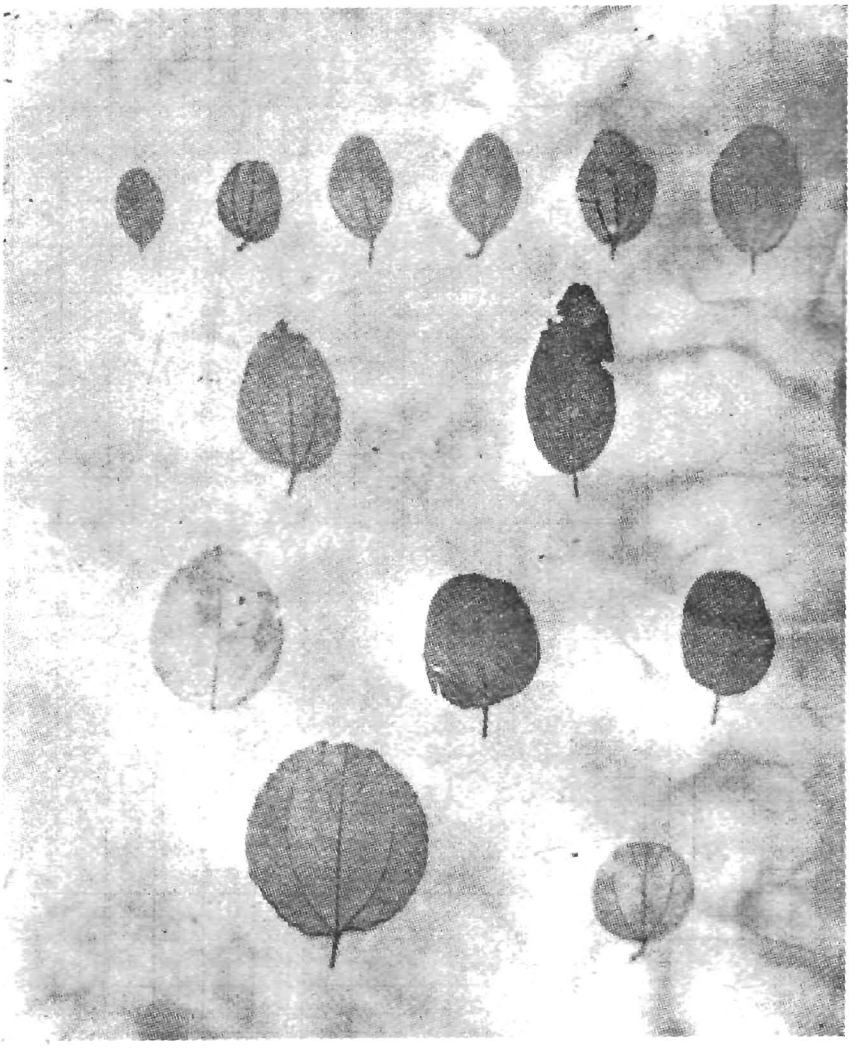


Plate 2. Four types of *Bordi* leaves.

Table 1. Variability in plant parts of *bordi (Zizyphus nummularia)* population in different bioclimatic zones of Western Rajasthan

Character*	Zones			Total	Average
	I 150–250	II 250–350	III 350–500**		
Leaf shape					
Ovate	45	47	52	144	48.0
Oblong	25	17	4	46	15.3
Round	20	24	22	66	22.0
Obovate	10	12	22	44	14.7
Leaf tip					
Emarginate	5	—	—	5	2.0
Obtuse	50	35	48	133	44.0
Mucronate	15	47	31	93	31.0
Acute	30	18	21	69	23.0
Leaf margin					
Entire	95	88	48	291	77.0
Serrate	5	12	52	69	23.0
Leaf surface (dorsal)					
Light green	35	12	13	60	20.0
Dull green	15	35	31	81	27.0
Dark green	10	6	43	59	19.7
Bright green	40	47	13	100	33.3
Leaf surface (ventral)					
Smooth	10	65	13	88	29.3
Densely hairy	20	35	17	72	24.0
Tomentose	70	—	70	140	46.4
Branch colour					
Brown	72	64	45	181	60 3
Brown with silvery tinge	14	12	—	26	8.7
Ash	5	12	46	63	21.0
Maroon	9	12	9	30	10.0
Fruit shape					
Oblong	10	33	—	43	21 5
Round	85	67	—	152	76 0
Obovate	5	—	—	5	2 5
Fruit colour					
Dark brown	20	27	—	47	23 5
Black	55	13	—	68	34.0
Green	—	14	—	14	7.0
Chocolate	20	27	—	47	23.5
Deep orange	5	19	—	24	12.0

* Characters expressed in per cent on various sites.
** Rainfall.

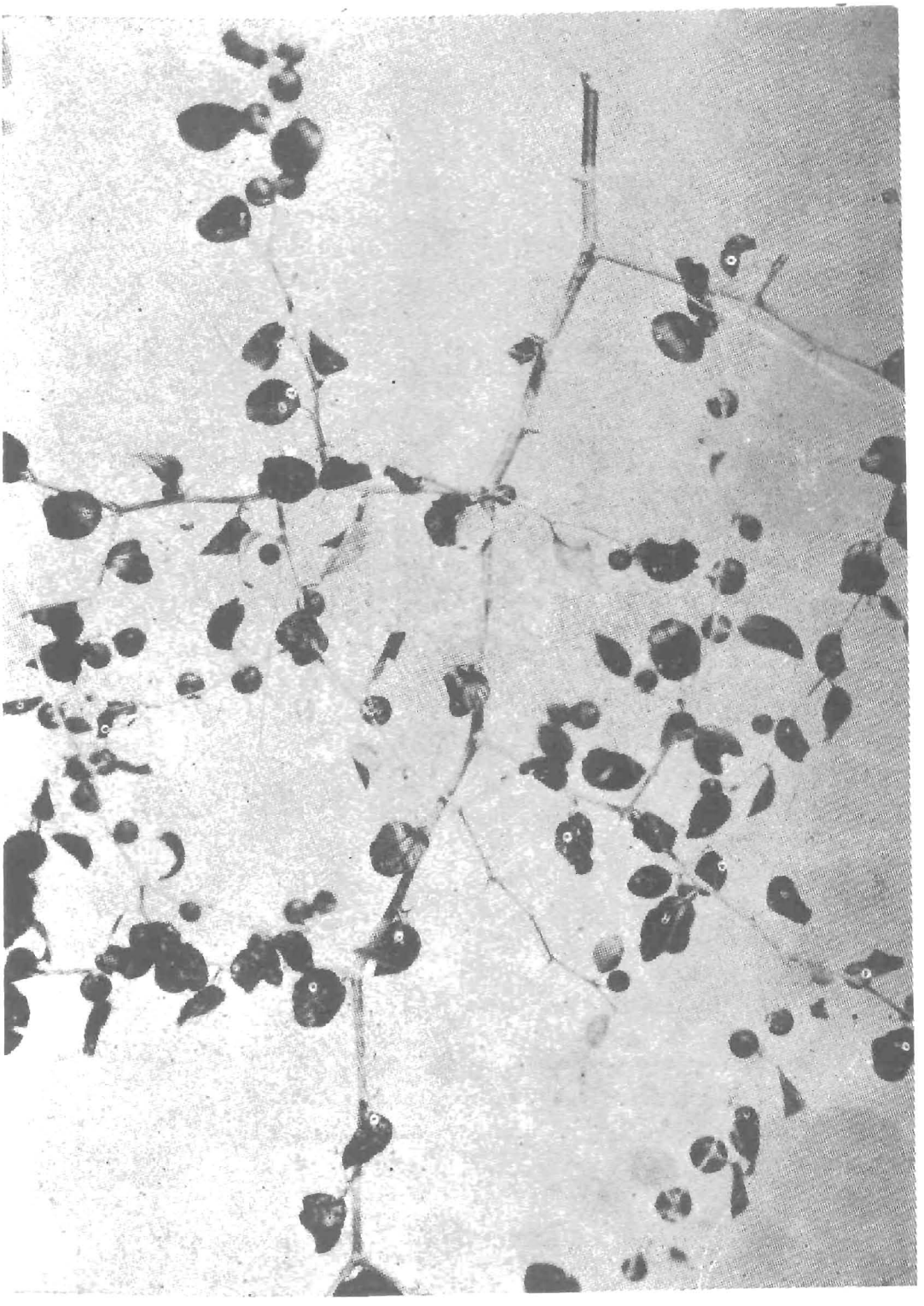
samples were drawn from these three bioclimatic zones. In each case a twig of 30 cm length, containing fruit, leaves, thorn and flowers, was cut from the extreme terminal end of the branch from 150-180 cm height. From each sample central leaves representing the branch were drawn to scale and other morphological features. Characters thus studied are given in Table 1. Qualitative morphological characters were converted into per cent of occurrence amongst the population lot while the quantitative figures and the ranges of variation are given in Table 2.

Leaf shape: In all four types of leaves (Plate 2) ovate, oblong, obovate and orbicular have been identified. In the entire population, ovate leaves were nearly 48% followed by orbicular (22.5%). Only 4% plants with oblong leaves were recorded in higher rainfall zone whereas

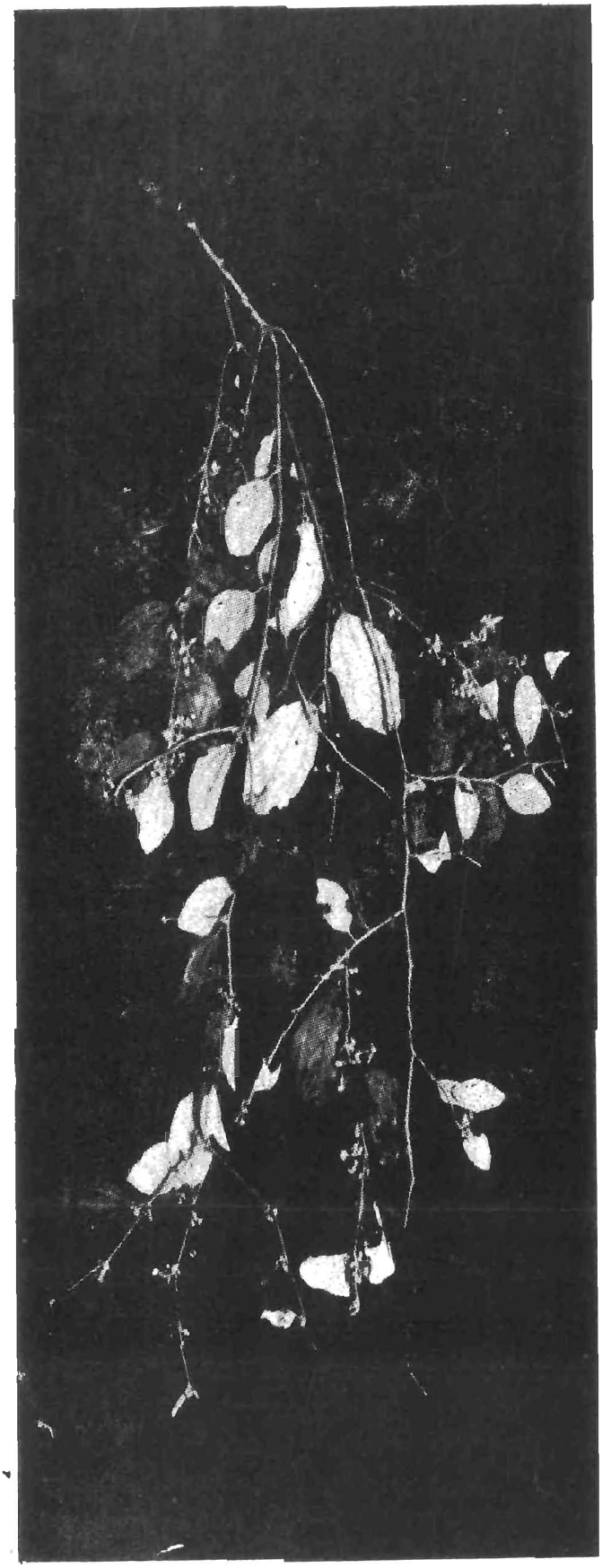
Table 2 Variability in *bordi* (*Z. nummularia*) population in different bioclimatic zones of Western Rajasthan

Characters★	I (150–250)	II (250–350)	III (350–500)★★	Total	Average
Length of leaf					
Mean★★★	20.4	25.3	26.8	72.5	24.2
Range	(12-26)	(16–32)	(14–24)	—	(12–32)
Breadth of leaf					
Mean	15 4	19.4	19.4	54.2	18.1
Range	(6.5–21.5)	(14-23 5)	(14–32)	—	(6 5–32.0)
Leaf petiole size					
Mean	4.6	6.4	4.6	15.6	5.2
Range	(2.5–11.5)	(4–12)	(2.5–7.0)	—	(2.5–12 0)
Hooked thorn size					
Mean	3 3	2.6	3.4	9.3	3.1
Range	(1.5–6.0)	(1.5–4.5)	(1.5–6.0)	—	(1.5–6 0)
Straight thorn size					
Mean	10.3	7.2	8 1	25.6	8 5
Range	(7 5–15.0)	(2–13)	(3–14.5)	—	(2 0–14 5)
Fruit size					
Mean	6 9	8.5	—	15.4	6.7
Range	(3.5–8 0)	(6.2–9.9)	—	—	(3 5–9 9)
Fruit weight/100 fruits					
Mean★★★★	48.7	50.0	—	98.7	49 3
Range	(33–66)	(32–74)	—	—	(32–74)

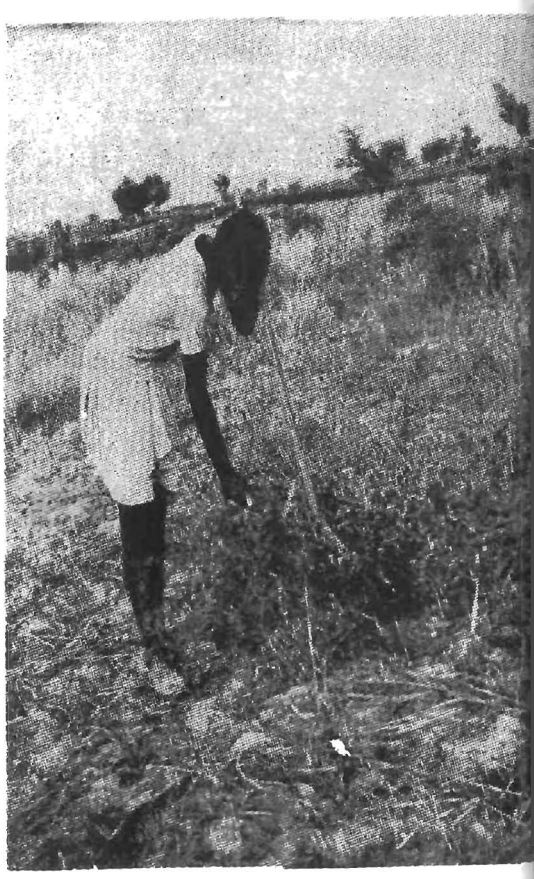
★Characters expressed in mm and gm.
★★Rainfall zone.
★★★Figures expressed in mm (mean and range)
★★★★Figures expressed in gm.



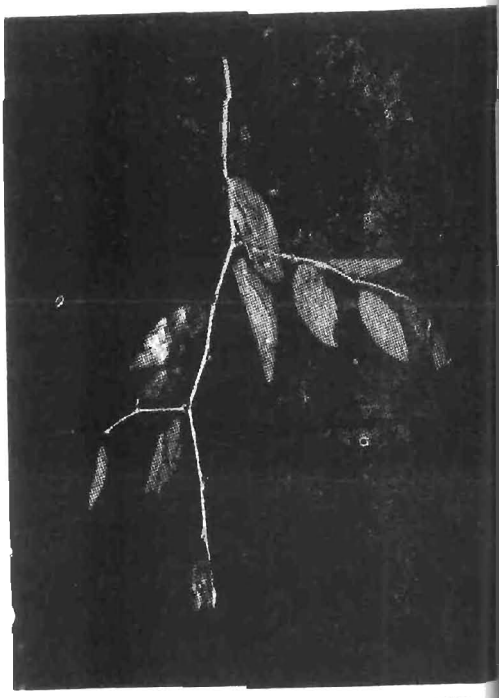
Fruiting in *Bordi*.



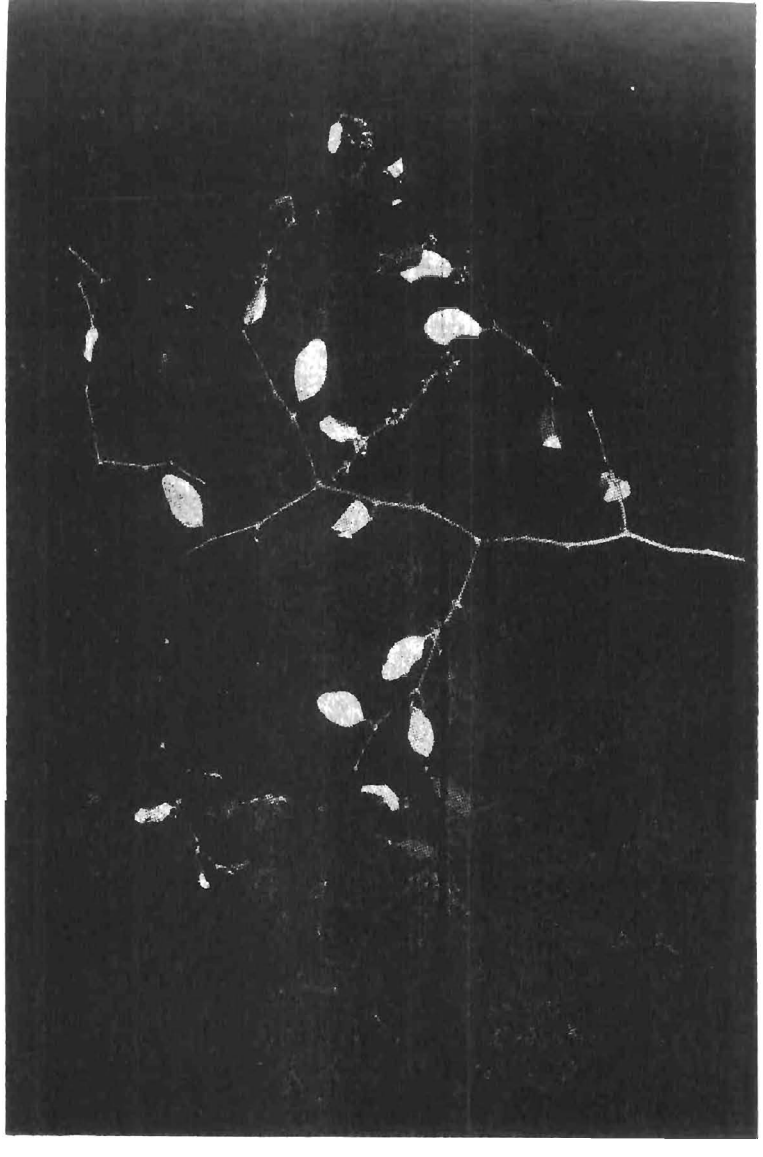
Flowering of *Bordi*.



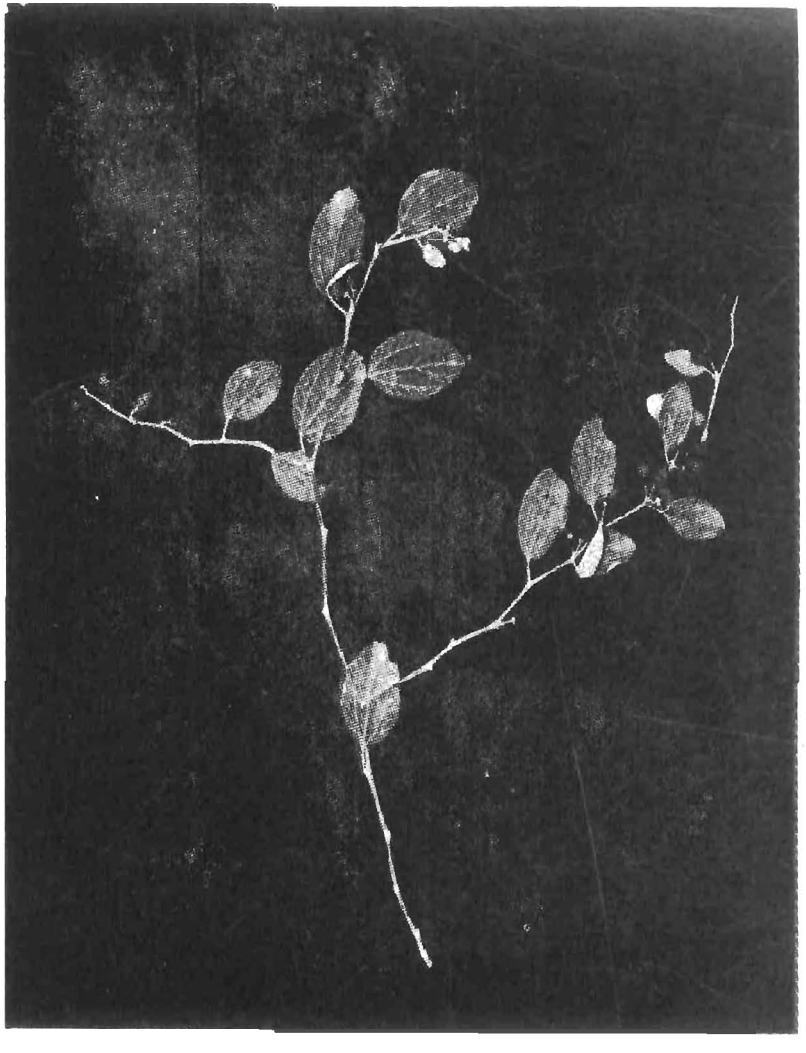
Harvesting *Pala* and heap making.



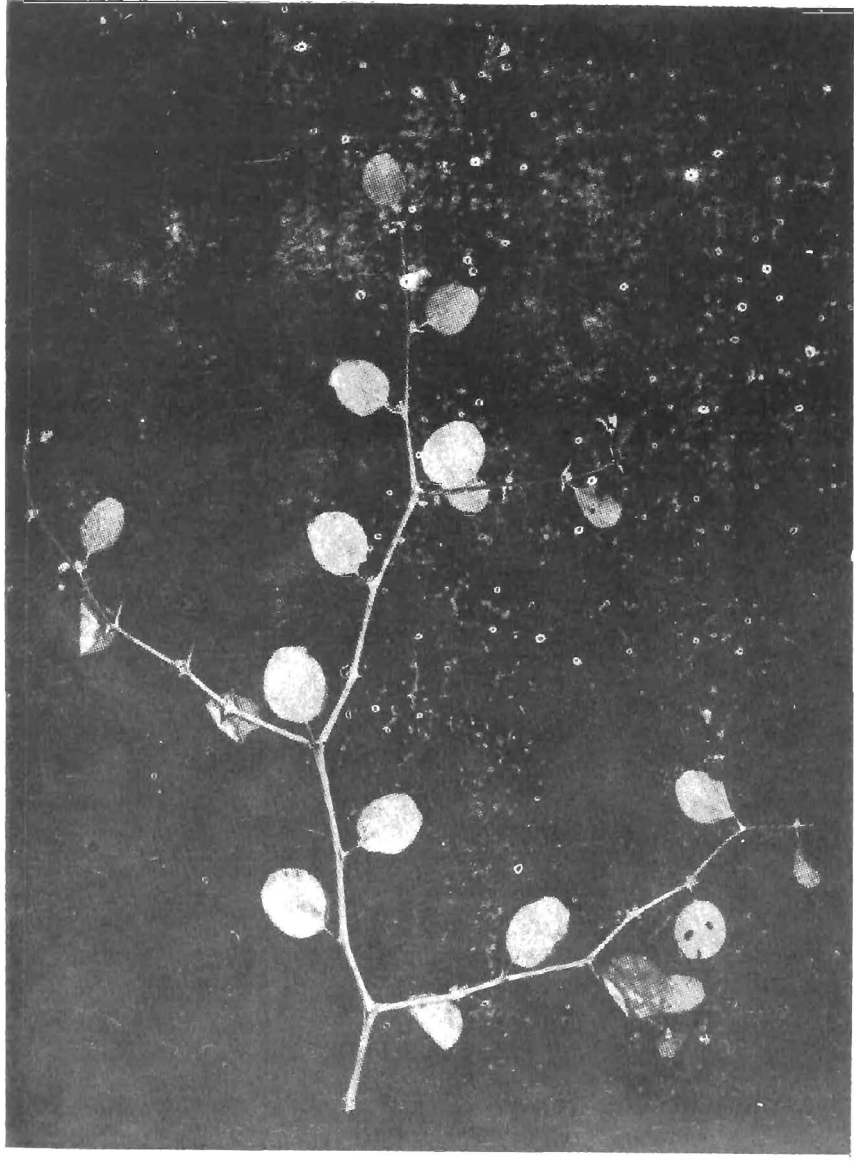
Ovate leaves in rainfall zone III.



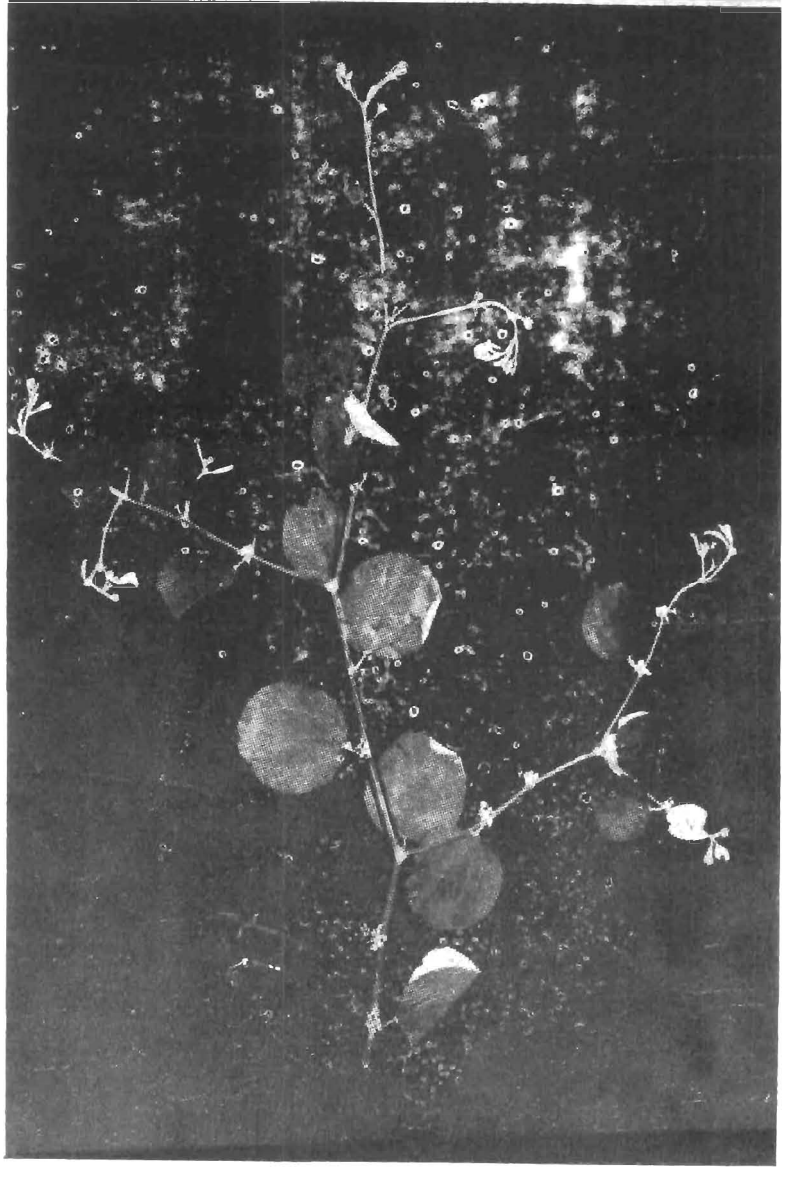
Small, ovate leaves in rainfall zone I.



Medium size ovate leaves in rainfall zone I.



Obovate to oblong in rainfall zone II.



Plants with orbicular leaves in rainfall zone III.

obovate leaves plants were least (10%) in low rainfall zone.

Leaf margin: Seventy seven per cent plants had entire leaf margins while 23% were serrate. In low rainfall zone 95 per cent plants had entire margin while higher rainfall zone showed 52% leaves with serrate margin.

Leaf tip: Plants with emarginate leaves tip were only 5% in dry tract. In majority of cases the population showed obtuse tipped leaves (44%) followed by mucronate (31%) tips.

Leaf surface: The colour of dorsal surface of the leaves vary from light green to dull green, green or bright green. On an average 33.3% population had bright green dorsal surface followed by dull green (27.0%). Nearly half of the population had tomentose ventral surface followed by hairy (24.0%). Leaves with smooth ventral surface were minimum (10%) in low rainfall zone.

Branches: Majority of *bordi* shrub had brown branches (60.3%) without any coating while 21% population showed ash colour branches. In low rainfall zone population of ash coloured twigs was very small (5%) whereas plants with silver touch were altogether absent in higher rainfall zone.

Fruit shape: Plants with almost round fruits had highest (76%) percentage followed by slightly elongated (oblong 21%). In dry tract 85% population was bearing round fruits.

Fruit colour: In early fruiting stage, majority of population showed black skinned fruits (55%) which later turn pale and finally dark brown or chocolate coloured. Fruits of 20% plants, in dry areas finally turn to brown at ripening. In Bikaner zone 14% poplation had pale green fruits in the beginning which also turn reddish brown on maturity.

Leaf size: In lower rainfall zone the leaves were smaller in size but the leaves size increased with higher rainfall (Table 2) showing the adaptability of this shrub to xeric conditions.

Leaf petiole: Population with small leaves and highly tomentose ventral surface had small size petiole (2-5 mm). Population of Bikaner zone showed relatively longer petiole (6.4 mm) than other zones.

Hooked thorn: Longer petiole leaves plant showed slightly shorter hooked thorns (2.6 mm), whereas on an average the size of hooked thorn was 3.3 mm.

Straight thorns: Population of lower rainfall zone showed thorn of longer size (10.3 mm) as compared to other two zones. Like hooked thorns, the straight thorns of Bikaner zone were shorter (7.2 mm).

Fruit size: In low rainfall zone the fruits were comparatively smaller (3.5-8.0 mm) than the moderate rainfall zone (6.2-9.2 mm). The flowering and fruiting of higher rainfall zone were nearly a fortnight late and hence seed could not be collected at the time of present study.

Fruit weight: The average hundred fruit weight did not show much variation in the two zones whereas moderate rainfall zone showed heavier fruits (74 g).

Thus the morphological characters of low rainfall zone plants of *Bordi* showed higher xerophytic characters than the other two zones indicating that this shrub is drought hardy.

Distribution pattern of *Jharber* and its leaf fodder and bushwood production on different habitats and landuse types

VINOD SHANKAR

INTRODUCTION

Jharber (*Z. nummularia*) typifies (Champion and Seth, 1964) *Zizyphus* (Type 6B, DS-1) scrub of the *Desert Thorn Forest* (type 6B, C-1). Out of the six formations that have been recognised (Satyanarayan, 1964; Gupta, 1975) for the Indian part of the Thar desert, *Jharber* occurs in abundance in two formations, i.e. Mixed Xeromorphic Woodland and Lithophytic Scrub Desert. *Jharber* was also a major component of the past (Holocene) vegetation of this tract (Shankar, 1978). As an economic plant it is presently highly valued specially for its nutritive leaf fodder (locally called *Pala*). Observations on the distribution pattern of *Jharber* and also other shrubs were recorded during the special survey on arid shrub-lands of western Rajasthan. In the present paper both geographical and ecological distribution of *Jharber* and its leaf fodder production on different habitats and landuse types are being described and discussed.

Geographical distribution

Jharber has been reported to be confined to Persia (Iran), Baluchistan, Arabia, Pakistan and India (Bhandari, 1978). Large, natural stands of *Jharber* are found in Punjab, Haryana, Rajasthan, Gujarat, Uttar Pradesh and Madhya Pradesh. Both alluvial and rocky/gravelly plains support stand of *Jharber* but, by and large, alluvial flats seem to be the preferred habitat of *Jharber*. Density of *Jharber* in various districts of Western Rajasthan is presented in Table 3. Highest density (720 plants/ha) was recorded in Nagaur followed by Jodhpur (471 plants/ha), Churu (405 plants/ha) and Bikaner (390 plants/ha). Lowest density (65 plants/ha) was recorded from Jaisalmer The density of *Jharber* was, by and large, poor in Jalore (76 plants/ha) and Sikar (78 plants/ha). The density range was very wide in all the districts. This indicated that average density described (Table 3) for each district is not representative figure and that extent

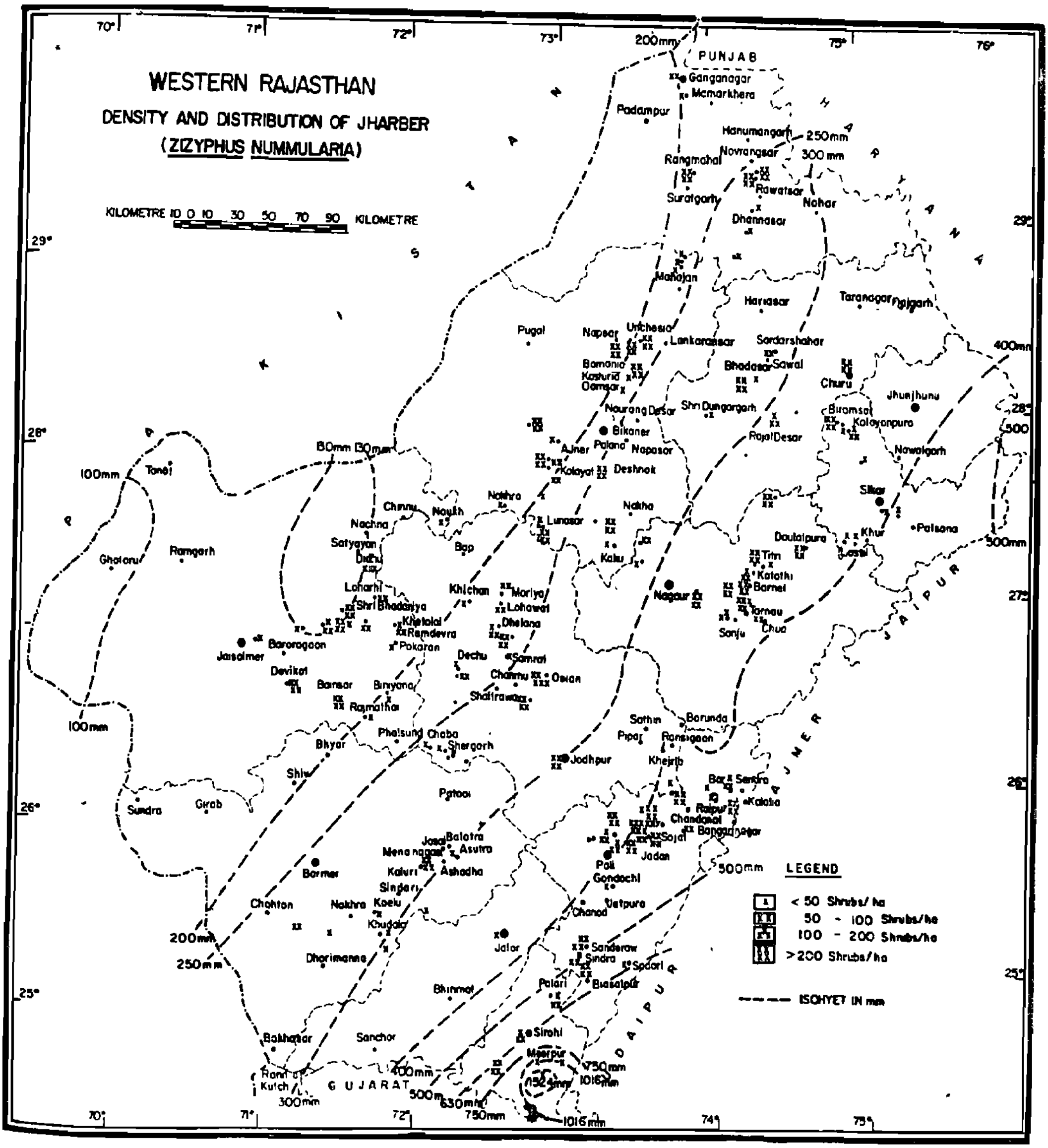

WESTERN RAJASTHAN
DENSITY AND DISTRIBUTION OF JHARBER
(ZIZYPHUS NUMMULARIA)
KILOMETRE 10 0 10 30 50 70 90 KILOMETRE
LEGEND
< 50 Shrubs/ha
50 - 100 Shrubs/ha
100 - 200 Shrubs/ha
>200 Shrubs/ha
ISOHYET IN mm
PUNJAB
GUJARAT
Jodhpur
Bikaner
Jaisalmer
Barmer
Nagaur
Churu
Jhunjhunu
Sikar
Pali
Jalor
Sirohi
Ganganagar

Fig. 1

Table 3. Density of *Jharber* on older alluvial plains of nine districts of W. Rajasthan

District	Range	Mean	No. of sites sampled
Nagaur	30–180	720	4
Sikar	10–160	78	4
Churu	10–1270	405	4
Bikaner	390	390	1
Ganganagar	210	210	1
Jaisalmer	65	65	2
Jodhpur	265–750	471	4
Pali	10–470	128	4
Jalore	10–160	76	5

of the preferred habitat and overall biotic interference are largely responsible for sparse or dense population of *Jharber* (Fig. 1).

Ecological distribution

Density of *Jharber* on various habitats in west Rajasthan is presented in Table 4. Older alluvial plains (373 plants/ha) followed by sandy undulating older alluvial plains (206 plants/ha), piedmonts (175 plants/ha) and gravelly plains are preferred habitats of *Khejri* (*Prosopis cineraria*). *Jharber* occurs in association with *Khejri* (Satyanarayan, 1963).

Preferential occupation of alluvial habitats by *Jharber* can be corroborated by studies on the soil types of the habitats (Table 5). Highest density (478 plants/ha) of *Jharber* was observed on loamy soil followed by sandy loam soils (453 plants/ha). The density of *Jharber* on heavy soils (clay and clay-loam) was poorest (64 plants/ha). On sandy and gravelly soils density of *Jharber* was 122

Table 4. Density of *Jharber* on various habitats in W. Rajasthan

Habitat	Range	Mean	No of sites sampled
Older alluvial plains	10 – 1880	373	31
Sandy undulating plains	10 – 1160	206	28
Sandy buried pediments	10 – 210	78	6
Interdunal sandy undulating plains	10 – 150	80	2
Sandy undulating pediment plains	10 – 580	95	17
Upper pediments	30 – 440	175	4
Lower pediments	10 – 90	50	2
Gravelly plains	10 – 270	105	4
Hilly/rocky areas	30 – 50	40	2
Low dunes	10 – 250	92	6
River beds	0 – 10	10	1

and 109 trees/ha, respectively.

Different landuse also affect the density of *Jharber* (Table 6). On comparatively protected areas, reserved pastures/ woodlands, for example, the density of *Jharber* was highest (345 trees/ha). Its density on cultivated fallows, grazing lands and marginal/wastelands was 212, 214 and 160 trees/ha, respectively. Very wide variations in its density was observed in cultivated fallows and grazing lands. This indicated that its density is largely governed by the biotic factors.

High density of *Jharber* in Jodhpur-Nagaur-Bikaner-Churu region, which broadly come within 250 to 350 mm rainfall zone, indicated that this rainfall zone favours optimum expression of *Jharber* density. In low rainfall zone of Jaisalmer, for example, its density was lowest (65 trees/ha.) In high rainfall zone, in Pali, for example, its density was also low (128 trees/ha).

Leaf fodder and bushwood production

Leaf fodder and bushwood production of *Z. nummularia* was studied on 7 sites covering 4 habitats, 5 soil types and 4 land use types (Table 7). On older alluvium and buried pediments the leaf fodder and bushwood yield were higher as compare to other habitats. Highest leaf fodder (169.2 kg/ha) and bushwood (147.0 kg/ha) were recorded from buried pediments and lowest (1.12 kg/ha leaf fodder and 6.3 kg/ha bushwood) from pediments and lower piedmonts. On loose sandy loam soils both leaf fodder and bushwood production was higher as compared to heavy (clay loam) and gravelly soils. Leaf fodder and bushwood production were higher in cultivated fields than those on grazinglands and protected grasslands. Average canopy cover and height followed the similar pattern. Major influence

Table 5. Density of *Jharber* on different soil types in W. Rajasthan

Soil type	Range	Mean	No. of sites sampled
Sandy	5 – 1160	122	74
Loamy	10 – 1880	478	15
Sandy loam	10 – 1640	453	12
Clay loam	10 – 170	64	6
Gravelly	10 – 440	109	16

Table 6. Density of *Jharber* on different land-use types in W. Rajasthan

Land use	Range	Mean	No. of sites sampled
Grazing lands *(Oran)*	5 – 1600	214	93
Wastelands	10 – 360	160	9
Cultivated fallows	5 – 1640	212	21
Reserved pastures	30 – 750	345	4

Table 7. Leaf fodder *(pala)* and firewood production on different habitats and landuse types

Sites	Habitat	Soil texture and depth (cm)	Landuse	Shrub density (No/ha)	Average canopy cover (m^2)	Average height (m)	Shrub cover per ha (%)	*Pala* yield (kg/ha)★	Bush wood yield (kg/ha)★	Bush wood *Pala* ratio
Dhareshwar (Pali)	Older alluvium	Clay loam 1.0	Cultivated field	1460	1.04	0 97	15 24	91 08	80 00	0 88
Jadan-1 (Pali)	Pediment plains	Gravelly 0.05	Grazing land	1250	0 09	0.16	1.12	6.36	23.72	3.73
Jadan-2 (Pali)	Pediment plains	Loamy 0.25	Protected grassland	1500	0 44	0.81	6 64	42.75	98 00	2.29
Beriganga (Jodhpur)	Lower piedmont	Gravelly 0.01	Grazing land	170	0 66	0.85	1.12	15.44	63.83	4.13
Netra-1 (Jodhpur)	Older alluvium	Sandy loam 0.65	Cultivated field	550	0 18	0 62	5 88	49.99	117.31	2 35
Netra-2 (Jodhpur)	Buried pediment	Silty loam 0 30	—do—	2820	1.07	0 85	5.14	142 33	323.10	2 27
Gharav (Jodhpur)	Buried pediment	Sandy loam 0.60	—do—	1660	0.63	0.91	10-46	169.20	147.00	0.87

★Oven dry weights.

of landuse types was reflected in the ratio of bushwood to leaf fodder. The ratio in cultivated field was invariably lower (0.88) than that in grazinglands (4.13). This indicated that high leaf fodder as well as bushwood can be obtained in cultivated fields with 10 to 15% of shrub cover per hectare.

Conclusions

On the basis of this study it can be concluded that (1) alluvial plains are preferred habitats of *Jharber* although fairly good density can be observed on piedmonts and gravelly plains, (2) loam and sandy loam soils support high density of *Jharber* and heavy (clay) soils do not seem to be preferred by it, (3) its density in nature is influenced by the magnitude of biotic disturbance in the form of felling for firewood and lopping etc., (4) *Jharber* has high regeneration and coppicing capacity as observed in reserved pastures, (5) optimum expression of its density can be seen in 250 to 350 mm rainfall zone and (6) Jodhpur-Nagaur-Bikaner-Churu region has high concentration of *Jharber,* (7) older alluvium and buried pediments with loose sandy loam soils favour high leaf fodder with 10 to 15% shrub cover per hectare produce high leaf fodder and bushwood production without adversely affecting the crop yield.

Silvicultural Aspects

K. D. MUTHANA

INTRODUCTION

Bordi (*Z. nummularia*) is a thorny, medium sized straggling shrub which grows to a height of 4-5 metres, if left uncut. It is always found in clusters of 2-5 due to its propagation by root suckers. It is a drought hardy shrub, thrives well in areas having 125 to 850 mm rainfall. Amongst the fodder shrubs, *Z. nummularia* (*Bordi*) is by far the superior and most important. Some of the silvicultural aspects carried out at CAZRI are mentioned here.

Seed germination

There are invariably 2 seeds in each nut. They can be extracted by breaking the nut. Prior to sowing, the seeds are soaked for 24 hours in normal tap water and sown in polythene bags or galvanised iron (G. I.) tubes (10 x 30 cm) at 0.5 to 0.75 cm depth. The bags are watered sparingly so as to keep the top layer of the soil moist. Germination takes place from the fifth day and continues for about fifteen days. Germination percentage ranged from 65 to 80 and seedling stand ranged from 60 to 75 per cent only.

Transplanting

Seed sowing is normally done in September-October and seedlings are transplanted in July after 9 to 10 months of growth by the time seedlings attained about 20-25 cm height. 60^3 cm pits are prepared before the onset of monsoon. Transplanting in the prepared pits is normally done after a good soaking shower in the month of July. In case rainfall distribution after the transplanting is poor, watering the planting pits at 9 litre per pit fortnightly is advocated till their establishment. Care should also be taken to straighten the tap root at the time of planting in the pits as the tap roots remain coiled when raised in polythene bags. No such problem is encountered when raised in G. I. tubes. Aldrex powder and some fungicide should be mixed in the soil at the time of transplanting. Such precautions provide 75 to 90 per cent establishment of the seed-

lings. Young plants need protection from browsing animals. Once established, they can withstand browsing.

Growth rate: The growth rate of this species in the first year is rather slow and recorded at 25 cm as mean annual increment but from the second year the mean annual increment (m.a.i.) was at the rate of 50 cm. In the case of *Zizyphus rotundifolia,* the m.a.i. recorded in the first year was 80 cm and from the second year onwards it was 65 cm on an average.

Maturity: *Zizyphus nummularia* starts bearing fruits after the second year of establishment, whereas *Z. rotundifolia* starts bearing fruits from the first year of establishment. A well developed bush of *Z. nummularia,* if allowed to grow for about 5 years yields 3.5 to 4 kg fruits per plant whereas that of *Z. rotundifolia* yields about 8 to 10 kg of fruits per plant.

Both are very good coppicers and produce innumerable shoots when headed back at 6-8 cm above the ground level for harvesting fodder and thorns.

A provenance trial on *Zizyphus* species was initiated at Jodhpur in 1976. It revealed that seeds of *Z. rotundifolia* collected from Jodhpur gave best performance in height, establishment, fodder and fuel yield (Table 8). The cut plants initiated their growth in the month of February-March and approximately reach to the same height by August.

Shrub density in grazing lands

Kaul and Ganguli (1963) studied the optimum density of *Bordi* shrub in a grazingland on flat alluvial plain where the heavy soils were only 30 cm deep and underlain by hard *kankar* pan. They classified the area into three classes, i.e. (i)Fully stocked, (ii) Medium stocked, and (iii) Poor stocked and evaluated their average yield of leaf fodder and grass in kg/plot (0.202 ha) (Table 9).

The average total forage yield from the plot having 14 per cent density of *Zizyphus* shrubs was 14 and 15 per cent higher than from 18 and 11 per cent density respectively. If shrub density is more than 14 per cent, it is likely to suppress the grass production from the grazing lands. This further suggests that the proper maintenance and management of optimum density (14%) of this useful shrub should therefore form an integral part of sound grassland improvement in arid zones.

From another study conducted to determine the correlation between leaf fodder yield and different plant characters, viz. (1) mean height, (2) number of shoots, and (3) crown spread, it was observed that the correlation between yield and crown spread, number of branches and crown spread was highly significant. The prediction equation for forecasting fodder yield for given values of 3 variates was calculated as under:-

$$Y = 0.0390 + 0.0441\ x_1 - 0.0012\ x_2 + 0.0407\ x_3$$

where, x_1 = Mean height

x_2 = Total number of shoots

x_3 = Crown spread (Kaul and Ganguli, 1963).

The leaves of several species, e.g. *Acacias nilotica* and *Prosopis juliflora* though contain high percentage of crude protein contents are not palatable to livestock due to certain bitter substances, perhaps some alkaloides. Thus available protein cannot be mixed with palatability (Ganguli *et al.*, 1964). Thus

Table 8. Provenance trial of *Zizyphus* sp. at Jodhpur

Species	Place of collection	Mean height (cm)			Establishment (%)		Biomass production (t/ha)	
		1976	1977	1978	1976	1977	Fodder	Fuel
Zizyphus rotundifolia	Jodhpur	97 0	264.0	274.0	100	100	1.180	2.99
Z. rotundifolia	- do -	96.0	264.0	225.0	88	88	0.742	2.50
Z. nummularia	Bikaner	33.0	133.0	147.0	100	100	0.595	2.83
Z. nummularia	Pali	74.0	239.0	182.0	100	100	9.536	2.00
Z. spina-cristae	Israel	84.0	256.0	235.0	100	100	0.722	1.17

Table 9. Grass and shrub leaf fodder yield (kg/ha) in a grazing land

Condition of stocking	Per cent density of *Zizyphus* shrubs	Yield of fodder		Yield of grass		Total yield of forage	
		Per plot	Per ha	Per plot	Per ha	Per plot	Per ha
Fully stocked	18	30	150	109	545	139	695
Medium stocked	14	25	125	175	875	200	1000
Poorly stocked	11	21	105	154	770	175	875

(After Kaul and Ganguli, 1963).

evaluating the palatability and acceptability, *Bordi* (*Z. nummularia*) and *Khejri* (*P. cineraria*) can be classified as the best top feed species for livestock.

Fuel energy value

Bordi yields very high quality heartwood, dark brown in colour having high calorific value (7900 Btu/pound of dry matter and thus is an excellent fuel, Ganguli *et al.*, 1962). But all the parts of this shrub have their use, and hence it hardly finds its way for burning.

Eradication of bordi

It is very difficult to remove established *bordi* plants once it is considered as a weed in irrigated fields. Method adopted for its eradication are (1) Painting of 5 ml "Spontox" (a mixture of 2, 4-D and 2, 4, 5-T) or "Bladex-k" (mixture of 2, 4-D and butox-ethanol ester of 2, 4, 5-T) after debarking at the collar region for complete eradication of this shrub. It was also reported that stump treatment with 2, 4, 5-T prevented resprouting of unwanted and pernicious woody perennial shrub and tree species infesting grasslands and helped in increasing the productivity of natural grasslands (Mukhtar Singh, 1969).

Physiological Aspects

S. KATHJU AND A. N. LAHIRI

INTRODUCTION

Zizyphus nummularia occurs in the Indian deserts in diverse habitats. The principal importance of this tree arises from the use of leaves as fodder. The stem is generally used as fencing material. This species is now used as resistant stock for grafting *Z. mauritiana* for large fruits. The present paper relates some of the available information on the water relations of this shrub in the context of its histological and metabolic parameters.

Morphological and histological adaptations

Root: Depending on the distribution of laterals, Tanwar and Sen (1980) have classified desert plants in seven groups. *Z. nummularia* falls in the category of plants which have a deep and spreading root system. It has a deep tap root system with laterals appearing along the entire root length. The extensive lateral and secondary roots spread horizontally, as well as vertically, and thus compete with other vegetation and crops for moisture and nutrients. The profuse branching along the entire root system makes *Z. nummularia* a good sand binder.

The roots are woody with multilayered cork surrounding the parenchymatous cortex in which are embedded patches of sclerenchyma. All around the stele parenchymatous cells are present which are supposed to be primary phloem. Multilayered fascicular cambium separates secondary phloem and xylem. Central vessel contains tyloses. Medullary rays with starch are also commonly found (Tanwar and Sen, 1980).

Stem: The epidermis is single layered. The cortex comprises of well developed sub-epidermal cork. There is a sclerenchymatous ring of pericycle below the cortex. Occasionally instead of complete cycle, patches of sclerenchymatous pericycle may also be found. The wood is well developed consisting of large vessels. Numerous uniseriate medullary rays are present in the wood. In the centre a small pith is present consisting of thin walled parenchymatous cells. Four to six large cavities secreting muscilage (Plate 3) may often be found in the pith region.

Leaf: There is a large variability in the leaf size and shape. Generally plants possess round leaves in which case length

of the leaf is either small or equal to the leaf width. Plants may also possess oval shaped leaves where leaf length is always more than the width (Plate 4).

Presence of stomata only on the lower surface of the leaf is an adaptive feature in this plant. The upper surface is devoid of stomata and only few small hairs are present. Profuse hairs are, however, found on the lower surface which imparts it a whitish woolly appearance (Plate 5). It seems obvious that these hairs help in leaf temperature regulation and possibly provide a better and humid micro-environment around the stomata. These hairs also impose mechanical barrier to the high wind, prevalent in the desert. These adaptive features are, however, present only in *Z. nummularia* but not in *Z. mauritiana* which grows in slightly higher rainfall areas. In *Z. mauritiana* the lower surface is devoid of hairs and green in appearance where prominent mid-rib and veins are clearly visible. Due to the absence of leaf hairs in this plant, distinct stomata possessing typical kidney shaped guard cells could be observed. However, in *Z. nummularia* it is difficult to observe stomata due to the presence of profuse hairs (Plate 6). Small leaves of *Z. nummularia* may also impart advantage to the plant in surviving the dry conditions due to the reduction in surface area. Studies undertaken on other desertic trees have shown (Lahiri and Kharabanda, 1967) that reduction in leaf area contributed much towards economy in water use.

Anatomical studies on leaves indicated that the upper epidermis consists of a single layer of large and thin walled cells. The outer walls are thickened. Occasionally, hairs may be observed on the upper epidermis, but stomata are absent. Below the upper epidermis there are about three to four layered columnar pallisade cells. These cells are compactly arranged without air spaces. The elongated spongy cells are loosely arranged towards the lower epidermis with profuse intercellular spaces. The lower epidermis is single layered with thin walled cells. The epidermis is perforated by stomata. The hairy covering on the lower epidermis consists of the uniseriate trichomes. Some furrows are also present in the lower surface giving a wavy appearance to the lower epidermis. Stomata are generally present only on the ridges (Plate 7).

Prominent mid-rib is present in the centre of the leaf lamina. On the upper surface there is a small depression over the mid-rib. In this region, the epidermal cells are comparatively small. On the lower surface the mid-rib is very prominent. Below the epidermis are present few layers of small but compact collenchymatous cells. The vascular bundles are collateral and closed with xylem present on the upper surface and phloem towards the lower surface. The vascular bundle is surrounded by thin walled cells. Occasionally four to five mucilaginous cavities could be observed in the mid-rib towards the lower surface. Collenchyma is present all around the vascular bundle.

Habitat effect on fruiting

According to Nanda (1967) the flowering behaviour of *Bordi* plants is influenced to a great extent by the habitat. Flowering in plants growing in the sandy habitat begins in May-June reaching a peak in July-August in contrast to rocky

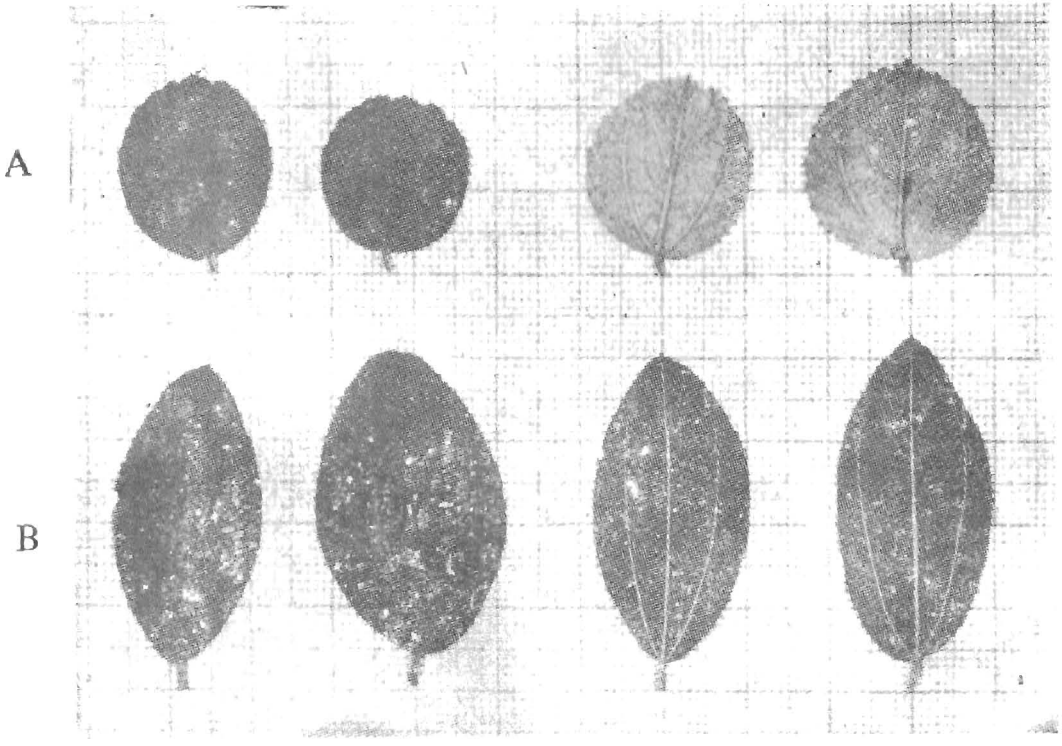


Plate 4. Profuse hairs present on the lower surface give whitish appearance to the leaves of *Z. nummularia* (A), but in *Z. mauritiana* these hairs are absent (B).

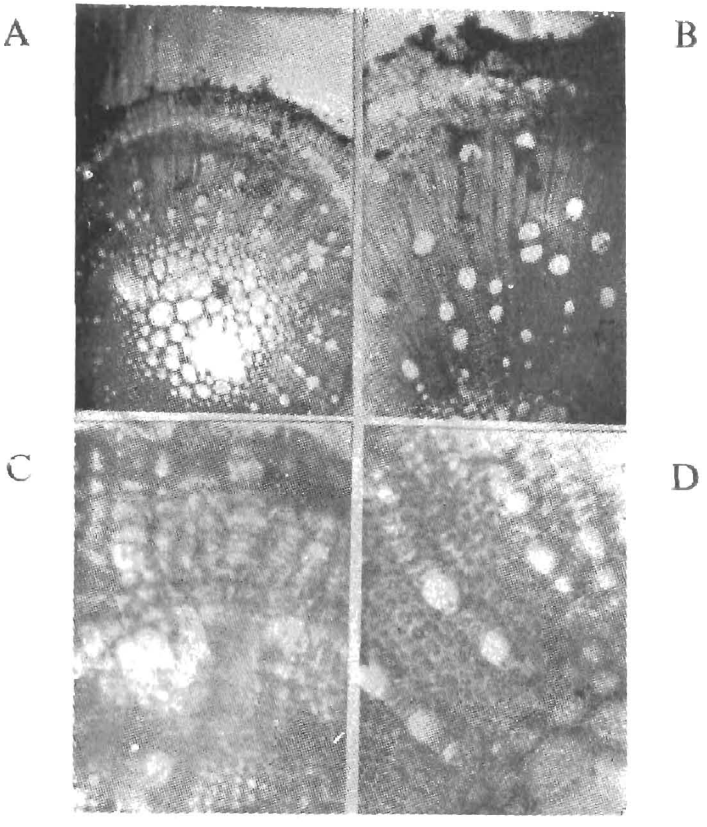


Plate 3. Transverse section of the stem of *Z. nummularia* showing mucilaginous cavities in the pith (A), well developed wood with large vessels (B), well developed periderm and cork (C), large thin walled cells enclosing mucilaginous cavities (D).

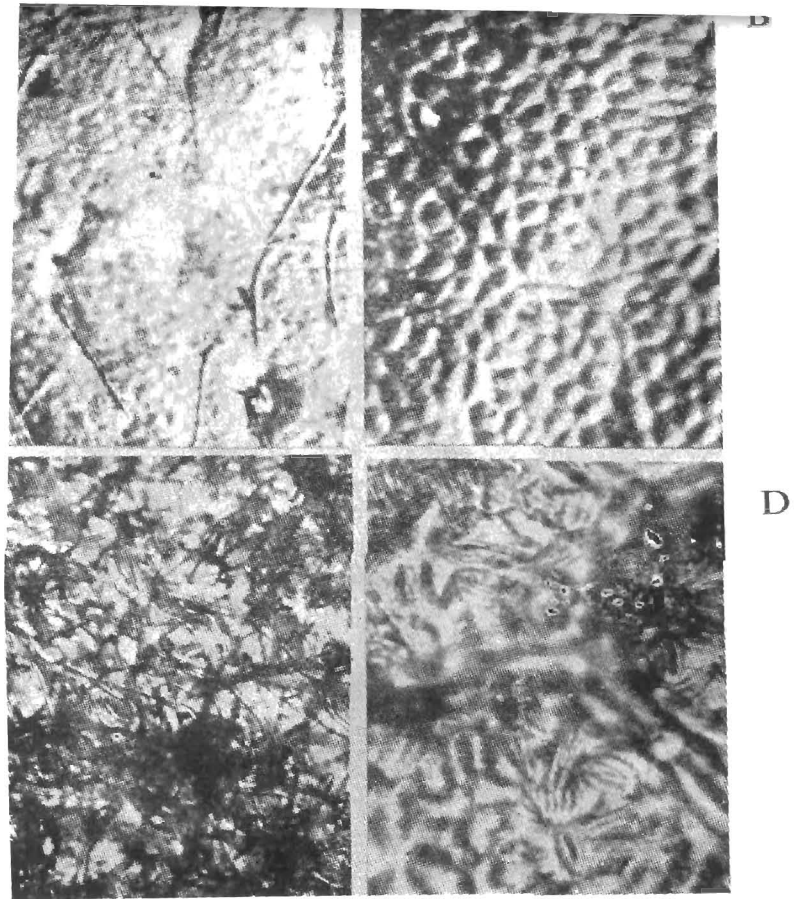


Plate 5. On the upper surface of *Z. nummularia* are present few hairs (A), but in *Z. mauritiana* such hairs are absent (B). On the lower surface of *Z. nummularia* leaves due to presence of profuse hairs it is difficult to observe stomata (C) but in *Z. mauritiana* typical dicotyledonous stomata may be observed (D).

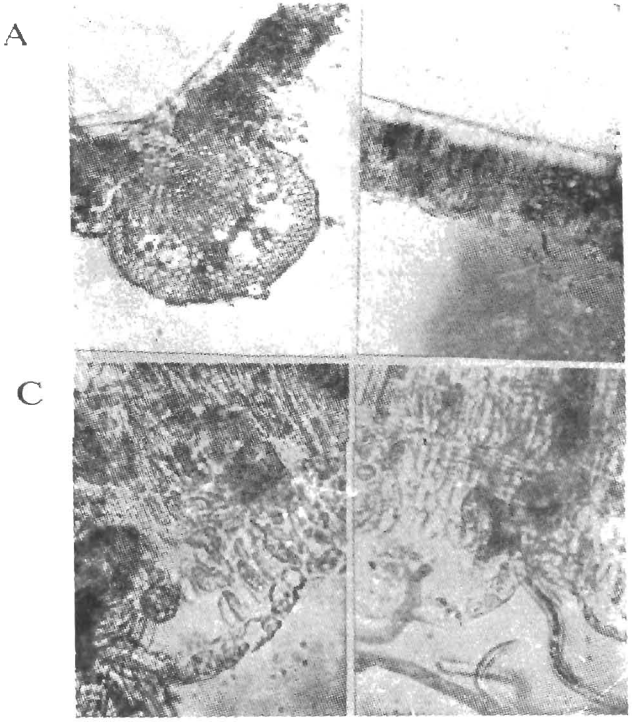


Plate 6. Transverse section of leaf showing prominent mid rib (A), elongated epidermal cells on the upper epidermis (B), wavy lower surface with stomatal cavity and loosely arranged palisade cells towards the lower epidermis (C), and hairs on the lower surface (D).

plants where flowering begins only in the late July reaching a peak in August-September. Size and shape of fruit have also been reported to differ in the plants of two habitats. Plants under sandy habitat produce fruits bigger in size having more of pulp (Table 10).

Table 10. Effect of habitat on the fruit characteristics of *Bordi* (after Nanda, 1967)

Habitat	Fruit diameter (mm)		Weight of 100 fruits (gm)		Weight of pulp of 100 fruits (gm)
	Unripe	ripe	Unripe	ripe	
Sandy	8.78	11.19	40.60	86.80	62.82
Rocky	7.35	10.96	27.84	72.68	46.30

Water relations

Transpiration: The rate of transpiration has been found to be consistently higher in the young leaves as compared to old ones. On an average, young leaves during the post-monsoon dry period lost water at the rate of about 964.9 mg/gm/hr whereas old leaves of the same plant transpired at the rate of only 679.7 mg/gm/hr. Calculations further indicated that young leaves transpired more than old leaves per unit of area. The average moisture loss from a cm^2 area of young leaf is 23.79 mg in an hour while in old leaves it is only 15.85 mg. Thus the young leaves lost moisture at a very fast rate. Diurnal variations indicate that the transpiration rate increases gradually after sunrise reaching a peak at 15 hrs and then again declines (Fig. 2). Slight drop in the rate of transpiration at 13 hrs was possibly related to the decline of temperature and also sunlight due to the appearance of clouds. But the rate again increased reaching a peak at 15 hours when the sky was clear. When the transpiration rate was at its peak, the small leaves may lose as much as 1.30 gm of moisture per gm of fresh leaf in an hour whereas old leaves lost only 0.95 gm moisture per gm of fresh leaf during the same period.

In afternoon the transpiration rate was apparently higher than the water uptake and consequently the leaf water content tended to decline. But a recovery was noted in the evening when transpiration rate gradually declined. It may be observed from Fig. 3 that this fall in leaf moisture content in the afternoon was more in the young leaves than that of the old leaves mainly due to the higher losses of moisture through transpiration from young leaves. The moisture content in the leaves varied from 62.5% to 52.6%, with highest being in the youngest leaves at the tip (Table 11).

Table 11. Moisture content in *Bordi* leaves

Leaf position from the tip	Fresh weight of leaf (mg)	Percentage moisture
1-2	15.50	62.50
10	68.53	55.56
20	89.17	52.63
40	102.41	52.64

Moisture relations of Bordi twigs

Twigs of *Z. nummularia* have been shown (Maulay and Joshi, 1966) to absorb considerable moisture from the atmosphere under Pilani conditions and after 16 hours the twigs may absorb as high as 0.049 and 0.045 mg/sq cm of surface area in case of young and old twigs respectively. It has further been observed that the young twigs may loose 0.092 gm water/cm^2 in 15 days, whereas old twigs loose considerably more water (0.169 gm/cm^2) during this period. Thus young twigs absorb moisture at a faster rate but lose moisture at a considerably less rate.

Metabolism

Titrable acid number: It has been reported (Nanda, 1969) that irrespective of the season and habitat, titrable acid number is extremely low in the root and high values are encountered in the young leaves and stems. In plants growing in the sandy habitat maximum titrable acid number values were obtained in the summer season while under rocky habitat maximum values were obtained in the rainy season. In winter, the titrable acid number values were extremely low irrespective of the habitat (Table 12). It has thus been concluded that the synthesis of organic acids is regulated by the soil environment conditions and organic acids probably help in the absorption mechanism for the maintenance of the cell structure.

Organic acids in plant parts: Chromatographic studies indicated that *Z. nummularia* plant predominantly contain seven organic acids, viz. succinic, malonic, malic, fumaric, citric, tartaric and oxalic (Nanda, 1969). The roots predominantly contain malic acid, other acids mentioned above are also present with their quantities varying with the habitat. Citric acid was absent in roots irrespective of the habitat. Most prominent acids in young stems include fumaric and succinic. It has been speculated that malic acid accumulates in leaves and stems during soil moisture stress (Nanda, 1969).

Leaf chlorophyll: A typical absorption spectra of the leaf chlorophyll is shown in Fig. 4. There are two major peaks at 438 μ and 672 μ. Apart from these, there is another peak at 625 μ. There is a large variability in the chlorophyll content in leaves. The youngest leaves appearing in October at the

Table 12. Seasonal fluctuations in the titrable acid number in *Z. nummularia* (after Nanda, 1969)

Plant part		Sandy habitat			Rocky habitat		
		Monsoon	Winter	Summer	Monsoon	Winter	Summer
Root	—	8.2	3.1	17.8	27.6	5.3	6.2
Stem	young	36.4	16.1	52.0	51.4	21.5	24.6
	mature	19.1	4.4	10.3	31.1	9.3	10.0
Leaf	young	69.5	20.5	79.9	43.8	34.9	61.8
	mature	38.5	14.5	28.2	29.3	27.4	65.8

tip which are also whitish in appearance contain less chlorophyll. First two leaves at the tip contain only 309 mg chlorophyll/gm dry leaf whereas in the 10th, 20th, and 40th leaf the chlorophyll content increases to 330.0, 343.6 and 405.7 mg/gm dry leaf respectively. With leaf ageing the magnitude of rise in the chlorophyll 'a' is much higher than that of chlorophyll 'b' resulting in an increase in the chlorophyll 'a' and 'b' ratio. The concentration of carotenoids is maximum in the youngest leaf at the tip (Table 13). However, during the fruiting stage in November when differentiation of new leaves is stopped the concentration of chlorophyll is higher in the leaves at the tip. For example, leaves at the tip contain 1.34 mg chlorophyll/gm fresh leaf, whereas 20th and the 40th leaves contain only 1.21 and 0.97 mg chlorophyll/gm fresh leaf.

Carbohydrates in leaves: Generally the concentration of carbohydrates was maximum in the oldest leaves (Table 14). The new leaves contained only 3.3% reducing sugars while old leaves contained 4.3 to 4.5% reducing sugars. Similarly, the concentration of total soluble carbohydrates in the youngest leaves was only 6.2% while it ranged from 9.0 to 11.4% in old leaves. Likewise new leaves contain only 4.6% starch while old leaves contain 6.4 to 7.6% starch. The high content of carbohydrates in the old leaves in October is probably due to high photosynthetic capacity of old leaves due to high chlorophyll content.

Leaf proteins: The extractable leaf protein content in young developing leaves ranged from 1.1 to 1.5% but in

Table 13. Chlorophyll content in *Bordi* leaves (mg/gm dry leaf)

Leaf position from the tip	Chlorophyll		a:b (ratio)	Total chlorophyll	Carotenoids
	a	b			
1-2	167.8	141.8	1.18	309.5	109.3
10	171.6	158.4	1.08	330.0	61.5
20	189.0	154.6	1.22	343.6	81.4
40	228.1	177.6	1.28	405.7	94.3

Table 14. Contents of carbohydrates and soluble proteins in *Bordi* leaves (mg/100 mg dry leaf)

Leaf position from the tip	Reducing sugars	Soluble carbohydrates	Starch	Soluble protein
1-2	3.32	6.24	4.61	1.50
10	4.51	9.02	7.64	1.13
20	4.37	11.37	6.61	1.21
40	4.30	10.23	6.38	5.17

fully developed leaves, e.g. 40th from the tip, the extractable leaf protein content was high (5.2%). Thus, large amount of leaf protein concentrate may only be obtained from the fully mature old leaves (Table 14). Usually the leaf protein concentration in desertic plants is meagre mainly due to the presence of well developed mechanical tissue which makes the extraction of leaf protein more difficult. Depending on the growth stage and other management conditions, desertic grasses like *Cenchrus ciliaris, C. setigerus* and *Lasiurus sindicus* are found to yield 9.4, 8.8 and 7.1% leaf protein. In grasslands, *Z. nummularia* with a density of 14% and grasses gave maximum yield of forage (10 q/ha). At this optimum density, *Z. nummularia* may give leaf yield of 125 kg/ha in addition to 8.75 q/ha of grass yield (Kaul and Ganguli, 1963). Since leaves may yield upto 5.2% soluble protein, about 6.5 kg of extractable proteins may be obtained from a hectare. The leaf protein yield of this shrub, is, however, less than that obtained from forage grasses of this area. Desertic grasses may yield 60-80 kg LPC/ha, mainly because high leaf yield is coupled with the higher percentage of extractable leaf protein (Kathju *et al.*, 1979). The presence of mucilage in the leaves of *Z. nummularia* also makes the extraction of leaf protein difficult. However, during the fodder scarcity months, leaves of this tree evidently serve as a good source of fodder to animals of this region.

Ecophysiological studies

Pandeya and Joshi (1972) have studied the ecophysiology of *Zizyphus nummularia*. They have shown that increase in traspiration enhanced the rate of net photosynthesis whereas respiration rate did not change. Upto a certain level, the transpiration rate increased with increase in the leaf energy and then it gradually fell. Leaf energy content decreased with increase in air temperature. The rate of net photosynthesis was positively correlated with the leaf energy content. The transpiration rate declined with increase in leaf moisture. The leaf moisture content indicated an inverse relationship with the net photosynthesis. Similarly photosynthetic efficiency was also inversely related with the temperature.

Weekly observations on physiological processes like transpiration, photosynthesis and respiration indicated large variations during seasonal changes. In winter both leaf moisture and leaf energy contents were higher. Whereas with increase in air temperature, the leaf energy content decreased. Seasonal variations also indicated positive correlation between net photosynthesis and leaf energy content.

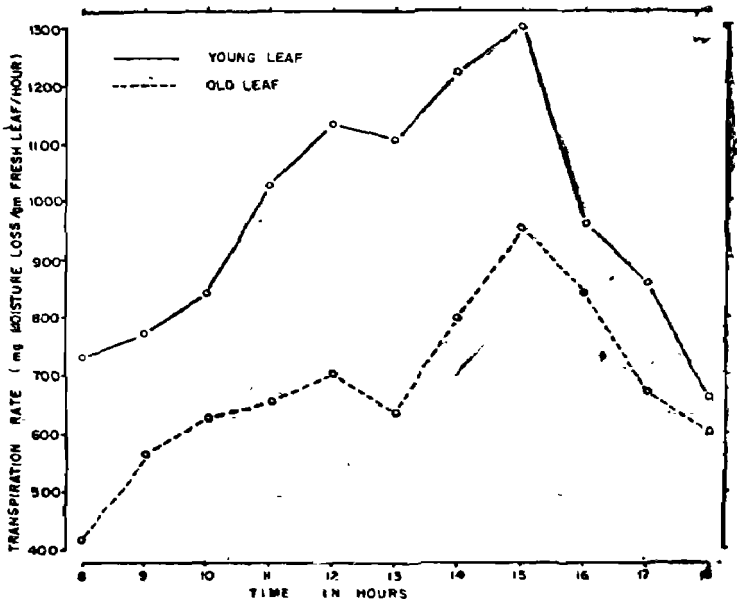


Fig. 2. Diurnal variation in the transpiration rate in old and young leaves of *Bordi*.

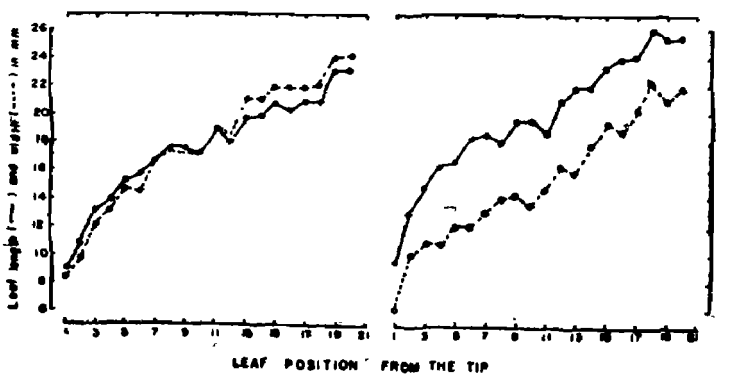


Fig. 3. Variation in the length and breadth of leaves at different positions from the tip.

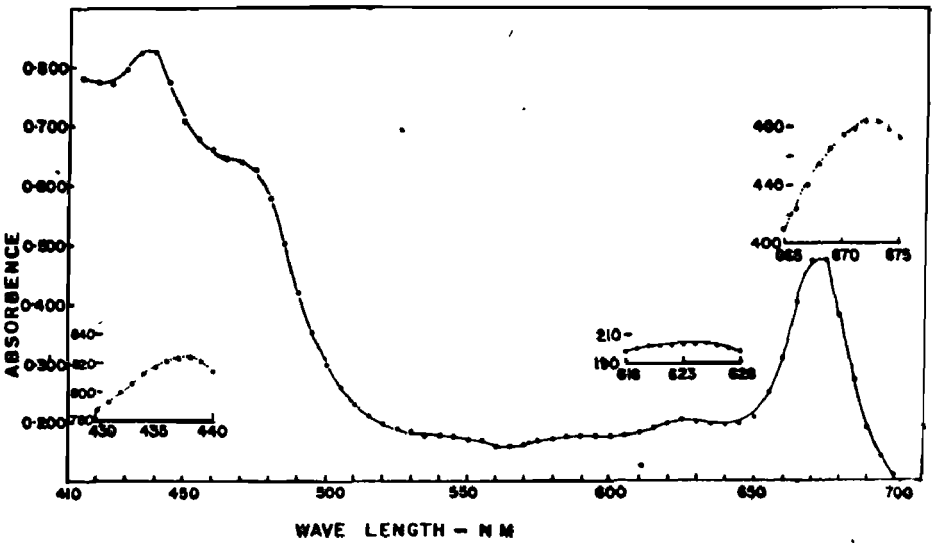


Fig. 4. Absorption spectra of chlorophyll extract of *Bordi* leaf.

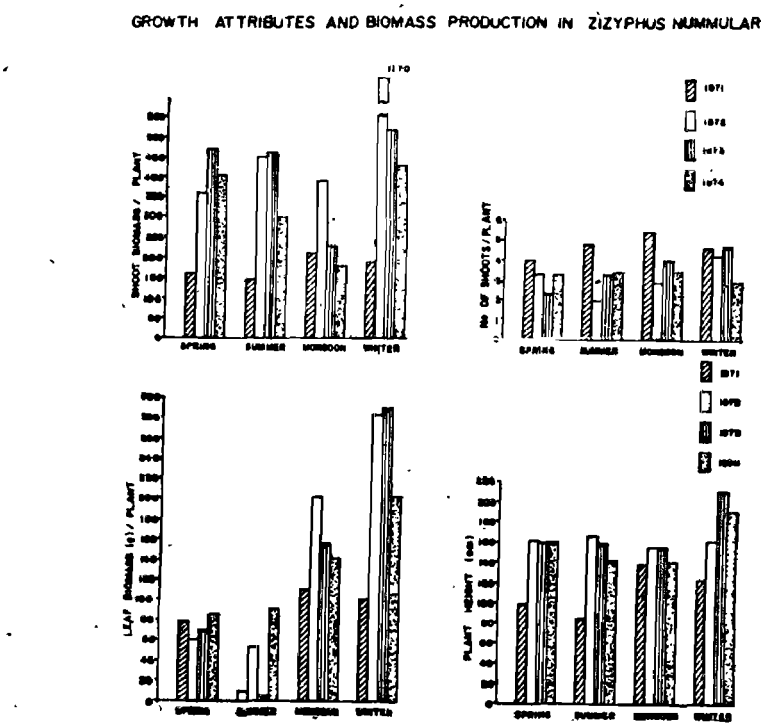


Fig. 5

Productivity of a desert shrub *(Zizyphus nummularia)*

S. K. SAXENA AND S. K. SHARMA

INTRODUCTION

In recent past much emphasis has been given to evaluate the productivity of a various ecosystem especially in the context of International Biological programme and also in Man and Biosphere programme. Much work on terrestrial ecosystem has been generated in India and abroad under these two programmes (Golley and Golley, 1972; Rohdin, 1972; Odum and Odum, 1960, 1963; Ovington, 1962).

Biological productivity studies in the desert areas acquire special significance as its vegetation greatly depends on the annual precipitation. Most of the plants grow in the arid tract are ephemerals and annual species. These species make their appearance with the onset of monsoon and complete their life cycle by the time it is receded. To the grazing population it is the perennial shrub and tree species which provide top feed when annual species are over. *Zizyphus nummularia (Bordi)* is one of such important shrub species of arid and semi-arid tract which continue to supply foliage for a longer period of time. It plays a vital role in the economy of desert people. Thus dry matter production of this shrub and its distribution into stem and leaves are of prime importance. The present study reports the preliminary observation made on the above ground biomass and productivity of *Bordi* (*Z. nummularia*).

Study site and environment

The present study was carried out at Jodhpur situated between 73°3'N longitude and 76°15'E latitude. The land was categorized as flat alluvial plains. Here the soils are deep to very deep (120-150 cm), sandy loam underlined by hard *kankar* pan. The site was protected from outside biotic influences by barbed wire fencing since 1960.

The climatic conditions are arid with Thornthwaite's moisture index as -46 and Gaussens xerothermic index being 260 physiological dry days. Extremes of temperature, low and erratic rainfall and high evaporation rates make the site characteristics of an arid climate. The average annual rainfall is 361 mm (60 years average). During the period of study (1970-74) the annual rainfall was 594.8,

307.6, 363.3, 641.8 and 244.3 mm respectively (Table 15). The onset of monsoon takes place by the end of June with maximum rainfall during August. It extends upto September and rarely to October. The perennial plants attain the maximum growth during this period. November to February constitute the winter, January being the coldest month. After February the temperature starts rising while the relative humidity goes down. The wind velocity is higher (12-15.8 km/hr) during March-June. Dry months result in desiccation and blowing of surface soil from one field to the other. Dust storm are more common during May-June. The depletion of soil moisture starts by September and continue throughout summer. Shrub species exhibit the moisture stress by shedding off their leaves.

Method of study

On the study site forty naturally growing bushes of *Bordi* (*Z. nummularia*), of almost similar age group were selected for bio-mass production in different seasons. These forty selected shrubs were randomly divided into four equal groups of ten plants each. Observation like plant height, basal cover, crown cover, leaf and stem weight were recorded during winter, spring, summer and monsoon season. The experiment was initiated in December 1970 and continued upto December 1974. The observations were recorded by the end of each quarter at an interval of ninety days. The labelled bushes were measured for height, ground cover, crown cover and the productivity. Each individual bush was cut once in a year in its respective season. The crown spread of individual bush was measured along the cross diameter of the crown and expressed in sq cm. There are number of shoots (stumps) in *Zizyphus* shrub. The perimeter of all the shoots in a bush was taken with the help of a thread at the ground level. The perimeter figures are converted into area by applying $2\pi r^2$. All the readings of shoots after conversion were added to

Table 15. Rainfall data at Jodhpur

1970	1971	1972	1973	1974
0.0	0.0	0.0	0.5	0.0
8.3	2.9	0.7	0.5	0.0
1.2	0.0	0 6	0.0	0.0
0.0	2.5	2.0	0.0	0.0
26.3	25.9	16.4	23.6	15.8
44.0	57.4	13.4	71.6	51.8
59.4	70.4	27.0	109.9	+119.3
364.2	112.1	299.2	365.3	16.5
91.4	33.5	4.4	70.4	36.1
0.0	2.9	0.0	0.0	4.8
0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.2	0.0	0.0
594.8	307.6	363.3	641.8	244.3

calculate the basal cover of an individual bush. The bushes were cut at ground level. Leaves and stem were weighed separately.

In order to find out the density of *Bordi* in the field, five belts transects of 5 m x 30 m were randomly laid out in the field. To study the ground vegetation on the study site, ten quadrats of 1 m x 1 m area were also randomly fixed. Observations were recorded in the beginning and end of the experiment.

RESULTS AND DISCUSSION

The natural vegetation of the study site comprised of *Prosopis cineraria* as the main tree. The well distributed shrubs are *Zizyphus nummularia, Capparis decidua, Mimosa hamata* and *Calotropis procera*. Some of the undershrubs like *Crotalaria burhia, Tephrosia purpurea, Sericostemma pauciflorum* and *Aerva pseudotomentosa* exhibit their presence with prominence because of their being nonpalatable. The ground flora include grasses and herbaceous flora which constituted nearby fifty species.

Some of the common weeds, grasses and legumes are: *Tribulus terrestris, Justicia simplex, Gisekia pharnacoides, Pulicaria angustifolia, Eleusine compressa, Cenchrus ciliaris, C. biflorus, Dactyloctenium sindicum, Aristida funiculata, Indigofera cordifolia* and *I. linifolia.*

There was no change in the number of trees and shrub species during the study period (Table 16). Shrubs had predominating role (50.3% relative dominance). The ground vegetation had fifty species in the beginning year of study which decreased to 43 in the concluding year. There was little variation in their relative dominance. Annual legumes like *I. cordifolia* (43.7 plants/m^2)

Table 16. Botanical composition of shrubland and grassland community

Type of vegetation	No. of plant species		Relative dominance	
	A. Shrubland			
	Before	After		
Trees	2	2	12.2	
Shrubs	4	4	50.3	
Undershrubs	4	4	37.5	
	B. Grassland			
	Before	After	Before	After
Grasses annual	13	13	5.5	5.0
Grasses perennial	5	5	4.3	2.3
Weeds annual	17	13	6.7	15.3
Weeds perennial	4	4	16.8	13.7
Legume annual	5	3	29.3	34.5
Legume perennial	3	3	15.7	12.5
Sedges	3	2	21.6	16.7

had very high density followed by annual weeds, 40.5 plants/m^2.

Five belt transects of 5 x 30 m were randomly laid out in the field to record the density, frequency, crown cover and above ground biomass production of the *Bordi* bushes. The results have been presented in Table 17.

Bush density and frequency: There were eighteen *Bordi* bushes per belt (150 sqm area or 1200/ha). Their dispersion was quite peculiar (Fig. 5) as they generally restricted themselves in clusters/colonies. The average frequency of these bushes was 79.9% only.

Plant height: There was a good variation in the height of individual bush and it ranged from 54.2 cm to 130.2 cm (94.5 cm average).

Crown and basal cover: The crown cover of the dispersed *Bordi* bushes varies from 28.62 sqm (1.84%) per belt to 54.72 sqm (14.2%) with an average of 7.3% crown cover. The aggregate basal cover of the shoots (stumps) was 44.98 sqcm/belt (2996.0 sqcm/ha).

Above ground biomass production: The plants were cut at the ground level and stored in the open for four to five days. Leaves and stems were separated and oven dried at 80°C ± 1°C. The bushes gave 99.6 kg/ha of leaf fodder *Pala* or 83 gm/plant whereas the shoot weighed 187 kg/ha (156 gm/bush). The annual production of above ground biomass from *Bordi* bush was 286.6 kg/ha or 239 gm/plant.

Seasonal variations in growth attributes

Plant height: There was some variation in the plant height when they were cut in different seasons. The bushes cut during summer season attain relatively low height as compared to winter cut plants. There was a steady increase in plant height in successive years of cutting except in 1974. In 1973 winter season cut bushes attained maximum height (210 cm). The active plant growth and height took place during monsoon season and continue upto November end. Monsoon season cut plants exhibited little variation in their height.

Number of shoots: Exceptionally good and well distributed rainfall (594.8 mm) was received in 1970. Much suitable conditions promoted higher number of shoots per plant and the same was repeated in 1973. Low rainfall had its effect in producing less number of shoots

Table 17. Performance of *Bordi* (*Z. nummularia*) shrub under different belts

Character	Belts							Per ha
	I	II	III	IV	V	T	A	
Plant height (cm)	95.10	123.00	89 98	54 20	130.20	472.80	94.56	—
Plant density/belt	11.00	23.00	26.00	20 00	10 00	90.00	18.00	1200.00
Crown cover (sq m)	2.76	9.00	5.22	16.44	21.30	54.72	10.94	729.30
Basal area (sq cm)	28.62	48.36	63.12	33.36	51.42	224.88	44.98	2996.00
Leaf weight (kg)	0.81	1.56	1.95	1.26	1.86	7.44	1.49	99.34
Shoot weight (kg)	1.57	3.30	3.60	2.37	3.16	14.00	2.80	186.70

per plant. Amongst the four seasons the plants cut during November (winter season) produced higher number of shoots/plant (Table 18).

Basal area: Higher number of stumps with better growth attained maximum basal area from winter cut bushes. Spring and summer cut plants showed minimum basal area, i.e. 2.2 and 2.3 cm^2 respectively. November cut bushes in 1972 recorded maximum values (11.74 cm^2). In 1972, higher values were recovered for monsoon cut bushes also. Overall the spring and summer cut bushes showed depressing effect and minimum values were obtained.

Above ground biomass

Leaf biomass: In the first year of observation (1970-71) the winter cut bushes produced 112 g/bush as against 10 g/bush in summer. Amongst four years winter cut plants produced the maximum foliage (292 g/plant) in 1973. Summer cut plants gave remarkably low foliage at the time of harvest. The low figure may be attributed to gradual leaf shedding from the bushes with the fast blowing winds and frequent dust storms. The wind storm finally leave behind almost leafless thorny skeleton of *Bordi* bushes. Sometimes good premonsoonic showers allow new growth or longer retention of old leaves and the same resulted in 1974 when 92 g/plant of foliage was harvested.

Shoot biomass: Like other characters, highest shoot biomass was obtained from winter cut bushes and in 1972, exceptionally higher biomass production (1170g/bush) as compared to rest of the the years was obtained. Unlike leaf biomass the wood biomass during summer was higher than the monsoon season. The loss of weight in the wood during monsoon period may be attributed to translocation of all the reserve food from the stem to the newly developed branches and foliage.

Net annual production and productivity

In four years experiment the lowest values of net above ground annual production (155 gm/bush) were obtained

Table 18. Growth attributes of *Bordi* in different seasons

Season	Aboveground biomass (gm)			Productivity/day	Plant height	Basal area	No. of stumps
	Leaf	Shoot	Production		(cm)	(cm^2)	
Spring	73.26	348.47	421.73	1.15	141.7	3.55	3.17
Summer	40.03	338.22	378.25	1.04	138.3	4.18	3.35
Monsoon	152.08	248.64	400.72	1.09	146.9	6.02	3.85
Winter	193.09	574.85	767.94	2.10	171.3	7.42	4.07
Mean	114.61	377.54	492.16	1.35	149.6	5.29	3.6
SEm±	±34.80	±69.87	—	—	±5.67	±0 61	±0.23
F test	Sig.	Sig.	—	—	H.Sig.	H.S.	Sig.
C.D. at 5%	100.7	202.15	—	—	16.40	1.76	0.66

from summer cut plants whereas the winter cut plants in 1972 produced exceptionally higher net production (1456 gm/bush). In 1973 and 1974 the net production ranged from 322 gm to 812 gm/bush/year. In all the four years winter cut plants produced higher net above ground production. These high production values in winter months suggest the harvest of *Bordi* during November-December.

Productivity values correspond to the net production values and hence the rate of production was as high as 4.0 gm/day/bush during winter harvest of 1972 whereas in other years during same months the value ranged from 0.85-2.23 gm/day/bush. On average basis the productivity of summer cut plants was lowest (1.04 gm/bush/day) whereas winter season harvest gave highest values (2.1 gm/bush/day) (Table 18). Maximum productivity values (2.03 gm/bush/day) were obtained in 1972 while minimum were in the year 1971 (0.70 gm/bush/day).

Statistical analysis of the growth attributes of *Bordi* (Table 18) have shown that significant differences exist in above-ground biomass production of summer and winter cut bushes. Even the number of stumps are significantly higher than summer and spring season plants. Plants gain highly significant height and their basal area by the end of November (start of winter) than summer and spring seasons' plants.

Thus it may be concluded that winter season, particularly November month is best for *Pala* harvest.

Horticultural qualities

B. B. VASHISHTHA

INTRODUCTION

Bordi (*Z. nummularia*), a drought hardy shrub, has much economic value to its inhabitants. The fruits are used by men and leaves by the livestock. Low rainfall tract (150-250 mm), where vast areas are largely utilized for grazing and animal husbandry is the major occupation of the people, this shrub plays a vital role in maintaining the good growth and health of livestock. But in slightly higher rainfall zone (250-450 mm) this shrub can be utilized for providing high quality fruits after grafting. In this tract there is another species called *Z. rotundifolia,* mostly grown along moist situations. It is very similar to *Z. nummularia* but a few horticultural characteristics are given as under which differentiate the two.

Difference of two species

Taxonomists consider *Z. nummularia* and *Z. rotundifolia* as synonyms while horticulturally both of them are different. To some extent *Z. nummularia* is locally known as *Jharber* and *Z. rotundifolia* as *Bordi* but in some parts *Z. nummularia* is also called as *Bordi.* Differences in some morphological characters are clear cut. *Z. nummularia* will form a bush on cutting whereas *Z. rotundifolia* will take the shape of a tree. The leaves of *Jharber* are generally round with dorsal surface green and ventral surface tomentose, whereas in *Z. rotundifolia* leaves are dark and light green on dorsal and ventral surfaces respectively. Generally there is no tomentum on ventral surfaces.

Fruits of *Z. nummularia* are small and mature in early November as compared to *Z. rotundifolia* having slightly bigger fruits which mature in February-March. Its fruits are eaten fresh as well as after drying. It is a common observation that *Z. rotundifolia* trees are concentrated at places having abundant soil moisture, i.e. along the dry river bed of Luni and its tributaries. Good tree density (25-30/ha) of *Z. rotundifolia* can be seen on younger alluvial plains of Western Rajasthan. *Z. nummularia* bushes can be seen on sandy to rocky areas with low soil moisture conditions. A survey conducted for the collection of variability of both the types further confirmed the observation.

Root stock has a direct influence on the growth and productivity of scion variety. 90 different variables in *Z. rotundifolia* and 80 variables of *Z. nummularia* have been collected at CAZRI, Jodhpur to undertake root stock trails for *ber* (*Z. mauritiana*). In *Z. nummularia* the variability was observed in leaf size (1.8 x 1.0-2.5 x 2.2 cm), leaf shape (round, oblong to oval), trunk diameter (15-60 cm), tree height (2-10 m), colour of immature fruits (green to dark purple) and colour of mature fruits from light to deep brown or red. Similarly in *Z. rotundifolia* the variation in tree height was from 6-22 m, trunk diameter from 0.5-1.2 m, size of fruits from 1.2 x 1.4 - 2.6 x 2.6 cm, fruit weight from 1.2 - 5.2 g, fruit volume from 1.4 - 6.2 cc and stone weight from 0.31 - 1.1 g.

Although both the types can be used for the purpose of root stock but *Z. rotundifolia* is preferred over *Z. nummularia* because of its vigorous growth and stout erect stem. It has been observed that plants budded on *Z. nummularia* (*Jharber*), the stem portion of root stock remains thin and it indirectly affects the rigidity of the bud union.

Cause of variability

Beside root sucker's development, the plant perpetuates largely by seeds. Due to sexual perpetuation of the species (in addition to root suckers) a wide range of variability has been observed in the naturally growing bushes. Such differences are more pronounced at places where the bushes have not been cut for fodder but were allowed to assume natural growth form (*in orans*). The flowering takes place in August-September and the pollination is entomophilous. Being a cross pollinated nature of the species, every time the natural hybridization goes on unnoticed which finally results in different segregates. Being tetraploid, the seedling progeny types are never uniform. It is, further because of this ploidy level, two important properties are exhibited, namely formation of reasonable number of multi-valents and exhibit segregation in their progenies (Khoshoo and Singh, 1963).

Both the species, i.e. *Zizyphus nummularia* and *Z. rotundifolia* are horticulturally important because of the availability of vast variability but the potential of such variability is yet to be utilized. Studies on root stock at CAZRI, Jodhpur, may bring out few selections of desired root stock.

Root studies

One of the important factors contributing to its drought resistance nature is the deep root system. Root growth studies undertaken on 4 year old shrub revealed that the roots penetrate as much as 4.5 m deep. Feeding roots are concentrated both on upper and lower portions of the root. The root structure and texture varied with the type of soil underneath (Plate 7). It reveals that the species is hard enough to grow not only in hostile arid environment but also in poor and different forms of soil profiles underneath (Pareek, 1977).

Naturally growing root stock

Bordi (*Zizyphus nummularia*) bears small red sub-acidic fruits having very

low pulp stone ratio. This drought hardy and naturally grown shrub can best be used as rootstocks on which superior varieties of *Z. mauritiana* (*Ber*) can be budded. Thus poor fruit bearing bushes can be converted into high yielding good quality fruit trees. The wild plants of any age can be budded with recommended varieties such as Seb, Gola and Mundia. If the thickness of the main stem is 2.5-5 cm it should be headed back, leaving about 15 cm from ground level. If the thickness is more than 5 cm and upto about 20 cm it should be headed back at about 1 m height If the tree is robust and well grown up, having 3-4 bifurcated main branches, these branches should be headed back having 45-60 cm length from the joint. Such trees are available on most of the field boundaries. In all the above mentioned stages, heading back is done in April-May to initiate new growth. The budding is done during monsoon (June to August) on the selected newly emerged shoots. Branch arising out of the bud is allowed to develop and buds of host plants are periodically removed. If the tree is big enough, the fruits can be harvested even in the very first year. In this way the naturally grown *Bordi* plant can be transformed into a cultivated one. Because of the already developed deep root system, the plant picks up very fast growth and full canopy develops in a year. Such work has already been standardized by CAZRI and more than five hundred *Z. nummularia* bushes have been converted into good quality fruits bearing plants at Gajner and Naurangdesar (Bikaner), Balad, Deva, Chandan and Bhojka (Jaisalmer).

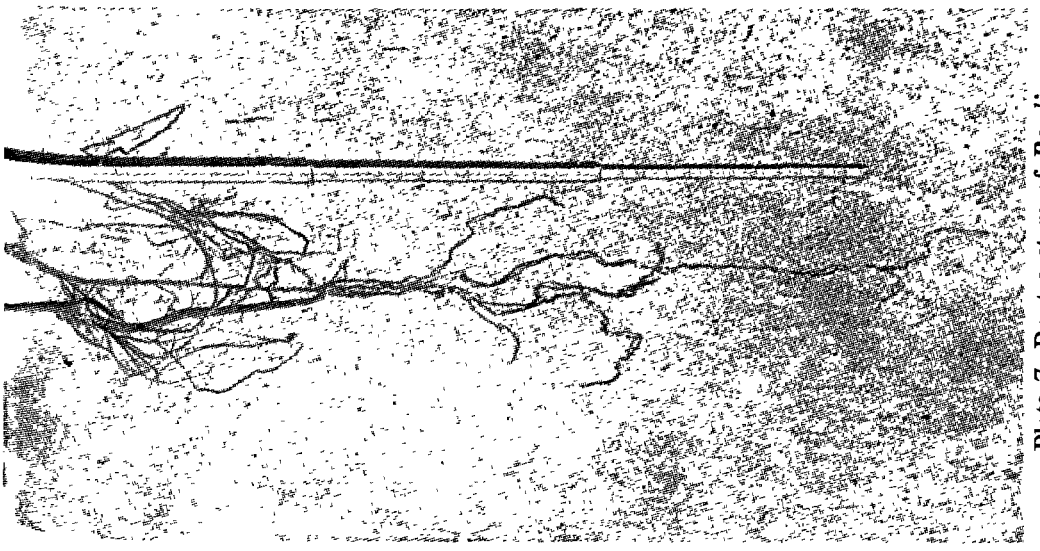


Plate 7. Root system of *Bordi*.

Mineral element in relation to animal requirement

B. K. DUTTA AND R. P. DHIR

INTRODUCTION

Minerals have many functions relating directly or indirectly to animal growth. These contribute to the rigidity of bones and teeth besides being involved several metabolic processes where they form a component of various enzyme systems. They are an important part of protein and lipid fractions of the animal body. Some of these, like sodium, help to preserve cellular integrity by osmotic pressure. Calcium is used in large amounts in synthesis of osseous (bone) tissue. Phosphorus contributes structurally and in addition has many regulatory functions. Further it is necessary also that ratio, between the elements is within optimum limits as otherwise some elements may not get assimilated even when present in the feed. All this justifies the need for analysis of the feed for its mineral contents.

MATERIAL AND METHODS

The samples of foliage were collected from 31 sites scattered all over Rajasthan in September from well grown shrubs of *'Bordi'*. These were washed, dried and then digested in nitric acid-per-chloric acid mixture and then analysed. Calcium and magnesium were estimated in suitable dilution upon addition of strontium chloride as ionisation suppresant using atomic absorption spectrophotometer, sodium and potassium flame photometrically and phosphorus colorimetrically by vanado-molybdate methods. Some results of analysis of other natural vegetation are also reported to afford a comparison with the *Bordi*.

RESULTS

Mineral content in the *Bordi* leaves collected from different sites are reported in Table 19. It will be seen that potassium and calcium are by far the dominant constituents with a concentration range mostly 0.6 to 1.5% on dry matter basis. These are followed by phosphorus and sodium which constitute mostly 0.12 to 0.20 and 0.065 to 0.15% respectively. Magnesium concentration is much less and varies from 0.02 to 0.05%.

The results also show that there is considerable variation amongst the sites

Table 19. Mineral elements content (%) in *Bordi* foliage from different sites in arid Rajasthan

Location		Ca	K	P	Na	Mg
			JAISALMER			
Larella		0.68	1.87	0.233	0.083	0.023
Jaisalmer		0.67	1.24	0.222	0.190	0.019
Chandan		0.88	1.10	0.072	0.220	0.018
Khetolai		0.70	1.26	0.210	0.170	0.019
	Mean	0.72	1.36	0.182	0.165	0.020
			BIKANER			
Balda		1.17	0.99	0.100	0.130	0.018
Kolayat		1.18	1.15	0.152	0.135	0.024
Kolayat		0.45	1.69	0.201	0.098	0.017
Beechwal		0.43	1.36	0.183	0.095	0.018
	Mean	0.67	1.17	0.158	0.110	0.020
			BARMER			
Kaluri		0.98	1.32	0.120	0.115	0.020
Takuberi		2.10	1.77	0.204	0.088	0.028
Sanverod		0.88	1.42	0.138	0.090	0.021
Chauhtan		0.85	1.24	0.152	0.105	0.022
Shiv		0.85	1.41	0.233	0.125	0.027
	Mean	1.13	1.43	0.169	0.104	0.023
			JODHPUR			
Dhawa		1.41	1.02	0.152	0.090	0.035
Dhawa		0.93	1 48	0.130	0.095	0.021
Khara		0.81	0.99	0.104	0.155	0.022
Phalodi		1.17	1.50	0.133	0.175	0.020
Bap		0.95	1.35	0.153	0.190	0.024
Binawas		1.54	0.65	0.122	0.125	0.041
	Mean	1.14	1.65	0.132	0.138	0.027
			NAGAUR			
Degana		0.58	1.87	0.213	0 250	0.036
Didwana		—	0.58	0.200	0.125	0.046
Merta		0.66	1.67	0.237	0.082	0.032
Merta		0.66	1.67	0.237	0.082	0.032
	Mean	0.71	1.25	0.186	0.125	0.037
			PALI			
Banwasa		1.05	0.53	0 122	0.065	0.050
Jaitaran		1.80	0.69	0.140	0.115	0.052
	Mean	1.43	0.61	0.131	0.090	0.052
			SIKAR			
Malkeda		1.00	1.07	0.173	0.075	0.035
Phalsana		0.80	0.89	0.199	0 075	0.043
Laxmangarh		0.65	0.65	0.135	0 085	0.021
	Mean	0.81	0.87	0.169	0.078	0.037
			CHURU			
Sardar Shahar		1.24	1.05	0.156	0.090	0.046
Churu		1.90	1.20	0.192	0.100	0.020
Ratangarh		0.59	0.85	0.127	0.870	0.057
	Mean	1.00	1.03	0.125	0.093	0.041

samples. Regarding calcium, the *Bordi* in Pali, Barmer, Jodhpur and Churu have relatively higher concentration than those in the Jaisalmer, Bikaner, Nagaur and Sikar. Potassium content presents a different picture. In more arid districts of Jaisalmer, Bikaner and Barmer its concentration is appreciably higher than that in Pali, Sikar and Churu. Plotting this mean concentration against the mean annual rainfall of the district tends to suggest an increasing potassium concentration with decreasing rainfall (Fig. 1).

In comparison to potassium, phosphorus concentration does not show much inter-district variation. What is more the inter-site variation also is much less. With a possible exception of few sites, its concentration is around 0.14%. Lowest value of sodium (0.065%) is at Banwasa in Pali and the highest values of over 0.22% are at Degana (Nagaur) and Chandan (Jaisalmer). Magnesium concentration is small but its spatial variation does present an interesting picture. The lowest values are encountered in Jaisalmer, Bikaner and Barmer, whereas the sites in Pali, Churu and Sikar have above average concentration. This relationship of higher concentration in less arid tract is reverse to that of potassium discussed earlier (Fig. 1).

Element concentration in comparison with other vegetation: Data presented in Table 20 suggest that *Bordi* leaves have similar content of phosphorus and potassium and generally higher amount of sodium as compared with the common top feed species. Calcium concentration is also more but magnesium concentration is less. *Bordi* has more of phosphorus and less of other elements than the *Calligonum polygonoides*. Compared with grasses it has a significantly higher concentration of sodium (with an exception of *Cenchrus biflorus*) and of

Table 20. Mineral composition of *Bordi* in relation to other top feed species

Plant species	P	Na	K	Ca	Mg
SHRUBS					
Zizyphus nummularia	0.159	0.116	1.17	0.92	0.029
Calligonum polygonoides	0.166	0.119	1.27	1.36	0.070
TREES					
Prosopis cineraria	0.168	0.093	1.31	0.683	0.033
Acacia nilotica	0 128	0.098	1.12	0.35	0.024
Acacia senegal	0.147	0.074	1.02	1.63	0.097
Tecomella undulata	0.160	0.126	1.32	1.06	0.058
GRASSES					
Cenchrus ciliaris	0.149	0.028	2.27	0.37	0.045
Cenchrus biflorus	0.145	0.231	1.31	0.21	0.046
Eleusine compressa	0.118	0.047	0.94	0.23	0.034
Lasiurus ecaudatus	0.110	0.025	0.77	0.41	0.043

* Source - Nat. Res. Council (1975).
** Source - Nat. Res. Council (1971).

Table 21. Mineral concentration in *Bordi* and animal requirement

Element	Conc. in *Bordi* (%)	Minimum requirement in feed for good growth for sheep*	Dairy cattle**		
			Dry	Lactating	Heifer
Calcium	0.92	0.21-0.52	0.43	0.47	0.31
Phosphorus	0.16	0.16-0.37	0.33	0.35	0.23
Potassium	1.17	0.50	0.70	0.70	0.70
Magnesium	0.03	0.04-0.08	0.10	0.10	0.07
Sodium	0.12	0.14-0.26	0.18	0.10	0.10

* Source - Nat. Res. council (1975).
** Source - Nat. Res. Council (1971).

calcium but is low in magnesium. Picture regarding potassium is variable whereas phosphorus is comparable.

Mineral content to meet animal requirement: Precise information is not available concerning mineral requirement from animal nutrition view point under arid environment. Under the circumstances evaluation of *Bordi* has been attempted by comparing with values as contained in standard text books on animal nutrition (Table 21). It will be seen that calcium requirement of a balanced feed should be of the order of 0.21 to 0.52%. Whereas *Bordi* has a mean calcium content of 0.92%. Similarly, potassium concentration content appear satisfactory. But phosphorus and magnesium content appear lower than the minimum required. Of these magnesium and sodium requirement may not be critical since it is present in abundance in ground and surface drinking waters.

Distribution of trace elements in foliage

B. K. SHARMA AND R. P. DHIR

INTRODUCTION

The role of trace elements has been well known for performing the normal physiological activities in the living animals. One of the primary functions of these actions in metabolism is formation of chelates between enzymes and substrate. This is an important mechanism through which trace elements act primarily as catalysts in enzyme system in the cells to serve a wide range of functions. Therefore, presence of these elements in adequate levels in animal diet is essential for optimum growth and productivity of the animals. Quite an appreciable work has been done on the proximate chemical composition, nutritive value and other aspects of *Zizyphus nummularia* (Malik and Nath 1970; Nath *et al.*, 1969; Kaul and Ganguli, 1963), but no work on trace elements in *Bordi* has been reported so far. Thus the present study was conducted for getting informations as regards to trace elements status of *Bordi* leaves which play an important role in feeding stuff during lean periods.

MATERIAL AND METHODS

Samples of *Zizyphus nummularia* foliage were collected from 38 sites located in eight districts of western Rajasthan from fully grown shrubs in the month of November, the time when the collection of the foliage is about to start for *Pala*. The samples were dried in the shade, washed three times with distilled water and dried in oven at 65° C. Then the material was digested in Nitric-perchloric acid mixture and estimated for trace elements concentration using atomic absorption spectro-photometer. Results are reported on dry matter basis (Tables 22 & 23).

RESULTS AND DISCUSSION

Iron: Iron concentration in majority of the samples ranges between 200 to 400 ppm (Mean 294 ppm). The extreme values being 162 and 447 ppm. Chohtan and Kaluri in Barmer have relatively low amount whereas those in Nagaur, Pali, Jodhpur and some

Table 22. Range and mean values of trace elements in *Bordi* foliage in different districts of Western Rajasthan

District	No of sites	Fe (ppm)		Mn (ppm)		Zn (ppm)		Cu (ppm)	
		Range	Mean	Range	Mean	Range	Mean	Range	Mean
Churu	5	243-430	346.8	18.0-45.0	32.2	21.3-45.6	32.3	15.6-30.6	22.5
Sikar	4	238-420	328.5	30.0-42.5	38.0	20.0-38.3	30.7	15.6-36.1	22.4
Nagaur	5	238-447	324.4	36.0-96.0	53.7	29.2-78.5	47.1	17.0-27.5	22.1
Pali	5	320-333	330.5	62.5-105.0	83.7	30.0-36.6	33 3	21.0-24.5	22.7
Jodhpur	6	172-395	299.0	32.5-75.0	47.5	29.2-41.0	33.0	17.0-38.5	26.3
Bikaner	4	190-313	232.7	27.5-60.0	42.3	30.7-51.5	39.7	23.8-30.0	27.4
Jaisalmer	4	162-323	244.7	30.0-45.0	34.6	25.0-36.5	30.7	22.0-25.4	23.7
Barmer	5	162-371	240.8	18.0-50.0	35.0	25.0-78.0	40.5	16.5-33.6	23.2

Table 23. Trace elements content present in *Bordi* foliage and the requirements of sheep and dairy cattle

Trace elements	Trace elements present in *Bordi* (ppm)	* Requirements of the trace elements for animal (ppm)			
		Sheep	Ccw	Bull	Heifer
Iron	293.4	30-50	100	100	100
Manganese	45.8	20-40	20	20	20
Zinc	36.7	35-30	40	40	40
Copper	23.7	5	10	10	10

* Source : Arthur, E. Gullison (1978) feeds and feedings; Animal Nutrition, Prentice-Hall of India Pvt. Ltd., New Delhi.

in Churu have well above average concentration. Nearly 47 per cent of the population are in the range of 160 to 300 ppm, 38 per cent in the range of 300 to 400 ppm concentration and another 14 per cent had above 400 ppm concentration. The large variations were seen among the sites which does not show any geographical consistency. This may be attributed because of soil types effect, the seasonal conditions during the growth and the stage of maturity of the plants. All the same *Bordi* foliage in different districts show fairly high concentration which compare well with the natural vegetation of Mojave desert (El. Ghonemy *et al.*, 1978).

Manganese: In various districts the mean manganese content ranges between 32.2 to 83.7 ppm with the extremely low value of 18 ppm at a site in Churu to as high as 105 ppm at Jaitaran were observed. Pali had the highest mean content (83.7 ppm). Nearly 15 per cent samples lie in the range of 15-30 ppm. 68.5 per cent in 30 to 50 ppm and another 15 per cent over 50 ppm. These are quite close to the vegetation of mediterranian region of Egypt (El. Ghonemy *et al.*, 1977) but is lower than those found in Mojave desert (El. Ghonemy *et al.*, 1978).

Zinc: *Bordi* leaves from different sites showed a zinc level of 21.3 to 78.5 ppm (Mean 36.6 ppm). More than half the samples had values in between 30 to 50 ppm. Remaining 26 per cent of the samples are in the range of 20 to 30 ppm and rest over 60 ppm. It is noteworthy that out of all the districts, Nagaur samples showed highest concentration. This is possibly due to high available level of zinc in soils.

Copper: Like other three elements copper does not show much inter-sites variation. More than 80 per cent of the samples range in between 15 to 30 ppm. Churu (Dewas) and Sikar (Palsana) show somewhat lower values, Jodhpur (Khara) had relatively higher content. In various districts its mean content were found 22.1 to 27.4 ppm. El. Ghonemy *et al.* (1978) found 3-7.7 ppm copper in different perennial plant species of the Mojave desert. When compared with these the *Bordi* shrub appear to have higher concentration of copper in Western Rajasthan.

Nutritive value of leaves

Deficiency of the trace elements concentration in animal feed is known to cause a variety of disorders in the animals. Anaemia in general and depressed growth, bone disorder, depigmentation of hairs and gastro-intestinal disturbances have also been observed in copper deficient diet (Underwood, 1956). Depressed reproductive functions, atexia in newborns have all been displayed in variety of animals in manganese deficient diet. Thus, it is imperative to know the level of these elements in the feeds vis-a-vis animal requirement. In the following sections the *'Bordi'* has been evaluated as feed, taking into consideration the known critical values in a well balanced feed.

Various reports (Underwood, 1977; NRC, 1975) had recommended 25 to 50 ppm and 30 to 50 ppm iron respectively in the feed as sufficient to meet the requirement of cattle and sheep. Experiment with growing lambs indicate that 10 ppm iron is inadequate and their minimum dietary requirement lie between 25 to 40 ppm (Lawlor *et al.*, 1965). In view of these standards the iron content in *Bordi* leaves (162-447 ppm) appears to be much higher to meet the normal requirement of the animals.

As regards manganese Bentley and Phillips (1951) stated that 10 ppm manganese is adequate for the growth of heifers, but is marginal for optimal reproductive performance. Whereas Rajos *et al.* (1965) suggested that the manganese requirement of cows for maximum fertility are in excess of 16 ppm. Judging from this, the concentration of manganese in the present study ranging from 18-105 ppm (Mean 45.8 ppm) in different areas in quite higher and as such it serves as rich feed.

Ott *et al.* (1965) have found a requirement between 18-33 ppm zinc to support maximal growth in lambs, while N. R. C. (1975) suggested 35-50 ppm zinc level in animal feed. The present study shows a range of 21.3-78.5 ppm zinc in *Bordi* which means zinc could be marginal or deficient in some cases.

The picture about the copper also stands similar, as this element is distributed in the samples evenly in the better proportion 15.6 to 38.5 ppm with an average of 22.1-27.4 ppm in different districts. The minimum copper requirements of sheep are close to 10 ppm of the dry diet. Pastures containing 4-6 ppm copper provide sufficient copper for full requirements of cattle and crossbred sheep (Beck and Harley, 1951). Compared to these, *Zizyphus nummularia* leaves seems to have been very rich in this element also.

CONCLUSION

From the foregoing discussion it can be concluded that *Bordi* foliage is quite rich in various trace elements studied, namely iron, manganese, zinc and copper. Mean iron content is invariably over 200 ppm as against 30 to 100 ppm required in a balanced feed for various animals. Likewise manganese and copper contents are far above the minimum required to meet the animals needs. Only zinc appears marginal.

Nutritive value of *Pala* for ruminants

H. C. Bohra and P. K. Ghosh

INTRODUCTION

Zizyphus nummularia, locally called as *Bordi* is a drought hardy indigenous thorny shrub that grows abundantly in the sandy soils of semi-arid and arid regions of the country and constitute an important fodder especially for the livestock of the arid districts of Western Rajasthan. Unlike *Prosopis cineraria,* this plant by virtue of its bushy nature, forms a parabolic canopy and becomes easily available to the grazing animals like sheep, cattle and buffaloes as well as to the browsers like goat, camel and donkey. Another important feature of this shrub, which forms about 14 per cent of the total composition of the desert flora of Rajasthan (Ganguli *et al.,* 1964), is that it remains abundantly available even when the associated grasses dried up or completely consumed by the grazing or browsing animals (Kaul and Ganguli, 1963).

Leaves and fruit as food

The fruit of this plant, locally called *Ber* contains considerable amounts of the soluble carbohydrates. The leaves of *Z. nummularia* (*Pala*) contain appreciable amounts of proximate nutrients and minerals. During summer months (April to June) when most of the ground level vegetation of the arable and non-arable grazing lands is consumed by the animals, and availability of free water becomes scanty, the sprouting suckers of *Bordi* prove to be a boon to the wild animals. The leaves provide considerable amounts of digestible nutrients. Preformed water makes about half of the total weight of the green leaves. Approximately 30 per cent of the total daily water requirements of sheep and goats may be met by maintaining the animals on *Pala* only.

Fodder production

Generally a *Bordi* bush become ready to provide fodder from 3rd year onward and may go on producing even after fifty years. A moderately grown *Bordi* plant (in life form) provide approximately 2.5 to 3.0 kg of air dried leaves per year. Though *Z. nummularia* is a fodder yielding plant, it has an edge over *P. cineraria* (*Khejri*) in that, the former takes

hardly three years to start yielding fodder while the latter takes ten years or even more. The leaves which are preserved in the form of *Pala* contain approximately 93 to 96 per cent dry matter, 93.4% organic matter and 12.6 per cent crude protein on dry matter basis. In urban areas especially, where larger animals cannot be kept due to the lack of space and where only milch goat-like animals can be kept, the *Pala* form the choicest feed for the animals.

Palatability of Pala

Using the cafetaria feeding system, Muthana and Shankarnarayan (1978) observed that the *Pala* fodder ranks fourth in terms of preference by the sheep, the first, second and third position having been occupied by leaves of *Acacia nilotica* (*Babool*), *Prosopis cineraria* (*Khejri*) and *Salvadora oleoides* (*Jal*), respectively. However, considering the overall low productivity of these three trees, and the much longer time they make to start yielding fodder, the palatability rating alone may not be a true index of the importance of top feed as an animal feed for the desert.

Since 1955, several attempts have been made to determine the intake of *Z. nummularia* leaves (dry matter) by animals of different species, viz. sheep, goat and camel (Kehar *et al.*, 1955; Nath *et al.*, 1969; Mathur, 1976). The average palatability (DMI/100 kg body weight) of *Pala* have been found to be 2.05 kg in Rambouillet, Malpura and Rambouillet X Chokla sheep breeds (Nath *et al.*, 1969) and 1.36 kg in camel (Mathur, 1976). Studies conducted at CAZRI have revealed that the goat consumes (3.3 kg/100 kg body weight), i.e. 0.5 kg more *Pala* than the sheep (2.8 kg/100 kg body weight). When these data were compared with an earlier report on *Loong* (*P. cineraria* leaves; Bohra, 1980), it was found that the palatability of *Pala* fodder is higher than that of *Loong* in both sheep and goat. Between these two animal species, dry matter intake (DMI) of both feeds were higher in the goat than in the sheep.

Chemical composition of Pala

The importance of this feed as an animal fodder has long been known to livestock owners and animal nutritionists.

Table 24. Chemical composition (% on DM basis) of *Pala*

Trait/Source	Kehar *et al.* (1955)	Sen & Ray (1964)	Ganguli *et al.* (1964)	Nath *et al.* (1969)	Malik & Nath (1970)	Mathur (1976)
Crude proteins	11.63	11.5	11.70	14.0	14.25	13.8
Crude fibres	33.8	33.8	16.0	17.0	15.73	30.7
Ether extract	1.50	1.6	—	3.0	4.34	1.7
Nitrogen free extract	—	46.8	—	56.0	57.12	44.2
Total ash	—	6.2	—	10.0	8.56	9.6
Calcium	—	1.9	1.60	2.8	2.43	2.1
Phosphorus	0.30	0.31	0.20	0.14	0.144	0.30

Several reports on the proximate composition of the *Bordi* leaves have been published (Kehar *et al.*, 1955) followed by those of Sen and Ray (1964), Ganguli *et al.* (1964), Nath *et al.* (1969), Malik and Nath (1970) and Mathur (1976) (Table 24). Data compiled in Table 24 reveal that crude protein (CP), ether extract (EE), nitrogen free extract (NFE) and inorganic matter are present in higher concentrations in green *Pala* than in the dry leaves. Crude fibre(CF), however, was present in higher concentrations in dry leaves. Singh and Gupta (1977) have reported the concentrations of various cell-wall constituents such as cellulose, hemi-cellulose, lignin and cell-wall associated silica in *Pala* (Table 25). Seasonal variations in the proximate components of this feed, reported by Patel *et al.* (1978) (Table 26), reveal that the levels of NFE and EE increase from monsoon to summer, and that of crude fibre change in the reverse order during the same period. The high concentrations of NFE, EE and CF in summer collected leaves make these more nutritious than the leaves collected in other seasons. Studies conducted in this Institute have revealed that *Pala* collected in summer and winter contains, respectively, 4.4 and 8.5 per cent (on DM basis) tannins.

Nutritive value of Pala and its improvement by chemical treatment

Nath *et al.* (1969), Malik and Nath (1970), Mathur (1976) and Singh and

Table 25. Chemical composition of the cell-wall of *Pala* (% on DM basis)

Trait/Source	Singh & Gupta (1977)	Present study
Cell-wall constituents	42.1	33.7
Cell contents	57.9	66.3
Hemi-celluloses	9.9	10.3
Ligno-cellulose	34.2	23.4
Cellulose	18.8	10.4
Lignin	6 9	11.0
Silica	8.3	2.0

Table 26. Seasonal variation in the proximate components (% on DM basis) of *Pala* (Patel *et al.*, 1978)

Constituent/season	Monsoon	Winter	Summer
Crude proteins	14.2	14.6	14.8
Crude fibres	20.0	11.7	8.2
Ether extract	3.2	5.2	5.9
Nitrogen free extract	51.8	57.8	60.7
Calcium	1.70	2.17	2.07
Phosphorus	0.19	0.16	0.16

Gupta (1977) have made attempts to evaluate the nutritive value of *Z. nummularia* leaves for sheep, goat and camel (Table 27). For sheep, the nutritive value, in terms of DCP (digestible crude proteins) and TDN (total digestible nutrients) of green *Pala* (Malik and Nath, 1970) was found to be higher than that of *Pala* hay (Singh and Gupta, 1977).

The nutritive values of *Pala* have been found to be significantly higher in the camel than in smaller ruminants like the sheep and the goat, though between sheep and goat the values did not differ significantly. Data presented in Table 28, compiled from unpublished observations of Ghosh and Bohra, would indicate that the digestibility of cell-wall constituents of *Pala* does not differ significantly between sheep and goat.

The nutrients from *P. cineraria* leaves are apparently more digestible in the goat than in the sheep (Bohra, 1980), whereas the digestibility of nutrients of *Z. nummularia* leaves (except for the hemi-cellulose fraction) are evidently higher in sheep than in goat (Table 28). Interestingly, the hemicelluloses from *P. cineraria* leaves are more digestible than that from *Z. nummularia* leaves, suggesting a probable inverse relationship between lignin content and hemicellulose digestibility. The lignin content of *P. cineraria* and *Z. nummularia* leaves have been found by authors to be 11.6 and 7.8 per cent, respectively. Though the intakes of dry matter and of *Pala* nitrogen are significantly higher in goat than in sheep, the apparently high losses of nitrogen through both faeces and urine in goats result in no significant difference in ni-

Table 27. Digestibility coefficients and balances of different nutrients of *Pala* in sheep, goat and camel.

Trait	Camel	Sheep		Goat
	B	A	B	B
A. Digestibility (%)				
Dry matter	56.8	52.6	50.1	51.3
Crude proteins	43.5	39.0	33.1	36.3
Ether extract	23.4	41.9	39.5	48.3
Crude fibre	56.2	40.9	48.9	45.5
Nitrogen free extract	64.3	71.6	54.2	54.2
B. Nutrient balance, g/day				
Nitrogen	5.8	3.1	3.2	2.8
Calcium	30.5	4.3	8 8	6.6
Phosphorus	17.9	0.18	0.05	0.15
C. Nutritive value				
Digestible crude proteins	6.0	5.7	3.5	3.8
Total digestible nutrients	51.6	58.0	39.5	39.6
	Mathur (1976)	Malik & Nath (1970)	Singh & Gupta (1977)	

A, Fed green leaves; B, Fed dry leaves.

Table 28. Dry matter intake, apparent digestibility of nutrients and nitrogen in sheep and goat maintained on *Pala*

Trait	Animal type		't' value
	Sheep	Goat	
Intake			
Dry matter, g/day	811.6±22.52	1227.7±35.30	8.55***
Dry matter, g/kg b.w/day	27.8± 0.34	33.2± 1.65	3.18*
Organic matter, g/day	676.8±18.77	1023.9±29.45	9.94***
Digestible energy,kcal/g, DMI	1.84± 0.106	1.77± 0.070	0.55(N.S.)
Digestible crude protein, g/100 g DM	4.05± 0.435	3.63± 0.252	0.84(N.S.)
Apparent digestibility (%)			
Dry matter	51.60± 2.23	48.10± 2.18	1.17(N.S.)
Organic matter	53.40±10.28	46.40± 2.09	2.12(N.S.)
Gross energy	45.70± 2.57	43.70± 1.70	0.65(N.S.)
Crude proteins	32.20± 3.45	28.80± 2.01	0.85(N.S.)
Cell-wall constituents	15 20± 4.14	15.80± 3.46	0.11(N.S.)
Cell-contents	70.10± 1.24	64.60± 1.25	3.12*
Acid detergent fibre	-6.60± 4.26	-7.10± 2.89	0.09(N.S.)
Hemi-celluloses	60.30± 3.69	67.90± 4.18	1.25(N.S.)
Cellulose	53.70±11.44	31.10± 3.72	1.88(N.S.)
Lignin	-46.80± 9.67	-50.50± 5.35	0.33(N S.)
Nitrogen balance, g/day			
Nitrogen intake	16.31± 0.453	24.69± 0.703	10.02***
Faecal nitrogen	11.04± 0.493	17.54± 0.474	9.51***
Urinary nitrogen	1.97± 0.234	3.72± 0.267	4.93**
Total nitrogen excretion	13.01± 0.613	21.26± 0.741	8.58***
Nitrogen retention	3.30± 0.624	3.43± 0.697	0.14(N.S.)

Treatment differed significantly, *P < 0.05; **P < 0.01; ***P < 0.001.

trogen retention between sheep and goat.

Although this feed contains appreciable amounts of the crude proteins (approx. 12. 8 per cent), its DCP value has been found to be only 3.6 g/100 gm of the dry feed. The low DCP of this feed has been attributed to the presence of tannic acid and trptic inhibitors (Nath *et al.,* 1969) in it. A successful attempt has been made to increase the nutritive value of this feed by treating it with formaldehyde (Ghosh *et al.,* 1971). As formaldehyde (HCHO) protects the feed proteins from microbial degradation in the rumen, most of the protein becomes available to the animal for maximum utilisation and wool production.

Studies conducted on the rates of passage of *Loong* and of *Pala* through the intestine of Magra sheep (Purohit and Mathur, 1971) have indicated a faster rate for *Pala*. These workers reasoned that this faster rate of passage of *Pala* through the sheep gut may be due to its low tannic acid content.

Conclusion

On the strength of the evidences reported so far, it may be concluded that among the livestock species studied, the camel is the most efficient, followed by the sheep and goat, in utilizing the nutrients from *Z. nummularia* leaves. Due to the flaky nature of the *Pala* leaves, the stored fodder becomes highly susceptible to water and gets damaged unless protected from rain water. The low digestibility of *Z. nummularia* leaf fodder may be due to its high lignin content whereas the possible cause of the low digestibility of nutrients of *P. cineraria* leaves may be due to the presence of high levels of tannins. Production of *Pala* leaf fodder may be augmented by following the scientific methods of propagation, management and collection of leaf-fodder from the plant. At the same time the availability of nutrients to the livestock may also be enhanced by selection, breeding and propagation of high foliage yielding plants containing low levels of lignin in their leaves and by suitable chemical treatments.

An important food centre for Indian desert animals

ISHWAR PRAKASH

INTRODUCTION

Desert consumers frequently use those dietary items which are most abundant as is evident from the intensive study of food of gerbils through the years (Prakash, 1962, 1969). Even the selective feeders shift to such diets as locust (cf. Squirrel, *Funambulus pennanti*; Prakash and Srivastava, 1953) which are profusely available or to insects in absence of other foods (cf. Desert gerbil, *Meriones hurrianae,* essentially a herbivore, feeds on vegetation but during summer when vegetal food is scare it switches over to insect diet partly to maintain water balance in the body; Prakash, 1959, 1975). *Bordi* or the native plum (*Zizyphus nummularia*), an abundant shrub found in almost all the habitats in the Indian desert, constitutes an important food centre for the browsers, frugivorous as well as seedivorous, and surprisingly for the carnivorous mammals too (Fig. 6).

The food centre

Birds: A number of birds thrive on the drupes of *Bordi*. The almost resident, *Godawan* or the Great Indian Bustard (*Choriotes nigriceps*), though primarily an insectivorous and carnivorous bird, prefers to feed upon ripe *Bordi* fruits during the winter months (Prakash, 1977). It has been observed to hop and snap them and also the fruits of *Kair* (*Capparis decidua*). Another bird, *Tilore* or Houbara (*Chlamydotis undulata*), the migratory period of which coincides with the fruiting period of *Z.*

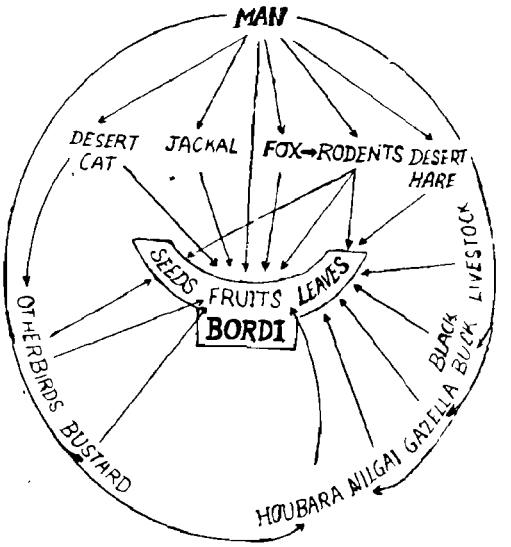


Fig. 6 Food web around *Bordi.*

nummularia in India, voraciously feeds on ripe fruits. Migrating from the middle-eastern Central Asia countries, it settles in the desert region, in the "*birs*" of *Z. nummularia* shrub/tree. In fact its habitat selection for its winter sojourn is based on the availability of *Bordi* fruits. A number of other birds also feed on ripe *ber* (Prakash, 1974).

Mammals: Carnivores: While studying the food of desert mammals, it was surprising to observe stomachs of several carnivores (Bengal fox, *Vulpes bengalensis*: Desert fox, *V .V. pusilla,* the Asiatic jackal, *Canis aureus*) full of ripe *Bordi* fruits. During winter months when *ber* ripen, all the lizards hibernate and it is arduous to catch rodents, and thus the carnivores fall upon easy-to-retrieve, vegetal food governs the dietary items of even carnivorous animals which take to feeding exclusively on the fruits of *Z. nummularia.*

Herbivores (Artiodactyles): Besides the livestock animals, wild ungulates also browse the green *Bordi* shrubs. The larger ungulates which occur in the desert in fairly large numbers are the Indian Gazelle or the Chinkara, *Gazella g. bennetti;* the Black buck (*Antilope cervicapra rajputanae*) and the Blue bull or the *Nilgai* (*Boselaphus tragocamelus*). Sometimes leaves and pulps of fruit of *Bordi* have also been observed in the stomach of the Desert hare (*Lepus nigricollis dayanus*).

Rodents (seedivores): The feeding propensities of the three desert adapted gerbils (*Gerbillus gleadowi, Tatera indica* and *Meriones hurrianae*) have been studied in detail (Prakash and Kumbhkarni, 1962; Prakash *et al.*, 1967). The studies revealed that *seeds* and fruits of *bordi* are preferred over seeds of all the desert vegetation (Table 29).

Table 29. Palatability index of seeds of tree and shrub species as rated by three species of gerbils

Tree and shrub species	Palatability index
Zizyphus nummmularia	5.3
Ricinus communis	2.5
Albizzia lebbek	2.3
Calligonum polygonoides	2.0
Prosopis juliflora	1.[illegible]
Tecomella undulata	1.7
Parkinsonia aculeata	1.7
Acacia senegal	1.3
A. tortilis	1.3
A. nilotica	1.3
Aerva pseudo-tomentosa	1.3
Prosopis cineraria	1.3
Azadirachta indica	1.0

Practical implications

Considering that even the dried *bordi* fruits (*ber*) are preferred by rodents, we evolved a new technique for baiting them for their control as they inflict serious losses to vegetation and crops. The air dried *bordi* drupes (*ber*) are soaked in a solution of compound 1080 (Sodium monofluoroacetate) having a dosage of 3 mg/kg. After soaking for 24 hours each fruit is impregnated with a lethal dose for rodents weighing up to 100 gm. One lethal fruit and four ordinary ones (untreated) are pushed inside burrow openings. This one-shot baiting technique is fairly economic (Prakash and Jain, 1970). Including the cost of labour, *ber* and poison, a farmer will spend 30 to 45 paise per hectare for effective rodent

control. If, however, he collects *ber* from wild stock and does the job himself, the method will cost him 0.5 to 1.0 paise per hectare as compared to Rs. 3 to 15 per hectare by conventional methods. Besides being cheap and extremely easy and effective, this method does not involve foodgrains which can be conserved for human use.

Considering the high protein content and food value of not only fruits of *bordi* (*Z. nummularia*) but also that of leaves (*pala*), used by wildlife species for browsing, plantations of *bordi* (*Z. nummularia*) should be taken up on a large scale in the desert region, especially in the Desert National Park and around Bishnoi villages where large populations of Black buck and gazelles are given protection.

Earlier work carried out in the Silviculture section of the Institute has revealed that the lac insects (*Kerria lacca*) inoculated on *bordi* had a superior survival rate as compared to that on other tree species. It has a hopeful possibility of enhancing the lean desert resources and it is necessary that healthy plantations of *bordi* are available for inoculation.

Associated insects and their management

D. R. PARIHAR

INTRODUCTION

Bordi (*Zizyphus nummularia*) a naturally grown shrub, is widely distributed in Rajasthan. It is of some economic importance like leaves for fodder, wood for fuel and fence and fruits as eatables. Very little information is available about the insect pests on this shrub (Pal, 1977; Parihar, 1978, 1980). The following insects have been observed as pests of *Bordi* in arid areas of Indian desert. Their pest status and classification are given in Table 30.

Termites (Isoptera: Termitidae)

Termites are the most serious pest of *bordi*. They attack both seedlings and old plantations. Roots are more susceptible to be attacked. Nearly 47% damage of seedlings has been observed (Parihar, 1980). The species responsible for attack are *Odontotermes obesus* Rambur, *Microtermes mycophagus, M. obesi*. The attack is due to worker caste. The infestation is initiated with the formation of runways on stems or roots. Because of the destruction of the tap root, the upper plant gradually turns yellowish. When the active root system is completely devoured, the plant ultimately dies.

White grubs (Scarabaeidae: Coleoptera):

The adult beetles are nocturnal feeders. During day they remain in the soil. They are observed just before monsoon shower in the months of May or June. They emerge from soil leaving behind a round hole between 8.00 a.m. to 9.00 p.m. and immediately they fly to their host plants almost in a swarm and start feeding on the foliage of *bordi* by first making holes and later eating the entire leaf leaving midrib only. The congregation of beetles start from the top of the shrub and move downward with the result that the defoliation of host also takes place in the same manner. The beetles leave the host plants between 5.00 a.m. to 5.30 a.m. next day and return to the soil. The insects defoliate the plantations are *Holotrachia consanguinea, H. insularis, Schizonycha ruficollis* and *S. fuscesens, Aserica* sp., *Serica assamensis*. This shrub is second in preference. As long as *Khejri* (*P. cineraria*)

Table 30 *Bordi* pests — their status and classification

Common name	Scientific name	Family	Order	Plant stage	Pest status
Termite	*Odontotermes obesus*	Termitidae	Isoptera	Seedling	Major
	Microtermes mycophagus			"	
	Microtermes obesi				
White grub	*Holotrachia consanguinea*	Scarabaeidae	Coleoptera	Shrub	Major
	H. insularis	Scarabaeidae		"	
	Schizonycha ruficollis	"			
	S. fuscesens	"		"	Major
Fruitfly	*Dacus cucurbitae*	Tephritidae	Diptera	Developing fruits	Major
	Dacus longistylus			"	
	Carpomyia vesuviana			"	
Ants	*Camponotus compressus*	Formicidae	Hymenoptera	Active vegetative growth	Minor
	Dorylus labiatus			"	
	Monomorium longi			"	
	Pheidole smythiesi				
Tree hopper	*Oxyrhachis* sp.	Membracidae	Hemiptera	Vegetative growth	Minor
Lac insect	*Kerria lacca (ker)*	Lacciferidae	Hemiptera	"	Minor
Locust	*Schistocerca gregaria*	Acridoidea	Orthoptera	Seedlings and other vegetative growth	Major

Grasshopper	*Poekilocerus pictus*				Minor
	Chrotogonus trachypterus trachypterus				Minor
	Pyrgomorpha bispinosa deserti				Minor
	Ochrilidia affinis	"	"	"	Minor
Katra	*Amsacta moorei*	Arctiidae	Lepidoptera	Seedlings and active vegetative growth	Major
Weevil	*Cyrtozemia cognata*	Curculionidae	Coleoptera	"	Minor
	Myllocerus sp.	Curculionidae	Coleoptera	"	Minor
	Inderbela sp.	Metarbelidae	Lepidoptera	Old plantation	"

exist, the attack will be first on this tree.

Integrated control

1) Use of light trap during beetle flight period offers an excellent mode of prevention from beetles.

2) They may also be collected by vigorous shaking of the shrub.

3) Shrubs may be sprayed with carbaryl 50 W. P. @ 0.15% to 0.2% or Fenitrothion @ 0.05% or BHC EC @ 0.2% or DDT 50% WP @ 0.1% to 0.2%.

Fruitflies (Diptera: Tephritidae)

They are the major pests of *ber* plantations damaging the fruits. They are found throughout the tropics. The species infesting the *bordi* are *Dacus cucurbitae, Leptodyda Dacus longistylus, Carpomyia vesuviana.*

Ber fruitfly (*Carpomyia vesuviana*): This pest is common in all parts of India, West Pakistan and the Middle East extending upto southern Europe. This pest starts its activity early in the spring, passes the summer in pupal stage, and becomes active again in autumn and is serious in winter. It is most serious during December to February. Eggs are laid by puncturing the developing fruits and the maggot feed inside. When fully grown, they fall out and pupate in the soil under the trees.

Integrated control

1) Destruction of infested fruits.

2) Ploughing and frequent stirring the soil under the infested plants should be done to kill the pupae.

3) Spraying with 0.1% carbaryl or 0.06% malathion emulsion can control the pest very effectively.

Ants (Formicidae)

They are seen throughout the year but more active in the rainy season. They are either predating upon the other insects or feeds on plant sap. The species associated with *bordi* plants are *Monomorium longi, Pheidole smythiesi, Combitae, Dacus longistylus, Carpomyia vesuviana.*

Jassids (*Jassidae*: Hemiptera)

They are generally called leaf hoppers (*Amrasca* spp.) and are feeding on the plant sap. They are slender, wedge-shaped insects, very active and hop up off at the least disturbance. Some transmit virus diseases. They are widely distributed in India. They feed on the leaves both in nymphal and adult stages and drain the plant sap resulting in yellowing and dropping of leaves. The total life period is about three to four weeks.

Control: Sprayings of Bidrin, Phosphamidon, Carbaryl malathion, diazinon, endosulfan (0.03 to 0.5%) etc. are effective.

Tree hoppers (Membracidae: Hemiptera): *Oxyrhachis* sp.

The insect can easily be distinguished by the pronotum which is produced backwards in the form of a hood over

the abdomen. The nymphs and adults are commonly attended by *Camponotus compressus* ants as they secrete a sweet fluid from their anal tube much relished by the ants. The eggs are laid in rows in slit cut into the tender stem. The male is generally darker in colour and more active than the female. They remain in clusters on branches. The insect is prevalent throughout the year but abundant during September-October.

Control: Phosphamidon and malathion are effective.

Lac insect (Lacciferidae: Hemiptera): *Kerria lacca* L. (Ker)

The resinous secretion of females provides the stick lac which is of great commercial importance. The apterous females are highly generate with vestigial antennae. The body is irregular, globose and enclosed in a resinous mass secreted by the twigs of host trees to a thickness of 6 to 12 mm. *Bordi* plants have proved as good host in arid areas.

Grasshoppers and locust

Grasshoppers are sporadic pests of *bordi* plantations distributed all over the desert. The nymphs and adults defoliate foliage. Female lays eggs inside the soil. The common species which are feeding on foliage are *Poekilocerus pictus, Chrotogonus trachypterus trachypterus, Pyrgomorpha bispinosa deserti* and *Ochrilidia affinis.*

Desert locust, *Schistocerca americana gregaria* Forsk. is one of the most serious pest of desert shrubs and trees (Pruthi, 1969; Bhanotar, 1975). During plague or swarming period, locust prefers *Bordi* shrub and devastate them. They eat leaves and bark of this shrub.

Grasshoppers and locusts are controlled by dusting aldrin or BHC @ 20-25 kg/ha.

Katra, Amsacta moorei (Butler) (Arctiidae: Lepidoptera)

This is a sporadic, serious and polyphagus pest of desert shrubs. The damage is caused by caterpillars which may be very active during July-August. They feed on leaves. The adults are nocturnal, positively phototropic and start emerging as the summer rains set in. The eggs are laid in clusters preferably on the underside of the leaves. The total larval period is 15-20 days. The pupation takes place inside the soil.

Control: As the incidence of pest is widely spread in vast areas and the damage in these areas have necessitated to take up the control measures on a cooperative basis. The moths are attracted to light, collected and destroyed. Dusting of BHC 10% @ 20 kg/ha or Parathion 2% @ 15 kg/h can protect the shrubs very effectively.

Black weevil, *Cyrtozemia cognata* (Curculionidae: Coleoptera)

In the first week of July, the insects first appear in the field and continue upto first week of October. The pest lays eggs on the tip of the leaf. Grubs after hatching move to the soil where the rest of cycle is completed. One life cycle is completed in 20-25 days having 4 larval instars of 10-15 days. The pupal

period takes 4-5 days to form adults. The longevity of the pest is 15-20 days.

No work on control aspects has been reported.

Grey weevil, *Myllocerus* spp. (*Curculionidae*: Coleoptera)

The incidence of *Myllocerus* spp. starts with the onset of rains and continues upto last week of August. The peak period of activity of this pest is 1st week of August. It does considerable damage to plants by feeding on the leaves from the edges in a characteristic manner. The grubs feed on the roots of plants. The adult is small with greyish white elytra. It lays ovoid light yellow eggs in the soil. 250-360 eggs are laid by a single female at a depth of about 8 cm in soil. The total life cycle from egg to adult takes 42 to 54 days.

Control: Study on control measures has not been carried out.

Bark borer, *Indarbela* spp. (Metarbelidae: Lepidoptera)

The larva bores into the stem to about 15 to 25 cm and feeds on the bark, mostly during night. Only one larva is seen inside a bore hole which is used as a shelter. They eat through the bark into the wood and in cases of severe infestation sap movement is interfered and the trees cease to flush.

Control: Injection of 5 ml. of Kerosene, CS_2 (Carbon-di-sulphide), BHC 0.2 per cent of DDT 0.5% into the hole and sealing it with cotton wool and mud gives good control. It is also preferable to spray the insecticide on the tree trunk after removing the webs to that effective control can be obtained.

Diseases

SAROJ SINGH

INTRODUCTION

The shrub of *Bordi* (*Zizyphus nummularia*) grows in abundance in the grazing lands of the arid and semi-arid areas of India. It forms about 14% of the total composition of the grassland flora in district Pali (Kaul and Ganguli, 1963). *Bordi* as it is commonly known, stands as codominant in several plant communities of Thar desert. In extreme arid areas of Thar desert, this drought hardy species forms pure community. This shrub is quite resistant to diseases. Stem gall disease is of the most common occurrence and rarely the fruits are reported to get disease in semi-arid areas. The detail of these diseases are described as under:-

Stem gall disease

The stem gall disease is one of the most injurious diseases of *Bordi* (*Zizyphus nummularia*). It is common everywhere and hardly any variety of *Zizyphus* escapes the cause of this disease. Sometimes the infection is so severe that it affects the fruit production considerably.

Symptoms: On an infected plant galls can be seen present either solitary or crowded on the stem. They are globose, lobed, rugose or tuberculated and hard (Plate 7). Galls represent axillary branches and have the appearance of a mass of cauliflower like surface (Mani, 1964). Hypertrophy and hyperplasia of cells play an important role in the development of gall. Galls were reddish brown to dark brown in colour and their diameter ranged from 33 mm to 50 mm. Heavily galled plants showed transformation of 50-60% of axillary buds on the tender branches into galls. In case of heavy infection it was observed that plants were stunted and showed symptoms of unusual deformity. Vegetative growth of the plant was also affected adversely. Severe infection affected the fruit production considerably.

Pathogen: The stem gall of *Bordi* (*Zizyphus nummularia*) is induced by *Eriophyes cernuus* massee, a mite belonging to the family Eriophydeae.

Control: The gall formation resembles cancerous growth in human cells, hence the disease has not been checked. If effective insecticide is sprayed for the

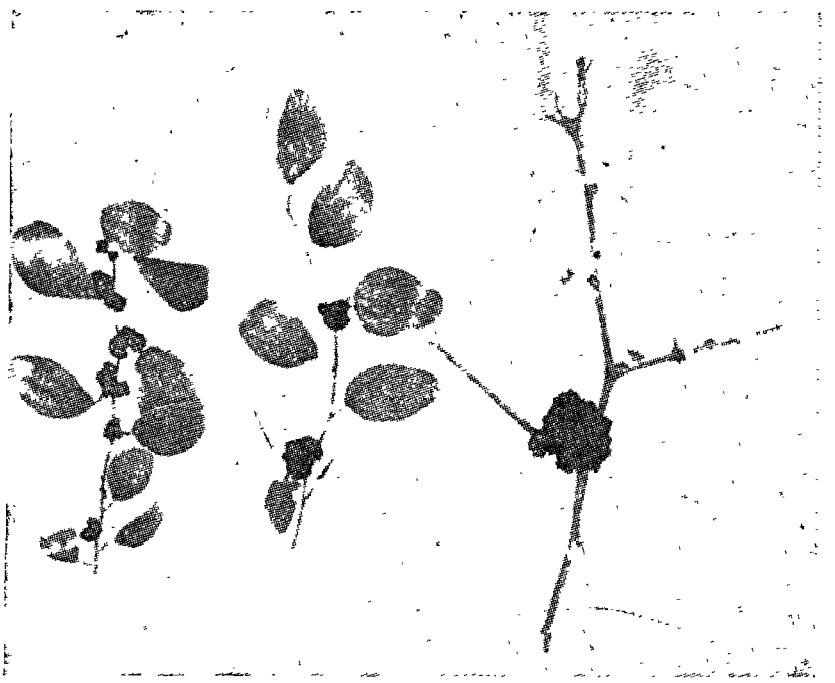


Plate 7 Galls development in *Bordi*.

control of the mite, the disease is checked to some extent.

Fruit decay

Fruit rot: This disease is of rare occurrence in *Bordi* fruits (*Zizyphus nummularia*).

Pathogen: The disease is caused by fungus *Glomerella cingulata*. The fungus is polyphagus in nature.

Symptoms: The disease produces brownish discolouration at the stalk end which gradually extend around the fruit. Severely infected fruits become mummified. The pathogen is weak and requires previous injury for the development of infection. *Bordi* is least susceptible to this disease as compared to other varieties of *Zizyphus*, i.e. *Z. mauritiana*.

Control

Application of ziram (1 kg/500 1) at 15 day interval for 2 months gives significant success in control of the disease.

Socio-Economic aspects

M. L. PUROHIT AND WAJID KHAN

INTRODUCTION

Bordi is famous among arid shrubs as a top feed for its high palatability and nutritive value as well as major edible fruit yielding shrub. The multifarious utility of this shrub proves its importance for the inhabitants of arid tracts. *Bordi* is adapted to the harsh climatic conditions of the arid regions. Almost all of its parts have been used by local inhabitants since time immemorial. *Bordi* frequently occurs in the cultivated fields of the arid region and the farmers allow it to grow in cropped fields. Sometimes in fairly good number of shrubs put the crop yields at a stake but this covers the drought risk.

A popular proverb

The fruits of *Bordi* appear in winter. They are much relished by women and children. The ripening period of the *bordi* fruits (alongwith other arid fruits) is narrated in a famous local proverb:-

"Deewali ra diya deetha
kachar bor matira meetha"

The ripening period of three arid fruits are in October/November during Deepawali festival. On the eve of this festival the fruits of *Kachra* (*Cucumis callosus*), *ber* (fruits of *Zizyphus nummularia*), and *matira* (water melon - *Citrullus lanatus*) ripen and became sweeten with the glimpses of lamps.

Bordi plant is never cultivated for its fruits but grows narually in the arid areas and propagates naturally through root suckers as well as by dispersal of seeds. The shrub is grazed by cattle when young and tender but when the plant becomes woody and thorny, only sheep and goats are able to browse on it. The *pala* is rich in digestible crude proteins and minerals and abundantly available even when the associated grasses have dried. Despite severe droughts the farmers are able to harvest its leaves (*Pala*) as fodder.

Pala harvesting

Pala harvesting is always done after the harvesting of *Kharif* crops in November-December. The harvesting of *pala* is usually carried out by women

folk. Though it is tough task but essential task in the arid rural areas for the maintenance of precious livestock. In reluctances to do this job a woman tells her beloved:-

"Mara hathaliyan re beech chhala pad gaya mara marooji, mei pala kiyan katoli"
"Dhalon ro katne mei barro ro katiyon. oh, pharawlon pala katiyoni jave mara marooji, mei pala kiyan katoli".

In this song wife says to her husband that blisters have developed in the centre of my palm, my love how shall I now cut the *Pala*. I have harvested *Pala* from shrubs along the slopes and around the animal barns, but I cannot cover that harsh rocky terrain.

These few lines of the folk song show the toughness of *Pala* harvesting but words sometimes vary from region to region but express the same meaning.

The *Bordi* has a virile regenuative potential and is capable of coming up vigorously even after severe cutting at ground level. While harvesting *Pala,* ten to twelve well sized bushes are cut and gathered by fork to make it round as a big ball locally termed as *'Bhitka'*. These are placed in 8-10 numbers in a line of 2' apart and usually 8 to 12 such lines are made at a suitable place in the field. After 4 to 7 days, a place near to it is cleaned. *Bhitkas* are removed one by one to that place with the help of fork, the *pala* is collected at the same place by beating the bundle. *Pala* then brought to the home either on head load in *poots*[1] if less, or on bullock-cart in a *Jhal*[2] (3 to 4 q *Pala* is transported in a *Jhal* in one trip).

These *bhitkas* formed a big heap locally called as *Bhitora*[3] (it consists of 64 to 96 *bhitkas*). The *bhitoras* are put near the place where these can be used for fencing in the form of *Phi*[4].

The relationship of *Bhitora* and *Phi* (sometimes called *pooni*) is clear from a famous proverb:-

"Bhitora to udiyaja poniya ro lekh lave"

It means the person is more concerned about small *pooni* and not taking care of big *bhitoras* composed of large number of *poonies*. It is similar to a English proverb:-

"Penny wise and pound foolish"

The meaning of the both is same but applies entirely in different environments, i.e. field and firms.

To avoid the painful prick of the thorns of the shrub fruits cannot be plucked like other fruits and have to be collected by a stylish beating of the branches before harvesting or collection of *pala* by *Bewla*[5], generally made from *ber*[6]-wood. *Tadi*[7] is used to hold fast the

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1. *Poots* : *Pala* collected and tied in a piece of cloth or blanket for bringing.
2. *Jhal* : Rough blanket type enclosure on the cart or some time for camel load made of goat hair or camel hair.
3. *Bhitora* : The heap which is to be transported in a cart and of 64 or 96 *Bhitkas*.
4. *Phi* : Small portion of thorns with slender branches used for fencing.
5. *Bawla* : Double horn fork like equipment with long handle generally made up of *Bordi* stem.
6. *Ber* : Fruits of *Bordi* (*Zizyphus nummularia*).
7. *Tadi* : A hook fastened to a long handle, mostly used for cutting *Khejri* twigs or providing jerks to *Bordi*.

branches and fruits are ground-dropped with the jerks to form a spatter on the ground. Because of this it is also called as *Jhar-beri* (spattered fruits) and fruits are called as *Jhari-ber*. These *ber* are first winnowed then dried on the roof or open floor covered with thin clothes to protect from birds damage. The fruits take two weeks to dry. They are mixed with small quantity of ash and stored in a earthenware pot. After one or two months new ash is added and again stored for further consumption. *Ber* is most nutritive and delicious fruit of arid zone, liked by all the age groups. These are eaten fresh as well as dried with the same interest. Even unripe fruits are plucked by kids and school going children.

Economic importance

Bordi from its apex to root tip has an economical potential. Seedling may be used as root stocks. It sometimes, becomes a troublesome weed in the irrigated fields but in dry land farming system it is a precious shrub. The farmers do maintain the self growing lot in their cultivated fields. Its economic viability is discussed below.

Importance of fruit: Dried fruit is used medicinally in the *Ayurveda* in one form or other. The seed is palatable and a study on palatability of intake of various feeds by three species of gerbils showed that these fruits rank first (Ishwar Prakash *et al.*, 1967).

The well ripened fruits fetch better prices in the market (Rs. 1-2/kg). Sometimes these fruits are grounded (fruits alongwith stone) and seived. The powder, so obtained, is consumed alone or mixed with *gur* or *sugar*. A delicious paste locally known as *Borakuti*, is also prepared and it is highly relished by young and old alike with great interest and pleasure.

Leaves as fodder: These leaves form a most valuable fodder for camel, goats and cattle and is highly esteemed in the region. Leaves can be given either alone or with some form of *Kutti, straw* (*Bhusa*) and *Loong* (leaves of *Khejri*) to cattle, camel, goats and sheep. These are supposed to promote milk production. Goats and camels are very fond of this fodder and prefer this to almost any other fodder. In scarcity or drought years *Bordi* is cut twice in a year, once in April/May and other in November/December. It is a good green/dry fodder for the livestock and fetches a sale value of Rs. 20 to 35 per 40 kg according to seasons and availability. The old stalk of *Bajra* or wheat *Bhusa*, which are not preferred by livestock, can be fed to them after mixing 50% *Pala* in them.

Wood: The wood is used for making the handles of local implements, and Y shape branches are made into *gulel* to scare birds at farm. Well seasoned wood is used for making yokes of bullock and *lathies* (sticks). A fancy *lathi* is prepared by a straight *Bordi* stem. First the bark is peeled off from the stem, and it is again tied round the stem in a particular fashion. It is then exposed to open fire. Tied bark on removal provide black and white strips on it. Some people decorate it further by putting metal rings on both ends. It is said that it is more stronger than Bumboo *lathies*. The wood is also a source for better charcoal with higher calorific value. Its charcoal is largely used by local blacksmith.

Thorny twigs: They are put to the following uses.

(a) *Fencing*: The dried branches are generally used in making heaped up fences or put on sand wall to protect them from damages by animals, etc. In certain localities these are more elaborately and permanently raised by sticking the branches upright and binding with rough ropes. Due to very sharp curved thorns the twigs stick very close to each other and make a good fence.

(b) *Walls of hut*: Thorny twigs are assembled together with the branches of *Akra* (*Calotropis procera*). *Munj* (*Saccharum bengalense*) rope is tied at the lower and upper side of assembled thorns and pressed by putting wooden sticks or stone slabs to make the lower wall of *Jhunpa* (village hut).

(c) *Doors and gates*: Similarly the doors and main gates of cattle shed, courtyard, fenced fields, storage yards and compounds of the villages of arid zones are generally made of the thorny twigs of *Bordi* and *Khejri*. In the frame of *Khejri* or *Akra* twigs, the *Bordi* twigs in four or five layers are put and pressed by some weight for at least a fortnight, then tightened by the rope of *Khimp* (*Leptadenia pyrotechnica*). This door is either used for hut or field gate, etc.

(d) *Tatas* (Screens): For making *tatas, bamboo* sticks are used below and above the thorns layers. All these are tied with *munj* rope. These screen provide cool air in summer after wetting.

(e) *Water huts*: Water huts are provided at important road junctions in villages. Walls and gates are made up of thorny twigs. These give cooling effect by providing shade and protection from wild animals at night.

(f) *Soil conservation purposes*: Thorny twigs are used in checking the soil erosion by wind, by putting twigs across the wind direction in various strips. These are covered with the sand or mud. Locally this practice is known as *Kana bandhana*. It acts as small barriers to wind and avoid soil blowing from the cultivated fields.

Bark of roots and twigs: The bark contains 12 percent of tannin. These are used for leather tanning in this area by following old method by traditional tanners. Root bark is also used for making country liquor and it is said to be a very intoxicative as compared to other locally prepared wines. In Udaipur region the local tribes prepare the wine by decomposing the *Ber* which is supposed to have less intoxicative effects.

Medicinal uses

The villagers opined the following medicinal uses and preparations from the bark of roots of *Bordi*.

(a) The bark of *Bordi* roots plus *Jawasa Dhamasa* (*Fagonia cretica*) roots are chopped into pieces and put in earthen pot along with water, it should be at least 9" to 12" above the material. The mouth of the earthen pot is covered with cloth and soil, and buried under the heap of the cattle dung called *okho-ordi*. After full decomposition (30-45 days) it is dug out. The water is stirred and boiled. It is given to weak sheep due for lambing.

(b) Similar process is followed but with small quantity of wheat tied in the cloth piece and put along with above mixture. After cooling the wheat is taken out, dried and ground into flour. From this flour sweet balls (*Ladoos*) are prepared by adding *Gur* (Jaggery) and

butter oil. It gives strength to old and young alike.

(c) The same process is used for preparation of *Jawa* (minor changes in composition as well as name) by adding 5 kg *gur*, 2 kg *Fitakari* (alum) and 2 kg salt along with 2 kg of chopped roots. After digging out the pot the filtered material is provided to bullocks with the help of bamboo tube locally known as *nal*. It is said to be a digestive and nutritive tonic for the bullocks.

Socio-religious uses

The *Ber* fruit and other part of *Bordi* becomes one of the important components in socio-religious rituals and rites on the lamp festival, i.e. *Deepawali*, people use the *Bordi* fruits for Laxami (Goddess of wealth) *puja* (worship) with the other fruits like *kachra* (*Cucumis callosus*), *Jowar* stalk (Sorghum) in the villages while in the cities it is used with *sitaphal* (*Anona squamosa*), sugarcane pieces (*Saccharum officinarum*), *Singhara* (*Trapa bispinosa*) and other seasonally available fruits. Even at the occasion of *Shivaratri*, though it falls in the month of February, dried fruits are used for worshipping Lord Shiva. Children wear the garland made of *Bordi* fruits and pod of radish on the eve of *Holi* or *Shivaratri*.

The importance of *Bordi fruits* is narrated well in a local song, sung at the time of child delivery. It is known as *Dai* (mid wife) song. The few lines from the song are as follows:-

Ho, Raja jaccha ne bhave khata, metha bor dono Chhane, chhanne, ho Sasu re channe ho chhanne Ho, Raja pala ra chirmi bore ke sharyab chogiya ho, Raja.

It describes the extreme fondness of the pregnant ladies for *Bordi* fruits for the delicious, sour and sweet taste. On account of strict dietary restriction imposed by the governing mother in law, the expectant lady arranges for *Ber* and consumes them secretly, same are sometime collected by her husband to please her.

In the form of gift it is to be sent to nearest relatives, daughter's in-law houses. It is so famous and the only fruit which can be preserved for long time. Whenever a villager goes to some nearest relatives house or goes to daughter's house he or she takes the fruits of *bordi* with other available local fruits like *Kachra* (*Cucmis-Callosus*), *Kakri* (*Cucumus melo* var. *Utolissimus*) and *Mateera* (water melon) and gives it to his/her relatives in cities as a token of love. Even these are sent to school or college going students residing in hostels.

In arid areas, friends and relatives sit at Chopal for gossiping and *panchavati*. *Ber* are used as *Kharbhanjana* (to bring back the sweet taste of mouth) after taking opium. Generally these fruits are taken instead of any sweet thing to sweeten the mouth taste. The fruit alongwith butter milk is given to heavy opium eater to neutralise the intoxicant effect.

In Muslim graveyards the thorny twigs of *bordi* are fixed upon the new grave to protect the buried soul from wild animals. These twigs act as tree guard for small and tender plantation as well.

An opinion survey

M. L. Purohit and Wajid Khan

Earlier surveys and personal interviews have revealed that *Bordi* is a shrub of economic importance preferred by villagers. It provides most nutritive feed even in famine, when other vegetation dry up. The value of the land is directly proportional to the number of *bordi* plants it sustains. The *Pala* (leaf fodder) provides additional returns which solely depends on the density and growth of *bordi* plants. It has also been observed that density of *bordi* vary among culturable waste, *orans*, old fallows and cultivated lands. With the help of participant observation technique it was observed that density of *bordi* is less where disc ploughing is practised, due to uprooting of the tender suckers and young plants during deep ploughing. Areas with traditional ploughing the *bordi* plants are maintained as such.

On the basis of farmer's opinion and participant observations study, an extensive opinion survey was conducted in different land from units of Nagaur district during socio-economic survey of Nagaur district.

The opinion of randomly selected sample respondents to the question-do you prefer grassland with *bordi* or without *bordi*? Give reasons for the same is set out in Table 31.

Table 31 reveals that out of total sample, 75% respondents said yes followed by negative opinion (15.32%) and not reported (5.92%). The proportion of respondents who did not know amounted to be very meager, i.e. 3.70%. It is discernible from the Table that almost all said yes in case of sandy undulating interdunal plain (92%), hills and rocky gravelly pediment (90%). On the other hand negative response and not reported were found highest (22.22% and 11.11%) from the respondents of sandy undulating older alluvial plain followed by 21% each in saline depression and hills and buried pediments. While 8.57% and 47% not reported at all and 5.71% and 4% absolutely did not have any opinion respectively in rocky interdunal plain, sand dune and flat interdunal plains.

It can easily be inferred that people preferred *bordi* plants in a majority of land form units of Nagaur district.

The views of respondents with regard to the advantages of the *bordi* in various land form units of Nagaur are set out in Table 32.

It revealed that the utility of *bordi* as a fruit, fodder, fencing material and wood providing shrub has been recognised by the highest per cent of sample respondents (94.44%) in hills and rocky gravelly pediments. followed by (93.33%) in flat buried pediments, (80.77%) in saline depressions; (77.27%) sand dunes and interdunal plains; (73.91%) in sand dunes and flat interdunal plains and (73.33%) rocky interdunal plains. The opinion expressed by sample respondents that *bordi* provide fuel, thorn for fencing and shade etc. ranged from (4.54%) on sand dunes and interdunal plains to (30.15%) in graded river bed and younger alluvial plains. Similarly few of the advantages opined by sample respondents varies from (9.09%) in hills and buried pediments to 17.46% in graded river bed and younger alluvial plains. Hardly 12.50% respondents in sandy undulating aggraded older alluvial plains and only (3.84%) in saline depression expressed that *Bordi* acts as sand stabilizer and as windbreaks. Respondents in sandy undulating aggraded older alluvial plains with (31.25%) response expressed the same views. The non reported respondents ranged from (6.66%) in rocky interdunal plain to (42.85%) in flat aggraded older alluvial plains. Irrespective of landform units about 77% opined usefulness of *bordi* as fodder, fuel, fencing and wood material, 4% as sand stabilizer and additional income and 19% did not report any opinion as the usefulness of *Bordi.*

The opinion expressed by the sample respondents in various landform units of district Nagaur, reveals the importance of *bordi* as one of the most important fruit, fodder and fence material yielding shrubs of the region. Beside this the shrub also acts as good sand stabilizer. In addition to the above said utilities for the shrub, it is a source of additional income for the farmers of arid zone of India.

Table 31. Opinion expressed by randomly selected respondents on preference for *Bordi* during socio-economic survey of Nagaur district (1977-78)

Landform units	Opinion of the respondents				Total respondents
	Yes	No	Not reported	Don't know	
Flat buried pediments	15 (65.21)	5 (21.74)	1 (4 34)	2 (8.68)	23 (100.00)
Sandy undulating buried pediments	14 (70.00)	4 (20.00)	—	2 (10.00)	20 (100.00)
Hills and rocky gravelly pediments	18 (90.00)	1 (5.00)	1 (5.00)	—	20 (100.00)
Sandy undulating interdunal plains	14 (100.00)	—	—	—	14 (100.00)
Rocky interdunal plains	30 (85.71)	—	3 (8.57)	2 (5.71)	35 (100.00)
Sand dune and flat interdunal plains	23 (92.00)	—	1 (4.00)	1 (4.00)	25 (100.00)
Flat aggraded older alluvial plains	35 (74.47)	8 (17.02)	3 (6.38)	1 (2.12)	47 (100.00)
Sandy undulating aggraded older alluvial plains	16 (59.25)	6 (22.22)	3 (11.11)	2 (7.40)	27 (100.00)
Saline flat aggraded older alluvial plains	17 (77.27)	4 (18.18)	—	1 (4.54)	2 (100 00)
Hills and buried pediments	11 (78.57)	3 (21.43)	—	—	14 (100.00)
Saline depressions	26 (78.78)	7 (21 22)	—	—	33 (100.00)

Sand dune and interdunal plains	22 (88.80)	2 (8.00)	1 (4 00)	—	25 (100.00)
Graded river bed and younger alluvial plains	63 (63.00)	22 (22 00)	12 (12.00)	3 (3.00)	100 (100.00)
Total	304 (75.06)	62 (15.32)	24 (5.92)	15 (3.70)	405 (100.00)

Figures in brackets show percentage.

Source : The Table computed from the data of the sub-project "Environmental factors and socio-demographic aspects of socio-economic survey of Nagaur district" (1977-78).

Table 32. Opinion expressed by randomly selected respondents for various advantages of *Bordi* during socio-economic survey of Nagaur district (1977-78)

Land form units	It gives fodder, thorn for fencing, wood	Fruit, fuel and shed	Wood for yoke, fodder, shade, fruit, etc.	Used as sand stabilizer, thorn for fencing & serve as windbreak	Gives additional income	Not reported	Total
Flat-buried pediments	14 (93.33)	1 (6.66)	—	—	—	—	15 (100.00)
Sandy undulating buried pediments	10 (52.38)	1 (7.14)	—	—	—	3 (21.42)	14 (100.00)
Hills and rocky gravelly pediments	17 (94.44)	1 (5.56)	—	—	—	—	18 (100.00)
Sandy undulating interdunal plains	10 (52.38)	1 (7.14)	—	—	—	3 (21.42)	14 (100.00)
Rocky interdunal plains	22 (73.33)	6 (20.00)	—	—	—	2 (6.66)	30 (100.00)
Sandy dune and flat interdunal plains	17 (73.91)	2 (8.69)	4 (17.39)	—	—	—	23 (100.00)
Flat aggraded older alluvial plains	15 (42.85)	5 (14.28)	—	—	—	15 (42.85)	35 (100.00)
Sandy undulating aggraded older alluvial plains	9 (56.25)	—	—	2 (15.50)	5 (31.25)	—	16 (100 00)
Saiine flat aggraded older alluvial plains	11 (64.70)	—	—	2 (11.76)	1 (5.80)	3 (17.60)	17 (100.00)
Hills and buried pediments	6 (54.54)	1 (9.09)	1 (9.09)	—	—	3 (27.27)	11 (100.00)

Saline depressions	21 (80.77)	—	4 (15.38)	1 (3.84)	—	—	26 (100.00)
Sand dune and interdunal plains	17 (77.27)	1 (4.54)	—	1 (4.54)	—	3 (13.63)	22 (100.00)
Graded river bed and younger alluvial plains	8 (12.69)	19 (30.15)	11 (17 46)	—	—	25 (39.68)	63 (100.00)
Total	177 (58.23)	38 (12.50)	20 (6.58)	6 (1.97)	6 (1.97)	57 (18.75)	304 (100.00)

Figures in brackets show percentage.

Source : The Table computed from the data of the sub-project "Environmental factors and socio-demographic aspects of socio-economic survey of Nagaur district" (1977-78).

Bordi in Indian desert - An overview

H. S. MANN

INTRODUCTION

In India *Jhar-ber/Bordi* (*Zizyphus nummularia* Burm. f.) Wt., Syn *Z. rotundifolia* Lamk. was well known in ancient India. It was widely distributed at least at the *Mahabharata* sites. According to Vishnu Mittre (1961), Om Prakash (1961) and Khosso and Singh (1967), *ber* has been in use for the last 4000 years. Mehra (1967) has given a detailed account of the use of *ber* in ancient India. Scriptural references are available like *Valmiki Ramayana* that there was a preponderance of *Jhar-ber* (*Z. nummularia*) in the *Sal* forests of central India (M. P.). This exactly lies in the North Indian Tropical Dry Deciduous (Type 5A) forest (Champion and Seth 1963). Even today the scrub forests of *Jhar-ber* exist there. The popularity of *Jharber/Bordi* can be gauged from several *Niti shlokas* of the *Panchtantra* and the *Ayurveda*.

Z. nummularia (Burm. f.) Wt. *Bordi/ Jharber* is found on almost all the habitats of arid and semi-arid parts of north-west India except the sand dunes and the saline patches. It plays an important role in the economy of desert people and is one of the major sources of top feed, fruit and field fencing material.

Large natural stands of *bordi* are found in Punjab, Rajasthan, Gujarat, Uttar Pradesh and Madhya Pradesh. It has also been reported from Pakistan, Baluchistan, Persia (Iran) and Arabia. In north and north western Iran this shrub covered about 40 million hectares of area but its unchecked grubbing for baking bread and domestic cooking, the area under the shrub dwindled to a negligible one (Francais, 1953).

In Rajasthan highest shrub density (720 plants/ha) has been recorded from Nagaur district and lowest (65 plants/ha) in the Jaisalmer district. The density range is very wide in all the districts of the Rajasthan desert. But older alluvial plains are the preferred habitat of this shrub where on an average 373 plant/ha have been recorded. Different land use also affect the density of this shrub. In protected areas like *Oran, Bir* and other reserved wood-lands, the density of *bordi* has been found to be high (345 shrubs/ha) whereas on marginal

land/wasteland, it is as low as 160 shrub/ha. Shrub density is gradually reducing in tractor ploughed lands as the deep ploughing uproots the tender suckers and young saplings.

In W. Rajasthan *Zizyphus nummularia* forms an important component of *Prosopis cineraria-Z. nummularia-C. decidua* community on the flat alluvial plains (Saxena, 1977). But due to yearly cutting this shrub fails to show any impact. On gravelly plains with shallow soils this shrub dominate in the form of pure communities. Most of the *Orans* of Indian desert, dedicated to some deity, are dominated by *Z. nummularia.* On eroded rocky surfaces, pediment plains and other rocky formations this shrub acts as codominant in *Capparis decidua-Z. nummularia* community. Saxena (1977) has demonstrated that under protection undershrubs and shrubs gain upperhand in short span of time over perennial grasses. The shrub layer dominates for a longer period to give way to the woodland. Thus shrub communities represent the disclimax.

Plants growing on alluvial flats assume early flowering (June-July) and reach its peak during July-August whereas flowering occurs during late July and attain the peak in August-September in rocky habitats. There is a variation in the size and weight of fruits of shrubs growing in the two habitats, viz. 63 g/100 fruits and 46 g respectively (Nanda, 1967). It has a deep root system with laterals appearing along the entire root length. The extensive laterals and secondary roots spread horizontally enable this species to act as good sand binder (Tanwar and Sen, 1980) whereas concentration of roots at lower and upper portion of the main root make it a drought hardy shrub (Pareek, 1977).

Bordi fruits ripe during late November and December and are much relished by children and women. Sometime the fruits are grounded (with stone) into a fine powder which is later mixed with sugar or *gur* to prepare a delicious sweet locally called as *Borakuti.* The dried leaves *Pala* form topfeed for the livestock. Small twigs and branches are largely used in fencing the field boundaries, walls of the huts, compounds of village houses and storage yards etc. *Bordi* wood is largely used for making yokes of bullocks and sticks etc. During summer months screens are prepared out of the finer thorny twigs of *Bordi* which keep the room cool on wetting. Its bark contain 12 per cent tannin and sometime used for tanning the leather whereas the root bark and fruits are used for making country liquor. Various vigour tonics are prepared from its root and few other ingradients. Its bark can be used as ointment for foul sores. Decoction of the same is largely used for gargle for sore throat and ulcerated gums. Cotyledons are used in the eye trouble (Watts, 1893). Leaves are also used for the treatment against scables and other skin diseases. Dried leaves are burnt and inhaled for the treatment of cough and cold. In one of the Hindu festival (*Shivaratri*) *bordi* fruits have much importance. The ripe fruits along with butter milk are given to heavy opium eater to neutralise intoxication effect. Its fruits served as food for thousands inhabitants in Thar desert during 1869 famine (Brandis, 1869).

More than seventy five per cent farmers prefer that *bordi* should be in

common village grazing lands. Nearly 94% people expressed their opinion for the usefulness of this shrub. It forms an additional source of income to the farmer and act as sand stabiliser.

Seeds removed from some showed 65-80 per cent germination. In the first year of growth this shrub is slow (25.0 cm) but in second year the mean annual increment was observed to be 80 cm. 2-3 years old plant start bearing fruits. Kaul and Ganguli (1963) obtained 150 kg/ha of leaf fodder with 14 per cent shrub cover whereas Shankar (1981) has shown that a well stocked area produce 91.0 to 169 kg/ha of leaf fodder, from bushy plant. A well developed plant with its full crown canopy produce 2-3 kg of air-dried leaf fodder in a year. A sown plantation of improved collection @ 1000 plants/ha produced 595 kg of leaf fodder after 3 years growth. It is difficult to remove an established shrub from the field. Spontox and 'Bladex-K' were found effective in killing the plant when applied after debarking the collar region.

The chopped stump of the shrub sprouts in early March and continues through summer months but the grazing animals utilize this growth during summer months. Plant assumes vigorous growth by the onset of monsoon: The shedding of leaves commences by middle of November and this time coincides with harvesting of the *pala*.

Z. nummularia and *Z. rotundifolia* are considered to be synonymous. But horticulturally they behave differently and can be distinguished. *Z. rotundifolia* provide a vigorous graft whereas the stock of *Z. nummularia* remains thin. Naturally grown shrubs of *Z. nummularia* can be converted into superior quality *ber* plants through grafting technique. This shrub exhibits high variability when grown from seeds due to segregation, pollination being entomophilous.

Histological studies of stem, root and leaf have indicated that this shrub has adaptive mechanism in the arrangement of various tissues which enable it to resist drought. Small tomentose leaves with sunken stomata are vital characters which help in the water economy of plant. Younger leaves show higher rate (964.9 mg/gm/hr) of transpiration as compared to older leaves (679.7 mg/gm/hr). The moisture loss from a cm^2 area of young leaf was 23.7 g mg/hr while in old leaves it was 15.85 mg/hr only. Though there was diurnal variation in the transpiration rate of leaves but it attains a peak at 15 hrs. The moisture content in the young and old leaves varied from 52.6 to 62.5 per cent respectively.

Ecophysiological studies have shown that the net photosynthesis increased with increase in transpiration rate whereas respiration rates did not increase. The photosynthesis was found to be positively correlated with leaf energy contents. Similarly transpiration and temperature were positively correlated. An inverse relationship exist between leaf moisture and net photosynthesis. Mulay and Joshi (1966) have shown that the small twigs of this shrub absorb as high as 0.049 and 0.045 mg/sq cm of surface area in case of young and old twigs respectively. Nanda (1969) demonstrated that titrable acid number was extremely low in root but high values were encountered in young leaves and twigs. Plants from

rocky habitat provided maximum titrable acid number values during monsoon while the plants of sandy habitat during summer. Irrespective of habitat the titrable acid number was extremely low during winter indicating that the synthesis of organic acid was regulated by soil environment. A *Zizyphus* shrub predominantly contains seven organic acids.

A large variability in the chlorophyll contents of the leaves has been observed. Younger leaves towards the terminal end of the branch have less chlorophyll (309 mg chloro/gm) as against 343.6 mg/gm of old leaves during monsoon. But the trend reverses by the time fruiting is over (1.34 mg chloro/gm young leaves VS 0.97 mg chloro/gm old leaves). The concentration of carotenoid was maximum in younger leaves (109 mg/gm). Carbohydrate concentration in the form of reducing sugars was higher in older leaves (4.5%) than young leaves (3.3%). Similarly total soluble carbohydrate in the younger leaves was 6.2% as against 11.0% in older leaves. New leaves also contained low starch values (4.6%) against 7.6% in older leaves. Extractable leaf protein contents in the developing leaves was upto 1.5% while in fully developed leaves it was as high as 5.7%. This higher amount of protein is obtainable from fully matured leaves.

Amongst the minerals potassium and calcium were by far the dominant constituents (0.6 to 1.5%) of the leaves. These are followed by phosphorus and sodium (0.12-0.20 and 0.065-0.15 per cent) respectively. Magnesium concentration varied from 0.02 to 0.05 per cent only. Judging the leaf forage from mineral requirement of animals, calcium and potassium contents are quite satisfactory while phosphorus and magnesium contents seem to be on lower side than the minimum required.

Analysis of trace elements in *bardi* leaves has shown that iron and copper occur in fairly high concentration as compared to other desert parts of the world. Similarly manganese values in the leaf fodder of *Bordi* are quite high and as such it can be categorized as rich feed. Zinc values when compared with International standard come to normal or in some cases marginally deficient. The leaf fodder consumption of *Bordi* by sheep and goat was estimated @ 2.2 kg/100 kg body wt. and 3.3 kg/100 kg body weight respectively. Amongst the leaf fodder the intake of *Khejri* leaf *loong* was comparatively less than *Pala*. The dry matter intake of both the feeds were higher in goat than in the sheep.

Bordi leaves contain 12.8% of crude protein contents but its digestible crude protein value has been found to be 3.6 g/100 gm of the dry feed.

The low value of digestibility was attributed to the presence of tannic acid and tryptic inhibitors (Nath *et al.*, 1969) but Ghosh *et al.* (1971) successfully tried to increase the nutritive value of *Pala* by treating it with formaldehyde. The faster rate of passage of *pala* than *loong* was due to its low tannic acid contents. Green leaves have higher concentration of crude protein contents, inorganic substances and ether extract etc. Singh and Gupta (1977) and Bohra and Ghosh (1981) have reported the concentration of various cell wall constituent such as cellulose, hemi-celluose, lignin and cell wall associated silica etc.

Several herbivorous and carnivorous mammals and rodents feed upon ripe

fruits *Bor*. Even migrating bird like Tilore (*Chlamydotis undulata*) voraciously feed upon *Zizyphus* fruits. Some of the carnivorous birds and mammals when left without their actual food, swiftly change over to feed upon its fruits. Amongst all the available seeds, the Gerbil prefers *Bordi* fruits first.

This shrub is quite resistant to disease. Stem gall disease was of the most common occurrence in arid area whereas in semi arid tract the fruit-rot disease occurs occasionally.

Termite is the main pest which attack the young *bordi* seedlings and also the old plantations. White grub beetles feed upon the foliage of this shrub during night but this shrub is second in preference over *Khejri*. There are few more pests but less damaging, e.g. Bark borer, tree hopper, and fruit-fly etc.

Animal production in *Dhaman-Bordi (Cenchrus-Zizyphus)* grasslands

L. N. HARSH AND K. A. SHANKARNARAYAN

INTRODUCTION

Western Rajasthan has a high population (18.1 m) of livestock which largely depend on the native grasslands. Due to excessive exploitation these grasslands are very much degraded. On priority basis these grasslands need the protection, development and management for higher animal and plant production. Under protection the degraded grasslands gradually develop and provide higher production (Ahuja, 1969). There is very little information available about the secondary productivity of sheep and goat on such protected grasslands. These two animals constitute high animal population (5.8 million goat and 4.2 million sheep) in Western Rajasthan. In order to get sustained production (both primary and secondary) for a larger period, the grazing experiments were conducted to know: (i) The effect of different intensities of grazing by secondary producers on the regeneration of grasses and shrubs, and (ii) growth rate of animals in different seasons.

Study site

The grazing studies were conducted for three consecutive years (1977 to 1979) with sheep and goat on the natural grasslands of older alluvial plains at Central Research Farm, Pali. Here the soils are heavy and moderately deep (30-45 cm) underlain by indurated *kankar* pan. The ground storey of the grassland under protection was dominated by *Cenchrus ciliaris* (*Dhaman*) whereas the middle storey showed the dominance of *Zizyphus nummularia* (*Bordi*) shrub. The grassland conformed to the good condition class (Bhimaya and Ahuja, 1969).

Methodology

The botanical composition of the grassland was studied by line intercept method (Canfield, 1941). The forage production was estimated by harvesting it during the middle of October from the protected quadrats, each of 10 sq m. For comparative performance of the sheep

and the goat, three intensities of grazing were maintained for recording secondary productivity.

T_1 — Light intensities of grazing (3 sheep/goat per ha).

T_2 — Medium intensities of grazing (4 sheep/goat per ha).

T_3 — Heavy intensities of grazing (6 sheep/goat per ha).

Here lambs (10-12 month-old) of Marwari breed of sheep were used for the study. For goats, the local breed of the same age group were taken. Fortnightly the body weight of the experimental animals was recorded. The rainfall during study period was 551.4, 441.5 and 828.5 mm in 1977, 1978, 1979 respectively. In all the grazing paddocks the bush cover was kept uniform, i.e. 20%. A measure of regeneration of *Zizyphus* shrubs was carried out immediately after the withdrawal of animals from grazing during December 1979 and again re-measured in the month of June and August 1980.

Growth of sheep under different intensities of grazing

Maximum body weight gain in the sheep was observed in the heavy intensity of grazing which was followed by medium and light intensity of grazing. The increase in live weight gains over light intensity was 32.9 and 21.1 per cent in heavy and medium intensities of grazing, respectively (Table 33). Under light intensity of grazing, the body weight gain was comparatively low which could be attributed to under utilisation of forage resulting in occurrence of greater standing biomass of *Cenchrus* which develops woody stems. In the sheep, the rate of production was highest with heavy grazing intensity (20.15 gm/day/animal) and lowest (15.16 gm/day/animal) with low intensity. Slow utilization of grasses made them woody which finally reflected in secondary production.

The secondary productivity per hectare was also calculated and it has been recorded that in heavy intensity of grazing 165.9 per cent more production was recorded as compared to light intensity (Table 33), without destroying the grasses and shrub (*Cenchrus-Zizyphus*).

Growth of goat under different intensities of grazing

In this case the maximum body weight gain was recorded by light intensity of grazing. The increase in body weight over heavy and medium intensity was 23.2 and 22.0 per cent respectively, because of greater availability of *Zizyphus nummularia (Bordi)* bushes while in heav intensity the gain in weight was minimum due to excessive utilisation of bushes (Table 33).

When the secondary production was calculated on per hectare basis, it showed 62.26 per cent higher productivity with heavy intensity over light intensity but this gain was at the cost of bushes. Thus moderate intensity seems to be better. The goat showed higher productivity rate (31.73 gm/day/animal) in all the intensities as compared to the sheep.

Comparative performance of sheep and goat

Studies on comparative performance of the goat and the sheep on *Cenchrus*

Table 33. Growth performance of the sheep and the goat under different intensities of grazing

Type of animal	Treatment	Average body weight		Gain in weight (kg/animal)	Secondary production (gm/day/animal)	Per cent increase under different intensities	Animal production (kg/ha)	Per cent increase in animal production under different treatments
		Sept. 1977	Dec. 1977					
Sheep	T_1	16.25	28.91	12.66	15.16	—	37.98	—
	T_2	16.25	31.59	15.34	18.37	21.1	61.36	61.55
	T_3	16.25	33.08	16.83	20.15	32.9	100.98	165.90
Goat	T_1	16.33	42.83	26 50	31.73	23.9	79.50	—
	T_2	16.33	42.58	26.25	31.42	22.0	105.00	32.07
	T_3	16.33	37.83	21.50	25.74	—	129.00	62.26

grassland dominated by *Bordi* bushes revealed a gain of 109.3 per cent increase in goat compared with sheep under light intensity of grazing. The corresponding increase in medium and heavy intensities of grazing was 71.1 and 27.7 per cent respectively (Table 34). The increase clearly indicate that the goat is faster in secondary production than the sheep.

Bush utilisation by sheep and goat

The maximum reduction in canopy cover of *Zizyphus nummularia* was recorded in all the intensities of grazing by the goat. The per cent canopy reduction was 90.2, 81.0 and 62.4 per cent in heavy, medium and light intensities of grazing by the goat whereas very nominal reduction in canopy cover of *Bordi* (*Zizyphus nummularia*) was observed in the sheep paddocks. The per cent reduction was 43.2, 19.2 and 7.2 per cent in heavy, medium and light intensity of grazing (Table 35).

Regeneration of bushes under different intensities of grazing

It is evident from the results (Table 36) that maximum regeneration of bushes was in heavy intensity of grazing both in the sheep and the goat. In the lean period, i.e. December to June, 10.2 to 66.3% regeneration was recorded in the case of the goat grazed paddocks, while in the active growth period (June to August) it was 16.27 to 96.44%. The regeneration of bushes in the sheep paddocks during lean period (March '80 to June '80) ranged from 18.5 to 31.5 per cent whereas in the active period of growth it ranged from 86.2 to 168.6 per cent (Table 36).

DISCUSSION

The performance of the goat over the sheep was better in all the intensities of grazing because of their unique feeding habits. The goats prefer to browse on shrubs while the sheep mainly graze on grasses. The goats ability to browse on shrubs is due to its mobile upper lips and very prehensile tongue permitting it to eat short grass (Mittal and Ghosh, 1980). The goats largely browse on the shrub like *Bordi* (*Zizyphus nummularia*) which has about 12% crude protein compared with 6-10% crude protein in grasses (Ganguli *et al.*, 1964; Mondal and Chakravarty, 1968).

The reason for maximum gain in body weight of sheep under heavy intensity of grazing was due to the availability of aftermath growth of more nutritious and proteineous forage. At high stocking rate, Hull *et al.* (1961) also reported more nutritious aftermath growth in rangeland. They contended that intensity of grazing influenced the chemical composition of the clipped forage when grazed more heavily and further concluded that as the stocking rate increased, the animal harvested and consumed more forage and digestible nutrients or energy per acre.

In the goats, the growth rate was better under light intensity of grazing over medium and heavy intensities, obviously, because of the sparse availability of shrub forage in heavy and medium intensity of grazing. Pollen and Lacey

Table 34. Comparative performance of the sheep and the goat under different intensities of grazing

Treatment	Experimental animal	Average body weight (kg)		Gain in body weight (kg/ animal)	Percentage increase over sheep body weight
		Sep. 1977	Dec. 1979		
T_1	Sheep	16.25	28.91	12.66	
	Goat	16.33	42.83	26.50	109.3
T_2	Sheep	16.25	31.59	15.34	
	Goat	16.33	42.58	26.25	71.1
T_3	Sheep	16.25	33.08	16.83	
	Goat	16.33	37.83	21.50	27.7

Table 35. Per cent canopy cover of *Zizyphus nummularia* under different intensities of grazing

Treatment/canopy cover	Intensity of grazing		
	T_1 (Light)	T_2 (Medium)	T_3 (Heavy)
Canopy cover in September 1977	20.00	20.00	20.00
Cover recorded in December 1979 in sheep paddock	18.55	16.16	11.36
Cover recorded in December 1979 in goat paddock	7.52	3.82	1.96
Cover reduced in sheep paddocks	7.20	19.20	43.20
Cover reduced in goat paddocks	62.40	81.00	90.20

Table 36. Regeneration of bushes under different intensities of grazing

Type of animal	Treatment	Cover in Dec. 1979	Cover in March 1980	Cover in June 1980	Regeneration (%)	Cover in Aug. 1980	Regeneration (%)	Total regeneration (Dec. to Aug.)
Sheep	T_1	18.55	6.21	7.36	18.51	13.70	86.27	120.61
	T_2	16.16	4.68	5.72	22.55	11.23	96.85	139.95
	T_3	11.36	2.38	3.13	31.51	8.41	168.68	253.36
Goat	T_1	7.52	—	8.29	10.23	9.79	16.27	30.38
	T_2	3.82	—	4.72	23.56	9.27	96.44	143.19
	T_3	1.96	—	3.26	66.32	4.73	75.00	141.32

(1979) reported that adjustment in livestock number has a greater effect on herbage production than the grazing system.

Thus, it is evident that the overall performance of the goat was better than the sheep in grasslands with diversity of species. Growth of the sheep under heavy intensity of grazing and that of the goats under light intensity were superior to other intensities of grazing. What is more, the regeneration of bushes under all the intensities was quite satisfactory after one year of deferment and rest. Thus, with appropriate management and control in the number of animals kept in the grassland, no deleterious effect on the vegetation occurred.

The grassland management by putting more than one kind of animals is always beneficial as it allows the utilisation of diversified forage species more efficiently as has also been emphasized by Brynot *et al.* (1979).

A shrub for silvipasture

S. K. SAXENA AND H .S. MANN

INTRODUCTION

In western Rajasthan about 1.88% area is covered under forest whereas nearly 23.8% land has been categorized as area not available for crop production (Mann *et al.*, 1977). These areas can largely be taken up for the development of agroforestry and silvipastoral system as there is large scale demand for fodder and forage for bovine population. Amongst the indigenous species, *Zizyphus nummularia* (*Bordi*), can fullfil this requirement.

Silvipastoral system: In order to provide higher amount of good quality forage the present strategy is to have plantation of multipurpose trees/shrubs and utilization of interspaces by growing palatable, high yielding forage grasses without affecting the growth of shrubs/trees. This approach of tree/shrub and grasses combination is termed as silvipastoral system. In this management, in a good rainfall year, the animal get ground forage right upto late winter. But in summer months (March-June) the ground becomes almost devoid of vegetation. At this stage the multipurpose species (food, fodder and fuel) provide substantial amount of leaf fodder to the grazing animals. Beside this a fully develop canopy of trees/shrubs, in the poor rainfall tract (150-250 mm) shall help in conserving the soil moisture, improve atmospheric humidity and protect the under storey forage grasses from scorching and dessicating winds. Developed canopy provide shade to grazing animals and checks excess water loss from their body. Thus development of silvipastoral system on the degraded lands shall improve the economy of the entire area. Amongst locally available shrub species, *Bordi* shall prove as the pioneer species for this purpose.

Old system of grasslands

Judging the adverse climatic conditions of the desert and drought hardiness of the indigenous shrub, the feudal Lords in the past have advocated the plantation of *Zizyphus nummularia* shrub in the tract having less than 300 mm rainfall especially in the district of Barmer, Bikaner, Jaisalmer and Jodhpur. So in these districts one can invariably come

across *Z. nummularia orans* (Table 37). The people were quite conscious of the suitability of this shrub in the tract. It was easy to establish *Bordi* shrubs by direct seed sowing or transplanting the saplings. Bhaduria (Jaisalmer) and Deshnokh (Bikaner) *orans* are good example. Allocation of area of the *Oran* or *Beer,* at the time of its initial establishment in the village, used to be very well conceived by the administrator of that time. Perhaps it was in excess to the carrying capacity of the livestock available during that period. Subsequently, the village population of men and his livestock swelled up manyfold and this system could no more bear the heavy pressure of animals. Because of this, at present, almost all the *oran* and *beers* could be seen with highly degraded grasslands (Table 37). Only annual grasses come up during monsoon. These are low in nutritive value and produce meagre amount of aboveground biomass production (0.5-1 q/ha). This annual flush is readily grazed by the large herds of animals leaving bare ground after the retreat of monsoon. After this the supply of the forage comes from the available top feed, i.e. *P. cineraria* (*Khejri*) and *Z. nummularia* (*Bordi*). Gradual fall of their leaves from November to June provide small quantity of nutritious feed to grazing lots.

Adaptability of shrub: Desert environment puts a limit on the growth of vegetation during summer months. There is a gradual loss of moisture in the profile of desert soils after the secession of monsoon. This phenomenon becomes evident when most of the trees and shrubs start shedding their leaves. They almost look leafless by the time high temperature and fast moving wind become prevalent (April-June) in this region. Here shrubs like *Zizyphus nummularia* (*Bordi*) can be seen with some leaves in higher rainfall zone (300 mm and above) and almost leafless in low rainfall (150-200 mm) tract. The plants remain dormant indicating drought hardiness. The plant produce good foliage with the onset of monsoon. Root system of this shrub is quite deep seated but do not reach the permanent moist zone of *kankar* pan. *Bordi* is known for its resistance to diseases and pests, except the gall formation at the time of flowering. *Z. nummularia* has remarkable power of regeneration from its root suckers. Once cut at ground level it throws several root suckers which assume a bushy form. Newly sprouted shoots provide some foliage, during summer months, to the browsing animals. Low rainfall tract (100-250 mm) support scrub-lands only. Here widely scattered trees (1-5/ha) of *Khejri* (*P. cineraria*) and *Rohida* (*T. undulata*) could be seen. Various hibitats of this dry tract witness other drought evading or drought resistant shrubs like *Leptadenia pyrotechnica* (*Khimp*), *Clerodendrum phlomoides* (*Arni*), *Lycium barbarum* (*Murali*), *Acacia jacquemontii* (*Bawli*), *Haloxylon salicornicum* (*Lana*) and *Calligonum polygonoides* (*Phog*). Amongst them, *Z. nummularia* (*Bordi*) ranks first in providing top feed.

Silvipastoral studies

These studies were carried out at the Central Research Farm, Jodhpur and Pali of CAZRI (Muthana and Shankarnarayan, 1978), where four tree plan-

Table 37. Common village grazing lands (*Oran/Beers*) and their status

Place of *Oran/Beer*	District	Shrub community	Density	Crown cover (%)	Present status			Potential status		
					Grass-land	Condi-tion class	Produc-tion (q/ha)	Grass-land	Condi-tion class	Produc-tion (q/ha)
Bhaduria	Jaisalmer	Zizyphus nummularia	135	6.7	D.S.	Poor	2.5-5.0	Lasiurus	Good	15-20
Sodakoar	-do-	-do-	87	5.9	Eragrostis	V. poor	1.5-3.0	-do-	-do-	10-15
Dholia	-do-	-do-	63	3.7	-do-	-do-	-do-	-do-	Fair	-do-
Deshnokh	Bikaner	Z. nummularia P. cineraria	110	8.2	D.S.	Poor	3 0-8.0	Cenchrus Lasiurus	Excellent	20-30
Kanot	Jaisalmer	Z. nummularia	95	4.5	Oropetium	V. poor	2-5	-do-	Fair	10-15
Gajner	Bikaner	Z. nummularia P. cineraria	250	8.9	Eleusine	Fair	12-28	-do-	Excellent	20-30
Nal	-do-	Z. nummularia-Capparis decidua	180	7.4	D.S.	Poor	3-5	-do-	Fair	10-15
Kalau	Jodhpur	Z. nummularia-Acacia jacquemontii	60	4.5	Eragrostis	-do-	2.5-5.0	-do-	Good	20-30
Lohawat	-do-	Z. nummularia-C. decidua	120	7.5	Eleusine	-do-	-do-	-do-	-do-	-do-

D. S. = *Dactyloctenium sindicum*

tation namely *Acacia tortilis, Albizzia lebbek, Azadirachta indica* and *Holoptelia integrifolia* were selected and four grasses i.e. *Cenchrus ciliaris, C. setigerus. Dichanthum annulatum* and *Panicum antidotale* were grown under them. Some tree without grasses were kept as control.

The results showed that there was no significant difference in the above ground biomass production of grasses under different tree species. Highest forage yield (36.1 q/ha) was obtained during 1975 (good year) and lowest (14.4 q/ha) in the year 1976 (bad year). The tree growth and height were unaffected by the intercropping with grasses and maximum height (2.16m) was recorded in *Azadirachta indica* followed by *Acacia tortilis.*

In another trial inter-row plantation of grasses like *C. ciliaris* (*Molopo*), *C. setigerus* (yellow *anjan*), *Chrysopogon fulvus* (*Mhow*) and *Sehima nervosum* were made between *Acacia nilotica, A. tortilis, Albizia lebbek* and *Kigelia pinnata.* Here three levels of N (0, 20, 40 kg N/ha) and two levels of P_2O_5 (0, 20 kg/ha) were supplemented. The results have indicated that 40 kg N/ha and 20 kg P_2O_5/ha have produced significantly higher dry matter production over control. *Chrysopogon fulvus* produced as high as 5.2 t/ha against 4.2 t/ha in control in a good rainfall year. Yield difference in *Cenchrus* grasses were not significant with fertilizer application. The tree growth in these cases also remained unaffected.

So far results on the performance of perennial grasses and shrub like *Bordi* are not available. But old system of raising *Bordi* in the common village grazing lands (*Orans*) is itself an indicator for grass shrub combination. Long and deep tap root system of this shrub will in no case deter the growth of the perennial grasses. Secondly limited density and crown cover as has already emphasized by Kaul and Ganguli (1963) shall produce maximum forage and top feed. For a better grass performance in a silvipastoral system the stem of the shrub should bear a clear bole and well defined crown. Few *Orans* as shown in Table 37 generally possess good trees of *Bordi* but the grasslands are in highly deteriorated condition representing very poor to poor range condition. These areas have high potential, if reseeded with appropriate grasses like *Lasiurus ecaudatus, Cenchrus ciliaris* and *C. setigerus.* These old grazing lands should be developed in phased manner. The developed patch should not be allowed to be grazed in the first two years. Subsequently grazing may be carried out according to the carrying capacity of the land. The developed plots may, preferably, be allowed to be grazed by milch animals only.

In developing the wastelands in a low rainfall zone (150-250 mm) systematic plantation of shrubs should be carried out at a distance of 6 x 6 m. Here brick planting or seedlings raised in polythene tubes (6-9 months old) shall give higher percentage survival. Interspace between tree rows should be reseeded with grasses after the seedlings become two years old. Two years gaps shall avoid the immediate root competition between grasses and shrub.

In low rainfall zone where trees and other shrubs fail to grow, the combination of *Bordi* and *Sewan* (*Lasiurus ecaudatus*) will be quite appropriate in developing silvipastoral system.

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