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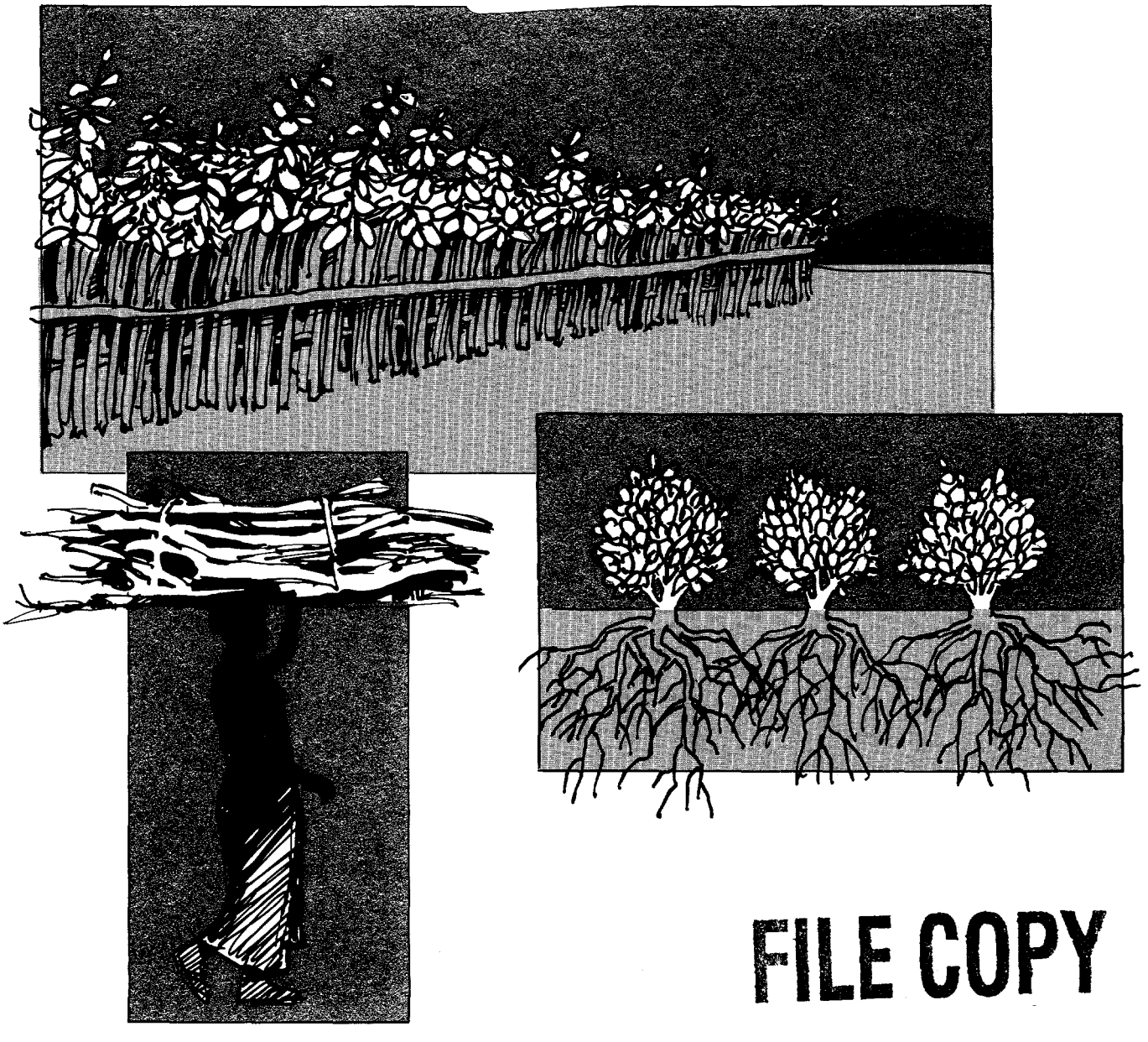
Shrubs in Tropical Forest Ecosystems

Examples from India

JULY, 1989

Ajit Kumar Banerjee



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Ajit Kumar Banerjee

The World Bank
Washington, D.C.

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ABSTRACT

Shrubs are a long-neglected life form in the forest ecosystem, playing many roles in the life not only of the forest itself but also of the human community that depends on the forest.

The planting of shrubs, separately and along with tree crops, should be encouraged in all afforestation programmes in tropical countries. If used correctly, shrubs can act as barriers to water run-off, increase *in situ* soil and moisture conservation, provide a continuous supply of biomass for use as fuel and fodder, particularly by the poor, and act as inexpensive live fences.

Although there are many books on the subject of shrubs in the disciplines of botany and forestry, few emphasise shrubs separately from trees. This paper considers shrubs' potential role in solving the fuelwood and fodder crisis in the biomass-deficient tropical world, which is being aggravated by deforestation. This paper also serves as a useful handbook of shrubs for practising foresters, ecologists, agriculturists and soil conservationists.

The first part of this paper concentrates on shrubs' presence in nature, their characteristics, their growth features and their usefulness. Examples, drawn from India, may be applied with appropriate modifications to all tropical forest lands. Propagation methods to multiply shrubs and shrub management are also dealt with in this part. In the second part, 81 shrubs are briefly described with respect to distribution, phenological characteristics, nursery and planting methods and appropriate locality factors.

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FOREWORD

Tropical and subtropical forest areas are being depleted at an alarming rate. The forests that still exist are of uneven quality. Many are understocked and quite often are bare below the tree canopy. In others, when trees are removed, the forests are colonised by spiny, unpalatable shrubs in an effort to protect the fragile soil. Finally, the shrubs are also removed, resulting in mainly low utility wasteland.

A tropical forest is generally incomplete without its tree, shrub and the forb layer. It is a delicately balanced and fragile ecosystem. Remove one of the layers and the balance is upset, sometimes irretrievably. Devoid of any one of the three layers, forests generally cannot perform fully their optimum productive and protective roles. Their collective value is more than the sum of the individual layers. Yet, in special circumstances, shrubs singly and with forbs play a particularly resilient role. In association with the forbs and grasses, the shrubs are the pioneers in colonising bare land. They resist erosion and desertification and are the last to fall before a forest turns into wasteland. Moreover, in countries with high population and low tree cover, it is the shrubs which have kept the hearths of the poor burning. Nevertheless, little attention has been given to shrubs in afforestation, reforestation and other forms of man-made forests. These days, there is a lot of justified reaction against the felling of trees. Yet removal of the shrub layer goes unnoticed, as it is reckoned that shrubs are nature's gift and are able to look after their own regeneration. This is perhaps the reason for neglect in shrub research and reporting, particularly regarding those which do not have immediate productive use.

In this book, the author attempts to bring into focus the importance of the shrubs, the long-neglected life form in the tropical forest ecosystem. The book not only discusses the many roles that shrubs play; it also describes eighty-one indigenous shrubs of the Indian subcontinent. The principles established can be applied elsewhere as well using different but similar shrub species.

The World Bank is most concerned with ongoing destruction of tropical forest ecosystem and is intervening in their rehabilitation. Information on shrubs will be most useful in these projects. Apart from the fact that this book will be useful for those working in forestry in the Indian subcontinent, I hope it will encourage others to take up studies of locally occurring shrubs of tropical and subtropical countries and fill an enormous gap in our current knowledge.

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April 1989

CHAPTER 1. SHRUBS IN NATURE

1.1 Introduction

A typical broadleaved forest, be it in the humid or arid zone, has more than one canopy. The top canopy of trees is underlain by a number of canopy layers one of which is the shrub layer or shrub synusiae. There is no standard definition of shrub but for the present purposes it is defined as vegetation which, in contrast to trees when mature, has a low branching habit with the first branch appearing between the shrub collar and rising to one meter in height from the base of the plant, the total height not exceeding 4 meters. The diameter at the collar remains below 10 cm. Shrubs are woody and do not die back annually which differentiates them from herbs or forb. However, there are exceptions. For example, there are herbs such as castor, which do not die back annually, have fair amount of woody tissue and herbs such as Musa can reach a height of more than 4 meters. On the other hand, there are trees such as the Japanese maple (Encyclopedia Americana, 1981) which branches at the collar. Shrubs do not include seedlings, saplings and the poles which mature into trees over time. However, a tree can be managed as a shrub e.g. tea, Prosopis. There are certain medium-sized trees, which under adverse ecoclimatic conditions survive by adopting shrub-like characteristics e.g. Junipers just below tree line in high altitudes. In-bred population such as trees of Acacia auriculiformis, also take on diminutive stature of a shrub.

In theory, the shrub layer is considered a very important synusiae as it acts as an interceptor of rain storms by reducing the impact of rain drops (Plate 1). But in practice, botanists and foresters have seldom studied them or utilized them (except for a few) for their productive or protective value. The presence of shrubs has always been taken for granted whether the forest is natural or man-made. As a result, literature on the phenology, propagation and management of the shrubs is negligible. Only those shrubs which have medicinal or other well-known uses, have been studied in depth.

This study attempts to fill this gap since shrubs have a multifaceted role to play in wasteland afforestation. It has been proved that a tree canopy of Tectona grandis (Teak) without a shrub synusiae does not provide soil protection or conserve moisture. In a totally different realm, namely, providing fuelwood specially, for the poor, a shrub layer can be a great asset. Trees have to be grown for a long period before they can be harvested, while shrubs, if scientifically managed, will yield fuelwood and fodder for more people within a year of planting and sustain the production annually for a number of years to come. In natural plant succession, shrubs play a dominant role in xerosere succession. Weaver and Clements (1938) observe that the shrub stage, which follows the herbaceous stage, furnishes an excellent nursery for tree seedlings. In degraded land afforestation, therefore, planting of pioneer shrubs is appropriate to ameliorate the site to allow seral and climax stage species to germinate and grow, and often serve as nurse plants in afforestation.

The present book deals with different aspects of this subject. In Chapter 1, some of the general characteristics of shrubs are set out and the more commonly found shrubs in different agro-ecological zones of India are listed, as is the available literature on the rate of growth, and growing

stock of shrubs of some areas. Chapter 2 deals with the potential of shrubs as a live fence, as an important synusiae for fuelwood supply and for soil and moisture conservation. These can be effected by growing shrubs as live hedge, as understorey in man-made block forests and as rows or continuous hedge in degraded land. Leguminous shrubs are a very important group, which will also be dealt with in this chapter. In Chapter 3, the shrub propagation methods in general are described while shrub management methods are investigated in Chapter 4. Chapter 5 summarizes by reiterating points discussed in the first four chapters. Finally, the characteristics, phenology, uses and propagation methods of eighty-one common shrubs have been described in Chapter 6.

1.2 Shrub Characteristics

Many shrubs have high adaptive power to suit different eco-climates. Some of the shrub species grow in areas ranging from the very dry to the very humid, e.g. Capparis horrida, Carissa spinarum, Nyctanthes arbor-tristis, Dodonaea viscosa, Rumex hastatus, Daphne papyraceae, Rubus lasiocarpus, Buddleia paniculata, Jatropha curcus. Similarly, some of the shrubs appearing in low hills persist at high altitudes. A number of shrub species are found in acid soils but are equally comfortable in alkaline areas (Euphorbia terrucalli, E. royleana, Agave sisalana, Zizyphus oxyphylla, Dodonaea viscosa). This adaptability makes it possible to deal with a small number of species and cover most of the agro-climatic zones of India. This will also limit the time required for developing technology for raising and managing shrubs.

Shrubs, by definition, have branches growing from near the ground. As a consequence, the rainwater drip from the shrub crown has the least impact on the soil. They have a cushioning effect against raindrop erosion (Plate 1) in contrast to trees where the first branches are at a height and the raindrops reach the ground with a high kinetic energy. Unlike trees, shrubs usually have a compact crown limiting excessive throughfall. Similarly, the soil-laden water run-off is physically obstructed not only by the main stem of the shrub but also by its side branches. Thus water filters gradually through the shrub leaving the soil behind forming terraces. Trees bearing a large crown have to be spaced out to accommodate it. Shrubs, on the other hand, can be grown very close to each other facilitating hedge formation to act as a soil trap. Shrubs, like trees, have root systems suited to the soil type. Many species of shrub can have surface spreading root systems (Calligonum polygonoides, Euphorbia spp., Indigofera cordifolia, Clerodendron spp.) in sandy soils but others have a deeproot system such as Capparis decidua (Troup, 1975)(Plate 11). This allows choice of specific shrubs to reduce wind erosion to protect land from landslips or to halt sheet and gully erosion depending on the objective of afforestation.

Shrubs being woody are often good fuelwood (Cassia auriculata, Rhus parviflora). Quite a few produce fuelwood of high calorific value as the density of the wood is high (e.g. Cleistanthus collinus). Some of them dry fast and give out little smoke. As the size of the branches of the shrubs is small, they are eminently suitable for the hearths of the rural poor.

Most shrubs are very hardy (Gymnosporia, Helicteres, Gardenia) and can withstand hacking. Being unpalatable, they grow back without hindrance.

Moreover, many produce abundant seeds (Berberis, Dodonaea viscosa) with long viability and high germination percentage.

Many of the shrubs are not palatable, some being spiny (Carissa, Capparis), others with alkaloid contents Ipomoea spp., Adathoda vasica, and still others possessing very rough leaves (Lantana spp.) and rough stems (Rubus spp.). These shrubs, during their early stages of growth, need little protection from cattle trespass. It may be argued that bias towards such shrubs may mean loss of cattle browse but many of them have fruits which are liked by the cattle. Most of the shrubby Acacias, Dichrostachys, Carissa and Gardenia have palatable pods/fruits.

A few shrubs proliferate by root suckers (Rhus parviflora, Viburnum, Woodfordia, Gymnosporia). Damage to roots of these species by trampling of cattle, helps propagation. Coppicing ability is another characteristic common to many shrubs (Ipomoea, Lantana, Callicarpa, Woodfordia, Zizyphus, Hollarhena, Tabernaemontana, Capparis decidua, Casaeria glomerata).

Shrubs are mostly evergreen, although the leaflife is short. The nutrient recyclying by leaf fall is rapid in some species, leading to higher growth thus allowing larger sustained yields. This additional growth can be fruitfully utilized in social forestry management by introducing shorter harvesting cycles.

Some of the morphological adaptations of the shrubs to tolerate aridity allow these species to be used in clothing degraded wastelands of arid regions. Shrubs like Euphorbia and Opuntia (cacti) are succulents which have the ability to store water. Some of the cacti roots have ephemeral characteristics dying out as soon as drought sets in and reviving within a day when rains come. Some of the Euphorbias have small thick leaves which close the stomata in the daytime in summer and open them at night thus reducing transpiration rates. Tamarix spp. are known to be adapted to salt areas. Tamarix spp. excrete salt through the needles, so much so that when the shrubs are shaken, saltgrains drop like rain.

Many shrub seeds are stony, with a hard shell. The fruits of these shrubs are pulpy and are often palatable to cattle (Carissa spp. Zizyphus spp.). The seeds passing through the cattle gut are softened by enzymes making them easy to germinate. In other shrubs where the pulpy fruits are not palatable and thus have low natural germination, the shrubs tend to fruit in abundance so that sufficient number of seedlings can germinate and grow. Larger seed production with low germination is a survival method adopted by many species through evolution.

Some shrubs which colonize as pioneer species belong to the two subfamilies, Mimoseae and Papilioneae of family Leguminosae. Most species belonging to these families have root modules which fix nitrogen from the atmosphere and supply it to the shrub. Nodule mortality and shrub leaf fall enrich soil nitrogen eventually assisting other indigenous vegetation to grow rapidly.

One of the most interesting things about many shrubs is the extreme harmony in which they co-exist with each other. Trees also do the same in

some areas, but quite often, consociation of one tree species takes precedence over co-existence with other tree species. Aggressive shrubs which eliminate others, such as Eupatorium, Lantana, Parthenium, etc., are exotics to India. This harmonious co-existence of most indigenous shrubs is not unexpected since, as mentioned earlier, many of them have a wide range of adaptability.

That the shrub as a vegetation form is more hardy than the tree is proved beyond doubt by the presence of shrubs beyond the tree limit. As a whole, the number of species in the shrub form is also more than that in the latter form, implying availability of more species to suit changes in the environment.

Plant communities in a site change in composition with time. A bare land, whether wet or dry, is generally first colonized by forbs followed by shrubs and then by trees. The early forb or shrub colonies lead to more favorable ecological conditions, add organic matter to the soil, fix nitrogen if the plants are leguminous and often provide shade for trees to grow. The shrubs are often spiny, preventing animals grazing the germinating tree seedlings under them. These shrubs also provide perches for the birds, which after eating the pulp, reject the tree seeds into the shrub bush so that tree seedlings can germinate there. A typical example, seen in nature, is that of the Neem tree (Azadirachta indica), coming up in shade provided by Gymnosporia spp. or spiny Zizyphus in bare degraded land in black soils. There are many other ways in which shrubs help trees to invade communities.

On the other hand the above form of change (called succession) can be retrograded, i.e. reversed, due to various unnatural perturbations such as biotic interference, fire, cattle overgrazing, etc. These retrogressions provide more xeric conditions and species suitable to the new conditions appear. Forward change starts anew mostly with forbs and shrubs. Overall, retrogression reduces vegetative productivity of the land.

1.3 Grouping of Naturally Growing Shrubs

The number of naturally growing shrub species in the country is large and it is impossible to list all or even most of them. The more common ones are listed here, selected as having one or more of the following characteristics, namely high growth rate, ability to withstand biotic pressure of hacking and grazing, potential to provide products useful to the local people such as fuelwood, fodder or minor forest produce, appropriate form (such as interlocking branching patterns) and architecture to conserve soil and moisture and ability to improve soil productivity. These lists will allow the plantation manager to choose the local indigenous species for successful propagation. It may be noted that some shrub species mentioned occur also as trees under suitable growing conditions.

This selection of naturally growing shrub species (genera, in case of a few groups, as these genera have a number of shrub species for these sites) is grouped mainly on the basis of their degree of tolerance of two growth parameters, namely, temperature and available soil moisture and two special soil conditions, viz. saline-alkaline and saline-estuarine.

Temperature is high throughout India in most parts of the year except where the elevation reduces it. From the temperature aspect, therefore, shrub occurrence is classified into three elevational groups: those occurring in sites above 2,000 m, those between 1,000 m - 2,000 m and others below 1,000 m. To cater to the moisture parameter, the last group has been further subdivided into subgroups tolerant of excess moisture (water logging), moderate moisture (moist), low moisture (semi-arid) and very low moisture (arid desert sand). In addition, two species groups: those tolerant of saline and alkaline soil conditions and those tolerant of mangrove conditions (saline-estuarine), have been added to cover these special eco-zones.

Many of the shrub genera are widely adaptable and thus grow in more than one of the above classes, e.g. Desmodium, Indigofera, Woodfordia, Murraya, Zizyphus, Gardenia, Ixora, Cassia to quote a few. There are some species also which are spread over a wide range. For example, Woodfordia fruticosa is found in the high moisture areas of West Bengal and also in very dry teak forests of Chittorgarh in Rajasthan. Only those species in a particular group where they are frequent and typical are mentioned, omitting those shrubs which are present but more comfortable in some other group.

The main groups and subgroups are tabulated below:

Group	Sub-groups	Regions in which commonly found (List of Regions not exhaustive)
3.A.	Low elevation (< 1,000 m)	
3.A.1	Wet and water logging soil tolerant shrubs	Eastern and north eastern India, west Karnataka and Kerala, moist fresh water swamps in different parts of India.
3.A.2	Moist soil tolerant shrubs	Alluvial areas of Uttar Pradesh (UP) and moist lateritic areas of West Bengal, Bihar, Orissa, central India, Tamil Nadu.
3.A.3	Semi-arid soil tolerant shrubs	Lateritic and inceptisol plateau areas of central India, Siwaliks of UP, Punjab, Haryana.
3.A.4	Arid (including desert sand) soil tolerant shrubs	Western Rajasthan, Gujarat, west Haryana, Punjab
3.A.5	Alkaline and saline soil tolerant shrubs	Western UP, Haryana, Punjab, Rajasthan, Gujarat and black soils areas of central India.
3.A.6	Mangrove soil tolerant shrubs	Sundarbans of West Bengal and other deltaic areas of India
3.B.	Middle elevation shrubs (1,000-2,000 m)	Middle Himalayas of 1,000-2,000 m, Ooty areas of Tamil Nadu, mountains of Karnataka and Kerala
3.C.	Upper elevation shrubs (>2,000 m)	Himalayas above 2,000 m

Low elevation wet and water logging soil tolerant shrubs (3.A.1). These shrubs occur in forest types found in the east, north east and south western India. The forests are varied but most are characterized by tall trees, heavy crowns and more than one tree canopy. The density of the trees is also high, so that very little direct sunlight (0.5-1% in a rain forest) pierces to the floor. The forest floor is covered with fallen leaves which retain moisture. In consequence the soil is wet and the shrubs, a mixture of mesophytes, are tolerant of wet and water logging soils during most of the year. Common nondicotyledonous species found in the shrub layer mixture in east and northeast parts of India are the cane, climbing bamboo (Dinochloa), Pandanus and large ferns. Common dicotyledonous shrubs are Leea, Strobilanthes, Clerodendron, Laportea, Ixora, Osbeckia etc. When the forest is disturbed, clear felled or burnt for shifting cultivation, the shrub composition changes drastically giving rise to a totally new mixture. The most important species replacing the original association is a bamboo Melocanna bambusioides. Similarly, Ochlandra reeds cover the area densely. Euphorbiaceous genera such as Trema, Mallotus and Macaranga also take over. In some areas Eupatorium, Lantana and Mikenia invade the area to make up the shrub layer. While it is true that most of these species have very little productive use at the moment, without them these high rainfall areas, some of which are mountainous, would have been totally eroded.

The more common genera selected on the basis of one or more of the characteristics described earlier in this section are tabulated in Table 1.1.

Table 1.1: LOW ELEVATION WET AND WATER LOGGING SOIL TOLERANT SHRUBS

	Genus	Family
1.	Callicarpa	(Verbenaceae)
2.	Canes	(Palmae)
3.	Casearia	(Samydaceae)
4.	Coffea	(Rubiaceae)
5.	Ferns	(Filicales)
6.	Macaranga	(Euphorbiaceae)
7.	Melastoma	(Melastomaceae)
8.	Mussaenda	(Rubiaceae)
9.	Osbeckia	(Melastomaceae)
10.	Wendlandia	(Rubiaceae)
11.	Woodfordia	(Lathyraceae)

Low elevation moist soil tolerant shrubs (3.A.2). Low elevation areas with moist soil are characterized by normal monsoon rainfall of about 750 - 1,150 mm annually, restricted to about 4-5 months a year. As the soil is sandy alluvial, this water quickly percolates or runs off. The evapo-transpiration is very high which results in low soil moisture for about six months of the year.

Moist lateritic areas of West Bengal, Bihar, Orissa, central India and Tamil Nadu have red nodular soils generally underlain by a laterite pan. The laterite pan, being microscopically porous, does not prevent the water table ascending close to the surface. As a result, there is high soil moisture during and a few months after the rains. On the other hand, these areas are subjected to a low watertable and an extended drought period in the spring and in summer when temperatures top 45°C. During these periods the overhead canopy is bare because the trees are deciduous thus the shrub layers are subjected to high temperature, low moisture and strong competition with climbers. The shrubs in these areas are characterized by having a wide range of tolerance of moisture. They can withstand high rainfall and water logging for part of the year and yet are comfortable when the soil dries up. Many of these species have coriaceous leaves, abundant spines, and contain alkaloids. Those having the last characteristic render them unpalatable to cattle.

The more common genera selected on the basis of characteristics established in earlier in this section are incorporated in Table 1.2

Table 1.2: LOW ELEVATION MOIST SOIL TOLERANT SHRUBS

1.	Boehmeria	(Urticaceae)
2.	Colebrookia	(Labiatae)
3.	Desmodium	(Leguminoseae)
4.	Flueggea	(Euphorbiaceae)
5.	Gardenia	(Rubiaceae)
6.	Hibiscus	(Malvaceae)
7.	Hollarhena	(Apocynaceae)
8.	Indigofera	(Leguminoseae)
9.	Ixora	(Rubiaceae)
10.	Mallotus	(Euphorbiaceae)
11.	Milletia	(Leguminoseae)
12.	Murraya	(Rutaceae)
13.	Urena	(Malvaceae)

Low elevation semi-arid soil tolerant shrubs (3.A.3). Low elevation, semi-arid areas have most erratic rainfall, varying from 400 mm to 750 mm annually. The rainfall is restricted to 90 days a year. The intensity of rainfall is very high and, as the land is mostly sloping, rain is the major cause of erosion. Because of erosion, the soil surface is often washed away leaving a fragile terrain. Areas with these problems are found mainly in the central Indian plateau and in the Siwaliks of western India.

The natural shrub layers have low to medium density and a spreading root system, as if tenaciously holding to the soil. These shrubs have small, thick leaves, often shiny, spreading evergreen crowns, producing abundant often palatable fruits.

The more common genera are tabulated in Table 1.3.

Table 1.3: LOW ELEVATION SEMI-ARID SOIL TOLERANT SHRUBS

	Genus	Family
1.	Adathoda	(Acanthaceae)
2.	Barleria	(Acanthaceae)
3.	Bridelia	(Euphorbiaceae)
4.	Calotropis	(Asclepiadaceae)
5.	Cannabis	(Urticaceae)
6.	Capparis	(Capparidaceae)
7.	Carissa	(Apocynaceae)
8.	Cassia	(Leguminoseae)
9.	Cleistanthus	(Euphorbiaceae)
10.	Dodonaea	(Sapindaceae)
11.	Euphorbia	(Euphorbiaceae)
12.	Flacourtia	(Bixaceae)
13.	Gardenia	(Rubiaceae)
14.	Grewia	(Tiliaceae)
15.	Gymnosporia	(Celastraceae)
16.	Mimosa	(Leguminoseae)
17.	Moringa	(Moringaceae)
18.	Nyctanthes	(Oleaceae)
19.	Ocimum	(Labiatae)
20.	Randia	(Rubiaceae)
21.	Rhus	(Rutaceae)
22.	Vitex	(Verbenaceae)
23.	Woodfordia	(Lathyraceae)
24.	Zizyphus	(Rhamnaceae)

Low elevation arid (including desert sand) soil tolerant shrubs (3.A.4). Low-elevation arid, particularly desert, areas are subjected to high day temperature, cold night and sand blasting due to high wind velocity. The rainfall is very low, seldom exceeding 400 mm a year. Quite often the landscape is undulating with sand piling up in low hills. The interesting thing about the shifting sand landscapes is the presence of some moisture at a low depth caused by dew and retained by the shifting sand acting as a mulch. The number of shrubs per unit area is low but they have a spreading crown with very little leaf surface, leaves being often replaced by a large number of spines. Some of the species of Cactus and Euphorbia have thick soft stems and spines replacing leaves. The root system of most of the shrub species of the desert sands has an unusually wide spread with little depth. Some of them produce abundant fruits, many of which are drupes with a fleshy outer cover and a hard nut inside.

Species are mentioned rather than genera as the latter, selected on the basis of one or more than one characteristic established earlier in this section, generally have only the named few species tolerant of the difficult conditions obtained in this subgroup.

Table 1.4: LOW ELEVATION ARID (INCLUDING DESERT) SALT TOLERANT SHRUBS

	Genus	Family
1.	Acacia jacquemontii	(Leguminoseae)
2.	Acacia senegal	(Leguminoseae)
3.	Anogeissus pendula	(Combretaceae)
4.	Capparis decidua	(Acanthaceae)
5.	Cassia auriculata	(Leguminoseae)
6.	Cassia obovata	(Leguminoseae)
7.	Crotolaria juncea	(Leguminoseae)
8.	Euphorbia spp.	(Euphorbiaceae)
9.	Euphorbia royleana	(Euphorbiaceae)
10.	Euphorbia terucalli	(Euphorbiaceae)
11.	Indigofera oblongifolia	(Leguminoseae)
12.	Inga dulcis	(Leguminoseae)
13.	Leptadenia pyrotechnica	(Asclepiadaceae)
14.	Mimosa hamata	(Leguminoseae)
15.	Opuntia spp.	(Cactaceae)
16.	Zizyphus nummularia	(Rhamnaceae)

Low elevation alkaline and saline soil tolerant shrubs (3.A.5). Large areas of Ultar Pradesh, Haryana, Punjab, Rajasthan, Gujarat and the black soil areas of central India have saline and alkaline soils. The saline soils have a salt pan of chlorides and sulphates at a very low depth and have alkaline pH. During the rains, some of the salts are leached from the top soil, surfacing again due to capillary action, later in the year. The alkaline soils on the other hand have predominant carbonate and bicarbonate ions associated with high exchangeable sodium and a pH more than 8.5. The landscape is often undulating leading to soil wash. Soil movement is high as the clays are in a dispersed state due to sodium ion concentration. Besides, the effect of the sodium on the montmorillonite clay soil produces variable soil appearance ending up in the gilgai landscape.

The variability of soils in northern India results in a patchy distribution of shrubs: in some parts the density is high, yet areas in the immediate neighborhood may be totally devoid of shrubs. The species constituting the shrub patches are spiny, having thick coriaceous unpalatable leaves and deep root systems.

The black soils of central and western India are also often alkaline with pH up to 9.0. The properties of the soil are totally different from the saline-alkaline soils of north India. They are clayey with uniformly spread alkalinity. Shrubs are common, dense in patches, but growth is poor. It is often noticed that dense shrubs protect the emerging trees from sun-scorch and browsing.

The common species selected on the basis of one or more than one characteristic earlier in this section are mentioned in Table 1.5.

Table 1.5

Low elevation alkaline and saline soil tolerant shrubs

1.	Agave americana	(Agavaceae)
2.	Balanites aegyptica	(Simarubiaceae)
3.	Euphorbia royleana	(Euphorbiaceae)
4.	Euphorbia terrucalli	(Euphorbiaceae)
5.	Opuntia dillenii	(Cactaceae)
6.	Pithecolobium dulci	(Leguminoseae)
7.	Prosopis juliflora	(Leguminoseae)
8.	Tamarix dioica	(Tamaricaceae)
9.	Vitex negundo	(Verbenaceae)
10.	Zizyphus oxyphylla	(Rhamnaceae)

Low elevation mangrove soil tolerant shrubs (3.A.6). Mangrove areas are regularly inundated twice daily by saline sea water. The soil is soggy throughout the year. The tree canopy is usually close and the pneumatophoric root system too dense to allow much of shrub layer to emerge. When the tree canopy is removed many shrubs, compatible with the micro-ecoclimate, come up naturally. These are salt tolerant, can withstand water logging and have fleshy leaves.

The species most commonly found are in Table 1.6

Table 1.6

Low elevation mangrove soil tolerant shrubs

1.	Acanthus silicifolia	(Acanthaceae)
2.	Clerodendron inerme	(Verbenaceae)
3.	Cycas numphii	(Cycadaceae)
4.	Erythrina variegata	(Leguminoseae)
5.	Hibiscus tiliaceus	(Malvaceae)
6.	Ixora spp.	(Rubiaceae)
7.	Nipa spp.	(Palmae)
8.	Pandanus spp.	(Monocotyledon)
9.	Tamarix troupii	(Tamaricacea)

Middle elevation shrubs (3B). The middle elevation areas are the most difficult terrains from the silvicultural management point of view. They lie mostly in the 1,000-2,000 m over sea level zone of the Himalayas, though such terrain is also found in eastern and western ghat mountains. Continuously affected by biotic interference, often with very steep slopes and fragile weathered rocks, shrubs in these areas have to withstand a lot of pressures to survive. Wherever forests exist, the indigenous shade loving shrub synusiae is dense. On the other hand where the forests do not exist, shrub species change to more xerophytic associations which are characterized by rough leaves, spiny stems and a deep root system.

The genera selected are listed in Table 1.7.

Table 1.7

Middle elevation shrubs

1.	Berberis	(Berberidaceae)
2.	Daphne	(Thymelaeceae)
3.	Debregesia	(Urticaceae)
4.	Desmodium	(Leguminoseae)
5.	Dodonaea	(Sapindaceae)
6.	Eurya	(Ternstroemiaceae)
7.	Maesa	(Labiatae)
8.	Murraya	(Rutacea)
9.	Myrsine	(Myrsinaceae)
10.	Osbeckia	(Melastomaceae)
11.	Rhus	(Anacardiacae)
12.	Rosa	(Rosaceae)
13.	Viburnum	(Verbenaceae)
14.	Wendlandia	(Rubiaceae)

Upper elevation shrubs (3C): Upper elevation areas (over 2000 m above sea level) are mostly located in the Himalayas and over small parts of the eastern and the western ghat mountains. Intensely cold in winter, the rainfall is variable from region to region. In the low rainfall areas of western Himalayas, the overhead canopy is of coniferous species. The needles pile up below the trees depriving the seeds a foothold leading to lack of natural regeneration of overhead canopy species. This layer inhibits the establishment of shrubs. Shrubs become dense only in the moist valleys with a northern aspect.

In high rainfall areas on the other hand, with broadleaved trees constituting the upper canopy, the shrub layer is quite dense and consists of numerous species. These shrubs are frost hardy with a linear rather than spreading crown, deep rooted and usually with non-glossy dark green leaves for maximum light absorption.

The common genera selected are mentioned in Table 1.8.

Table 1.8

Upper elevation shrubs

1.	Berberis	(Berberidaceae)
2.	Cotoneaster	(Rosaceae)
3.	Daphne	(Urticaceae)
4.	Desmodium	(Leguminoseae)
5.	Lonicera	(Caprifoliaceae)
6.	Rosa	(Rosaceae)
7.	Rubus	(Rosaceae)
8.	Spiraea	(Rosaceae)
9.	Viburnum	(Caprifoliaceae)

1.4 Growth Data of Shrubs

Each plant species allocates its energy resources in a specific pattern for various activities of its life cycle which includes dormancy, vegetable production, growth, maintenance and reproduction.

Plants basically seem to lie in a continuum between two extremes of resource allocation, namely V-selection and K-selection (Barbour et al, 1980). V-selection leads to short-lived plants which allocate large amount of energy in reproduction, while K-selection plants allocate more energy to the vegetative stage. Most shrub species belong to V-selection in contrast to trees which are K-selection. There are exceptions, however, as some shrubs, such as Strobilanthes, Bamboo, Agave (century plant), reproduce abundantly once in many years only and then die. Similarly, there are trees (e.g. Leucaena leucoephala) which seed heavily annually. Allocation of energy by shrubs to reproduction does not, however, cut vegetation production to the minimal, it only reduces it. Of the vegetable allocation, the plant can allocate more in roots or in aerial parts, etc. For example, grasses allocate more in roots while trees concentrate on aerial parts. Shrubs generally occupy an intermediate position, allocating energy equally between root and shoot. Tangible data to prove this general statement, however, is not available.

Many of the shrubs are evergreen under a deciduous tree canopy even on arid sites. Aridity is tolerated by development of sclerophyllous leaves, modification of leaves by spines, chlorophyllous stems substituting caducous leaves, phyllodes replacing regular leaves, etc. These modifications allow photosynthetic production throughout the year provided moisture is available even though the rate of production is lowered due to lower gas exchange (as leaf stomata are reduced in number) and absence of an appropriate quantity of regular leaves.

Stocking by weight of shrub biomass in a regular forest, however, is less than that of trees. In a biomass study on two sites, Jalpaiguri district of West Bengal and Mayurbhanj district of Orissa, the following data have been reported (Mukherjee and Sen, 1984):

Forest site	No. of trees/ha	Dry wt. (mt.) of tree biomass/ha	Dry wt. (mt.) of shrub biomass/ha	% by weight of shrub biomass to total of 2&3 columns
	(1)	(2)	(3)	(4)
Mayurbhanj (Orissa) dense forest	205	97	12.51	12
Less dense forest	105	44	6.23	14
Open forest	62	47	4.12	8

Jalpaiguri (W. Bengal) natural forest	187	155	2.98	2
Tree plantation	315	193	1.55	0
Grassland	25	36	0.75	

Mayurbhanj forest has more shrubs than that of Jalpaiguri. The latter forest has a larger tree biomass weight indicating more canopy coverage and thus less sunlight for shrub growth.

In the matter of rate of production of shrubs, Vitex negundo have been found to produce 300 kg in two years in Punjab (Troup, 1975). Dodonaea viscosa has slow stem growth (mean annual girth increment 1.3 to 1.5 cm) but fast height growth (op. cit.). Zizyphus mauritania is fast growing in open situations: it has a mean annual girth measurement of 2.6 cm - 4 cm and in five years reaches a height of 2.9 m, hence growing by 1 m a year (op. cit.). Zizyphus xylopara of seedling origin grows slowly but coppice growth is fairly rapid. In Jhana district (Rajasthan), it is reported to reach 14.7 cm height and in Banda district (Rajasthan) 15.5 cm in five years (op. cit.). Flacourtia indica is reported to be slow growing having mean annual girth increments of 0.5-0.8 cm in the Landsdowne district of Uttar Pradesh (op. cit.). Casearia elliptica shows mean annual girth increment of 0.23-0.86 cm in Shorea robusta forest of UP (op. cit.); but coppice shoots grow more rapidly by 6.0 cm girth and 2.9 cm height in six years. Tamarix dioica has a rapid growth rate; annual girth increment of 11.38 cm has been achieved in the Delhi Bela plantations. Indian Grass and Fodder Research Institute, Jhansi, report growth of Leucaena leucocephala grown in moist wastelands and managed as shrubs. Per tree biomass accumulation of K-8 variety of the species was 0.045 kg in 0.33 years, 0.775 kg in 0.66 years, 1.097 kg in 1.00 year, 1.540 kg in 5.00 years. These figures work out to a current annual increment of about 5.4 tons/ha by year one, 28.6 tons in year 1-2, and upto 122.2 tons/ha in year 4-5 (with 5,000 trees/ha).

In general, it has been found that most of the shrubs grow faster by coppice and by pruning and topping even though they do not reach the rate of growth of trees. The annual growth rate of the main stem may look low but the total aerial biomass growth, seldom measured, can be quite high as shrub allocation of energy is often on twig and branches rather than on main stem. Fully stocked, the shrub production, under an overhead canopy, varies between 1-6 tons/ha per year, depending on the site ecoclimate.

CHAPTER 2. UTILIZATION OF SHRUB SYNUSIAE

2.1 General

As indicated earlier, the shrub layer is a unique vegetation form which has not been sufficiently utilized in land management. In forestry management, for example, few people have favored artificially enriching the shrub layer. While it is accepted by the foresters that shrubs are an essential component in the successional history of a landscape and as a site indicator (e.g. Aegaratum conizoides indicates a rich well drained site), shrubs are generally considered a weed inhibiting the growth of the primary tree species. In all man-made plantations, initial removal of shrubs at a financial cost is assumed to be a beneficial treatment. While this may be so for the growth of some planted trees, it is otherwise in areas where evaporation from the bare soil surface exceeds the transpiration from the shrubs. Shade from shrubs on these sites assists retention of soil moisture; in most sub-tropical countries, overheating of the soil leading to excessive evaporation is a crucial problem. The argument in favor of weeding of shrubs is based on the competition of nutrition which shrubs offer the primary trees. The nutrient uptake of shrubs may be more than compensated by the amelioration effects of leaf litter and in some instances by nitrogen fixation. But this competition for nutrition is also, to a large extent, eliminated as the tree sends out its roots to the deeper zones while shrubs in most cases have the roots restricted between the surface and intermediate depth. Shrubs can act as a nurse crop for the young tree as well; regeneration of top canopy dominant species (e.g. Dipterocarpus macrocarpus, Shorea assamica) in tropical rain forests under the shrubs is a common observation. Shrubs act as a cushion to energized raindrops and, as a continuous hedge, a physical barrier to water eroding the slopes. Reconsideration of the role of shrubs and their effect on the planted trees, therefore, is necessary.

The role of shrubs in mitigating the fuelwood problem has also not been explored. In India, for example, tree species (Eucalyptus, Pine, Shorea robusta) are being planted to close the gap between the fuelwood demand and supply. Some of these trees are truly fast growing and have prevented fuelwood famine. But trees do not solve the problem of necessity of supplying the fuelwood within a short period from the time shortage develops. The tree, however fast growing it is, has a minimum gestation period before it can be harvested to obtain optimum productivity. Presently this problem is solved either by overcutting of indigenous vegetation or by transporting fuelwood from elsewhere to the place of shortage. The latter not only adds to the price of fuelwood but also wastes energy in transport. The answer to this has been found by the rural poor who have switched over to using locally growing shrubs to meet their fuelwood needs.

The characteristics of shrubs make them extremely useful in preventing soil erosion and conserving soil moisture. Even in this field, due attention has not been paid to the role of shrubs. It was mentioned earlier that some shrub species develop moderately deep and wide root systems in landslide areas. By contrast, in the sandy areas, shrubs develop a shallow one over a bigger surface area. Where the shrubs do not have spreading root system, such as Rhus parviflora, Viburnum foetens, Clerodendron inerme, they proliferate to cover a large patch through root sucker regeneration (Plate 2).

These characteristics and others mentioned earlier, make them very effective soil conservation agents. Similarly, the run-off is checked by shrubs acting as physical barriers because their first set of branches is also close to the ground. Use of shrubs as an understorey contributes to the reduction of erosion and conservation of moisture and they should be introduced widely.

Shrubs can be grown artificially with a number of objectives. They can be planted to enrich the existing shrub population of a natural forest. They can also be planted as a major crop in conjunction with the tree crops in man-made forests. Live-plant fences can be established with shrubs to augment firewood production and act as a cattle enclosure or as a barrier to grazing. Shrubs can be grown on roadside strips, canal banks, on either side of railway lines and so on. In agricultural bunds, shrub species are not normally planted as they are mostly surface rooted and compete with the agricultural crops. But trees can be managed in a shrub-like form in order to minimize the shadow effect, eliminate nutrient competition and augment farmers' fuelwood and fodder supply. Use of shrubs as a continuous hedge along the contour at defined vertical intervals in degraded wastelands can be highly effective for soil conservation and water retention. In most villages of the highly populated developing countries in Asia and Africa, fuelwood shortage needs to be immediately reduced to counteract the increasing denudation of forests and tree cover. The properly managed shrubs which grow quickly and which can withstand a lot of hacking, could be a very useful means to meet fuelwood demand. In the context of the above discussion, the subject of shrub plantation has been divided into the following sections (a) shrub as live fence; (b) shrub as a understorey to man-made forests; and (c) shrub as rows of continuous hedge in degraded land.

2.2 Shrub as Live Fence

Fencing in India is perhaps one of the most unproductive components of land management practices. Unlike England where, even recently, live fences were used for cattle enclosures, fences in India are expected to keep away trespassers, men as well as animals. Theoretically, unless used for enclosures to keep own cattle and small stock under control, fences should be redundant. In practice, it is most necessary, particularly in many developing countries where there is fodder shortage and poverty.

Fences can be of various types. In India, in land management, fences of barbed wire, stones, brushwood, trench-cum-mounds and live hedges are commonly used. Excepting for the last kind, all the others suffer from some deficiency. Barbed wire fencing and the stone walls are either costly or often stolen, while brushwood fences need continuous repair. The trench-cum-mounds are not only expensive but are a source of gully erosion. More often than not, they also block the run-off of the upper catchment, depriving the land owner in the lower reaches of water. Trenches also become silted and need repair.

Live hedges, on the other hand, have a number of advantages. They need some attention at the beginning but once they are established, the live fence develops on its own in perpetuity, unless mismanaged. The cost of this type of fencing is low, yet this fence can be a source of fuelwood, if managed properly. They also act as barriers reducing wind velocity. Live fences may

reduce production of agricultural crop in their immediate neighborhood; this loss should, however, be considered as a trade-off against the gains obtained from them.

The species in live fences are many and will vary from region to region and also within regions. In India, broadly speaking, there are two categories of live fences, viz. (i) trees grown as live fences; cut down to a certain height regularly and managed as a fence (tree-shrub fence), and (ii) shrubs as a fence (shrub fence).

2.2.1 Tree-shrub Fence

Tree-shrub fences are made up of tree species which can be intermittently pollarded. The best examples are Erythrina spp. and Lannea grandis, which can be grown in West Bengal by digging in large sized stem/branch cuttings. Glyricidia sepium is another species extensively used as tree-shrub fence especially in Kerala (Plate 3). The leaves of Glyricidia are used as green manure by the farmers and hence the fence periodically contributes to organic manure for the land it protects. Syzygium cumini is managed as a tree-shrub fence in western districts of Uttar Pradesh. Salix sp. (willow) fencing grown by planting long cuttings is a popular tree-shrub fence in the moist areas of Kashmir. Pongamia pinnata is used in Karnataka as a live fence to yield green leaf manure and oil seeds. Zizyphus is a fruit yielding genera, often raised as a tree-shrub in many states. Leucaena leucocephala is also a good tree-shrub fence found in Maharashtra. The problem with this species is that it is good fodder as well and browsing cattle damage it. Management practices should involve pollarding it at a height beyond the reach of the cattle. Prosopis juliflora is another tree which can be managed as a fence. Some experimentation needs to be carried out in the `laying' of live hedges to `thicken' the hedge and make it more impenetrable to cattle and small stock. A list of trees in different regions of India which can also be utilized as tree-shrub live fences is included in Table 2.1.

The management of tree-shrub live fence should have the twin objectives of keeping the fence healthy and producing the optimum quantity of biomass. Biomass can be in the form of fuelwood, fodder, green manure, fruits, seeds etc. In order to maintain the tree as a shrub and to obtain a periodic supply of the biomass, the tree has to be pollarded or topped at regular intervals which may lead to deterioration of the health of the tree due to pathogenic infection. Prophylactic treatments may be necessary. In some instances, green manuring of the fence itself is recommended. Replacement of the tree-shrub fence when trees start deteriorating, is necessary. Experiments have shown that Leucaena leucocephala can be pollarded/debranched three times a year without damaging its health. This experiment, however, has continued only for a few years and the long term effect is yet to be assessed. Similarly, Glyricidia sepium is cut once every year and so is Erythrina spp. However, a disadvantage of trees' management as shrub is the ugly appearance it produces. Most trees form a mal-shaped callus lending the fence a contorted look, which is partly compensated by the abundance of the beautiful flowers of some of these species, such as Glyricidia or Erythrina.

Table 2.1 gives the names of species which pollard well.

Table 2.1

List of Trees Suitable for Management by pollarding as Tree-Shrub Live Fence

Site	Soil	Recommended Species
Low elevation Wet and moist	Red, lateritic, alluvial (oxisols, ultisols inceptisol)	Erythrina suberosa, E. Indica Glyricidia sepium, Leucaena leucocephala, Sesbania grandiflora, Moringa pterygosperma, Lannea grandis Macaranga species, Acacia auriculiformis
Low elevation Wet and moist	Black (Vertisols)	Albizia lebbek, Leucaena leucocephala, Hardwickia binata, Erythrina suberosa Zizyphus mauritiana, Pongamia pinnata, Prosopis juliflora, Azadirachta indica, Melia azederach
Low elevation arid	Red, latritic and black alluvial (ultisols, alfisols, vertisols, inceptisols)	Trema politoria, Casuarina equisetifolia, Azadirachta indica, Eucalyptus camaldulensis, Inga dulcis, Prosopis juliflora, Tamarix aphylla, Ailanthus excelsa
Low elevation very arid (including desert)	Sand	Tamarix aphylla, Salvadora oleoides
Low elevation semi-arid	Saline-alkaline	Prosopis juliflora, Azadirachta indica, Inga dulcis, Cassia siamea
Low elevation wet (mangroves)	Mangrove saline soils	Nipa spp. Ceriops roxburghiana
Middle and and upper elevations	Podzolic clastic soils (ultisols and inceptisols)	Arundinaria spp. Saurauja nepaulensis Quercus spp., Salix spp. Alnus nepalensis

2.2.2 Shrub Fence

Shrub fences are made up of species most of which are either spiny or contain alkaloids making them unpalatable. These species are also characterized by prolific branching. This habit makes the fence dense enough to protect an area from stray cattle. They are also able to revive from periodic branch cutting or deleafing. Commonly used species include succulents such as Agave spp., Opuntia spp. and Euphorbia spp.; woody shrub species such as Vitex negundo; Dodonaea viscosa in arid areas; Carissa spp. in semi-arid black clay regions; Jatropha spp.(Plate 6), Calotropis gigantea in alkaline areas; Duranta spp. on moist sandy loams (Plate 4); Ipomoea spp. in wet soils (Plate 5) and Barberis spp. on arid hill slopes.

The shrub fence is raised either by cuttings, sowing, bulbils or by transplanting. Dodonaea viscosa can be grown from cuttings as can Ipomoea, Jatropha, Calotropis, Euphorbia, Cactus, etc. Shrub fencing requires dense seeds, as germination and survival percentage under the difficult conditions common to fence areas may be low. Carissa, Lantana, Gymnosporia, Flacourtia, Nyctanthes are some of the genera which can be raised by sowing. Agave spp. is raised by bulbil planting.

While some attention is initially necessary to see that the cuttings, seed sowing or plantings are not smothered by weeds, watering, fertilization or pesticide treatments are generally unnecessary as the selected species are expected to hold their own against competition. The live shrub fence is inexpensive and needs little attention; it is likely to grow taller than required and the owner may, under such circumstances, cut it once a year to supplement fuelwood needs. Leaves may be cut from Agave plants for sale for fiber.

Table 2.2 lists the recommended species to be used for shrub fence in various agro-ecological zones.

Table 2.2

Shrub Species for Live Fence

Climate	Soil	Recommended Species
Low elevation and moist	Red, lateritic, alluvial (oxisols, ultisols inceptisol)	Justicia adathoda, Ipomoea wet carnea, Glycosmis pentaphylla, Lawsonia alba, Lantana camara, Cassia occidentalis, Cassia glauca
Low elevation wet and moist	Black (vertisols)	Gymnosporia spp., Carissa opaca, Lantana camara, Ipomoea carnea

Low elevation arid	Red, lateritic and black alluvial (ultisols, alfisols, vertisols, inceptisols)	Colebrookia oppositifolia, Euphorbia royaleana, E. tirucalli, Carissa carandas, C. opaca, Vitex negundo, Agave sisalana Dodonaea viscosa, Tecoma undulata
Low elevation very arid (including desert)	Sand	Calotropis gigantea, Euphorbia royaleana, E. terrucalli, Opuntia spp. Euphorbia neriifolia
Low elevation semi-arid	Saline-alkaline	Cassia auriculata, Opuntia spp., Euphorbia terrucalli
Low elevation wet (mangroves)	Saline soils	Nipa spp., Acanthus ilicifolius, Hibiscus tiliaceus.
Middle and upper elevations	Podzolic clastic soils (ultisols, inceptisols etc.)	Berberis lycium, B. aristata Rhus parviflora, Desmodium tiliaefolium, Viburuum cotonifolium, Cestrum spp., Rubus ellipticus, R. niveus Rosa macrophylla, Daphne cannabina

2.3 Shrubs as Understorey in Man-made Forests

A decade ago, most man-made forests were planted on forest areas for timber, ply and pulpwood. Of late, the objectives of some of the man-made forests have been differently formulated and the forests are being raised on village common lands and government wastelands; both areas are often degraded. The objectives include growing the trees to supply fuelwood, fodder, small timber and poles for the neighborhood. In spite of these clear objectives, more often than not, the products are sold for use in the urban areas against cash benefits leaving the rural fuelwood-fodder situation unchanged. One valid reason for this incongruity is the fact that rural people, particularly the poor, who comprise the majority, cannot pay for tree products. Forest products are produced at relatively high cost and cannot be freely distributed for all time. Hence, shrubs can play an important role in providing a low cost to free source of fuelwood/fodder.

Trees in man-made forests are planted in a carefully spaced manner, leaving room in between lines. This is quite appropriate as each tree needs a minimum space to spread its crown for optimum growth. Gaps are shaded when trees spread their crowns and raising of agricultural crops beneath the canopy becomes difficult. On the other hand, there are many indigenous shrubs which flourish under such conditions. In fact some come up naturally proving that the land can cater to more bio-mass production than from tree planting alone. It follows, therefore, that raising an understorey of shrubs to augment

biomass production is a distinct possibility which has not yet been explored. On of the reasons for neglect of shrubs as an understory is that they have no immediate cash value; and this is precisely the reason why shrub underplanting should be strongly advocated--that is a raw material which is free for the local poor to use.

One of the locally growing shrubs commonly used by the rural people in Gujarat, parts of Rajasthan and Maharashtra is Cassia auriculata (Plate 7). This species has a high calorific value: it can withstand annual coppicing, has beautiful yellow flowers and produces abundant seeds. Propagation is by sowing and transplanting. Data regarding its propagation by cutting is not available but success is considered likely. In Gujarat and the neighboring states, Acacia nilotica is extensively used as a tree crop in wastelands, village common lands etc. The rotation of this species is generally 10 to 15 years. The species is planted at 2.5m x 2.5m or 3m x 3m. There is an acute shortage of fuelwood in the countryside and it is a common sight to see poor people foraging for it. Introduction of Cassia auriculata as an undercrop with Acacia nilotica can immensely help in reducing fuelwood shortage. A similar case can be made out for Prosopis juliflora as an understorey for Acacia nilotica. Prosopis juliflora is a tree species but unlike Acecia nilotica, coppices vigorously and thus can be managed as a shrub. Acacia nilotica as an overstory can produce a mean annual increment up to about 10 tons/ha, while Prosopis managed as a shrub (even under shade) has been found to produce more than half of that produced by Acacia in a gomal woodlot in Karnataka. In the Siwaliks, Acacia catechu can be underplanted with Dodonaea viscosa which is a dense fuelwood and is extensively used by the farmers. In Andhra Pradesh, Gymnosporia spp. can be a good fuelwood undercrop in areas planted with Eucalyptus spp. or Cassia siamea. In the outer Himalayas, where slopes are steep and soil is arid because of high run-off, Rhus parviflora, Berberis aristata and Coriaria nepalensis can be grown with Pinus roxburghii in the ridges and Quercus incana in the valleys.

Most of the species mentioned can be grown by sowing seeds which are available in plenty. In all probability some of them can be grown by cutting as well but little research has been done on indigenous shrubs. Management of these species has to be simple which may be only an annual topping carefully done. The aerial biomass growth of most of these species will allow harvesting of 1-4 tons/ha per year. It is worthwhile to explore the possibility of growing some leguminous fodder such as Stylosanthes spp. and Macroptilium spp. in conjunction with the shrubs to give the latter a source of nitrogen.

Table 2.3 incorporates some of the possible combinations of tree and shrub species for different agro-climate zones. Further research is required to identify optimum planting distances between trees to allow for the best combination of trees, shrubs, and fodder grasses.

Table 2.3

Tree-shrub Combination Recommended in Man-made Social Forests

Climate	Soil	Overhead tree	Shrub
Low elevation wet and moist	Red, lateritic, alluvial, (oxisols, ultisols, inceptisols)	Eucalyptus tereticornis, Acacia auriculiformis, Casuarina equisetifolia, Cassia siamea	Leucaena leucocephala, Sesbania bispinosa, Crotolaria juncea, Hibiscus subdariffa, Cassia occidentalis, Albizia amara, Murraya koeniggi
Low evaluation semi arid	Red, lateritic, black (ultisols alfisols, vertisols)	Acacia nilotica, Acacia catechu, Acacia tortilis, Eucalyptus camaldulensis	Cassia auriculata, Carissa spp., Gymnosporia spp., Justicia adathoda, Capparis spinosa, Balanites aegyptica, Tecoma undulata, Cleistanthus collinus, Dodonaea viscosa, Zizyphus mauritiana
Low elevation very arid (including desert)	Sand	Acacia tortilis, Acacia albida, Prosopis juliflora	Euphorbia terrucalli, Euphorbia royaleana, Opuntia spp., Calotropis gigantea
Low elevation arid	Saline alkaline	Terminalia arjuna, Prosopis juliflora, Acacia nilotica, Casuarina equisetifolia	Inga dulcis, Euphorbia spp., Opuntia spp., Agave spp.
Middle elevation	Podzolic clastic (ultisols, inceptisols)	Pinus spp., Quercus spp., Alnus spp., Acer spp., Populus spp.,	Berberis spp., Rhus spp., Desmodium sp., Viburnum spp., Daphne spp., Eurya spp., Buddleia paniculata, Coriaria nepalensis
Upper elevation	Podzol clastic (spodosols, ultisols	Cedrus spp., Populus spp., Betula spp., Prunus spp., Juglans spp.	Arundinaria, Rosa, Rubus, Desmodium, Viburnum

2.4 Shrubs Useful for Soil Conservation in Degraded Land

In many parts of India, forest areas are degraded. This degradation is manifest in forest architecture. The usual number of canopies in a natural forest is often reduced and density of trees per unit areas is substantially decreased. Quite often, shrubs have been removed and the litter swept away leaving the soil surface exposed. The rain falling on such areas causes soil erosion resulting in gullies, and removal of soil in sheets. Brunig in UNESCO's publication on tropical forest ecosystems (1978) calculates that the annual rate of erosion at 2-10 t/ha and 20-160 t/ha of a teak plantation with or without an understorey. In course of time, the forest areas are turned into unproductive wastes. As soil is generally leached of fertility in tropical countries, removal of forest cover deprives the soil of additional organic matter, thus making the soil very unproductive. Water erosion, in addition, causes irreparable damage to the soil.

Rehabilitation of these areas by planting trees alone is a popular misconception (Plate 8). There is no doubt that trees can, to a certain extent, reduce erosion. But it is the total forest eco-system comprising a number of layers of forest canopies which plays the main role in prevention of erosion. Nye and Greenland (op. cit.) make the same point when they propose that in agro-silviculture there should be an erosion reducing understorey and the overstorey species should be so chosen as not to eliminate undergrowth. Forest departments, managing the degraded forests, operate on the notion that once trees are planted the undergrowth and other components of the eco-system will automatically take care of itself. While this is true to a certain extent, as undergrowth of shrubs and forbs grow naturally, they are seldom sufficiently dense and uniformly grown to counteract the progress of erosion. (Plate 10). Assistance to nature for the growth of shrubs and forbs therefore should be an integral part of the rehabilitation of degraded forests or wastelands.

Enrichment by shrubs will be most effective if they are grown as rows of continuous hedges on the contour. Hedges should be made out of such species which have low branches with interlocking branching patterns and the stems sufficiently lignified to withstand water run-off pressures. The vertical distances between the rows will vary with the slope, distance increasing with decreasing slope.

The appropriate species, among many others, for these rows of hedges are Gardenia gummifera, Nyctanthes arbor-tristis in the moist lateritic areas of West Bengal and Bihar; Vitex negundo and Euphorbia royaleana and Agave spp. in some of the areas of Gujarat, Rajasthan; Carissa spp. in Maharashtra, Madhya Pradesh and Andhra Pradesh; Cleisthanthus collinus in Orissa; Viburnum spp. and Cotoneaster spp. in middle and upper hills in Jammu and Kashmir, Uttar Pradesh, etc.

Table 2.4 gives a list of species suitable for contour hedge planting in degraded forest areas.

These hedges, except for some care in the first two years, require no special attention. They act as a soil trap for the sediment-loaded run-off water. In course of time, the trapped soil will form terraces and the shrub rows will grow up and out of the terraces and continue to serve as effective hedges.

Table 2.4

Species Suitable for Contour Hedge Planting

Climate	Soil	Species Recommended
Low elevation Wet and moist	Red, lateritic, alluvial (oxisols, ultisols inceptisols, vertisols)	Adathoda vasica, Holarrhena antidysenterica, Cleistanthus collinus, Carissa spinarum
Low elevation arid	Red, latritic and black (ultisols, alfisols, inceptisols)	Cassia auriculata
Low elevation arid	Black (vertisol)	Gymnosporia spinosa
Low elevation desert	Sand	Opuntia spp., Euphorbia royleana, Capparis decidua
Middle and upper elevations	Podzolic clastic (ultisols, spodosols, inceptisols)	Rhus parviflora, Buddleia paniculata, Coriaria nepaulensis Desmodium spp., Berberis spp., Rumex spp.

2.5 Leguminous Shrubs

It has been reasoned that shrub planting or management of the trees as shrubs has a number of advantages which the tree plantations alone do not have, therefore the advocacy for shrubs as supports. To refine the idea, it is suggested that wherever possible, shrubs should belong to a family which develops symbiotic relationships with bacterial nodules, actinomycetes and fungus. Symbiosis leads to nitrogen fixation from the atmosphere, better phosphorous intake and even better moisture absorption by the shrub. The most important families known to include genera having these properties are the Leguminoseae, Casurinaceae, and Ericeae; the first is the most important. Fortunately, in India, Leguminoseae is represented by a very large number of trees, shrubs, herbs and climber species. Leguminous shrub species are found growing naturally in almost every agroclimatic zone of the country. There are leguminous shrub species having nitrogen fixing properties which are indicators of the best agro-climatic conditions (e.g., Desmodium, Indigofera), while there are others (e.g., Mimosa pudica) indicating very degraded soil conditions.

It will be possible to pick out suitable leguminous species for growing as shrubs in most parts of the country. The genera that should be explored are Acacia, Albizia, Cajanus, Cassia, Desmanthus, Desmodium,

Dichrostachys, Flemingia, Gliricidia, Indigofera, Leucaena, Millettia, Mimosa, Parkinsonia, Prosopis and Sesbania. In the other two families mentioned, namely Casuarinaceae and Ericaceae, the common genera comprise a few species only and they too have tree forms. For example, the only genus of Casuarinaceae is Casuarina and that of Betulaceae is Alnus. Both these genera have species which are trees. Casuarina, however can be managed as a shrub.

Table 2.5 lists the possible choice of leguminous shrubs for different agro-climatic zones in the country.

Table 2.5

A list of nitrogen fixing Leguminous species suitable for under-planting.

Climate	Soil	Leguminoseae or other nitrogen fixing genera/species
Low elevation wet and moist	Red, lateritic, alluvial (oxisols, ultisols, inceptisols)	Acacia auriculiformis managed as shrubs. Crotolaria spp., Flemingia spp., Leucaena spp., Parkinsonia spp.
Low elevation dry	Lateritic, alluvial (alfisols, inceptisols, ultisols)	Indigofera pulchella, Mimosa spp., Acacia spp., Prosopis spp.
Low elevation moist and dry	Vertisols	Mimosa spp., Butea spp., managed by pollarding, Erythrina spp., managed by pollarding.
Low elevation arid and desert	Sand	Dichrostacys cineraria, Acacia spp., Casuarina, all managed as shrub.
Middle and high elevations	Podzol, podzolic, clastic (spodosals, inceptisols, ultisols)	Desmodium spp.,

While growing leguminous shrubs a few difficulties have to be kept in mind. Firstly, except for some species belonging to the subfamily Mimosoideae, which are spiny, most are palatable and are often preferred by cattle. As the wastelands and village common lands are subjected to heavy grazing, introduction of palatable species will need protection not only in the initial stages, but for all time as the shrubs will be within the reach of the feeding cattle. The second problem for the leguminous shrubs is that the

fruits of many of these species have food and fodder uses. As a consequence, natural regeneration of these species may not be possible. The advantage of leguminoseae however outweigh the disadvantages. Apart from the fact that the symbiotic nodules fix nitrogen, the leaves of many of these species have high protein values which can supplement the low nutrient feed of rural cattle. Nitrogen fixed by the nodules initially helps the shrub to grow quickly but on maturing the nodules die off to add nitrogen to the soil. The released nitrogen is used by trees and grasses as well. The wood of these species also has high density making them suitable for fuelwood uses. Many of the timbers of leguminoseae species of arid and semi-arid areas (most of the species of Acacia) are strong so that they can also be used as plough pieces and in low cost buildings.

CHAPTER 3. PROPAGATION METHODS

3.1 General

The method of propagation of shrubs depends on the species and the object for which they are being planted. Some species can be propagated easily by branch cuttings, some by sowing while others may have to be grown by layering in the nursery and planted out. Still others can be grown from root suckers. Shrub plantations, although hardy by nature, may need some assistance such as weeding, mulching and fertilization in the initial stages to help them to compete with other indigenous species. Once they are established, they hardly need attention. In fact, the benefits accruing from them far outnumber the inputs. The method of growing common shrubs, eighty-one in number, will be described in greater detail later in this book. But at this stage, some general principles are discussed.

3.2 Propagation by Seeds

Most shrub species can be grown from seeds. The seeds are generally small, and as such, they are likely to be washed away by rains or blown away by strong winds. This can be avoided if sown deep but this is often not possible because the plumule of small seeds cannot pierce the the soil cover. As the seeds have to be sown densely, they are likely to attract insects. Moreover, many of the seeds have a hard coat, and germination takes time unless pre-treated. Even when they do germinate, the emerging seedlings are very small and are likely die if rain fails for a long period subsequent to germination.

Steps need to be taken to counteract these problems: seeds should be pretreated to break the testa; they should be coated with some insecticide, fertilizer, micorrhiza, inoculated with bacteria (if the shrub belongs to family of leguminoseae), etc.; finally, a large number of seeds should be sown in furrows made by a plough or a tractor ripper.

Pretreatment of seeds is species-specific. Generally, however, pretreatment methods can be classified into five categories: viz. (a) scarification; (b) stratification; (c) hot and cold water treatment; (d) chemical treatment; and (e) micro-biological treatment. A brief description of each method is given below.

(a) Scarification is a mechanical measure to crack the testa. This can be done by mixing rough rock pebbles with the seeds and tumbling them in a concrete mixer. The testa can also be broken by rubbing the seeds against each other. Alternative method is to prick or crack the seeds individually before sowing. The last method, however, is a very laborious process when a large number of seeds are to be used.

(b) Stratification involves arranging the seeds in a layer which is covered with a layer of soil, followed by another layer of seeds, and so on. The stratified seeds are then provided with slow supply of water for sometime. Subsequently, they are allowed to dry. This process of alternate soaking and baking is followed till the hard coat is softened.

(c) Hot water treatment consists of boiling the water, then removing the water from the heat and immersing the seeds in it and then allowing them to remain in the water for 24 hours. Cold water treatment, on the other hand, is to soak the seeds in cold water for 24 hours before sowing.

(d) Chemical treatment is done by putting the seeds for a few minutes in a glass containing concentrated sulphuric acid and then taking them out and thoroughly washing in water. Diluted sulphuric acid (sp. gr. 1.84) can be used but the seeds should then be immersed for six hours. Alcohol and concentrated alkali, such as NaOH, are also used.

(e) Micro-biological treatment is carried out by feeding the seeds to specific animals or birds and collecting them later from their dung or droppings.

Pelleting of seeds by a number of layers, as mentioned earlier, is done mechanically in pelleting machines. The advantage of pelleting is that seeds germinate only when an adequate amount of moisture is available in the soil. Thus they will not germinate if rains do not follow sowing. An insecticide layer on the seed protects against insects. Similarly, fungicides can be applied against fungi. A layer of phosphate boosts seedling growth on germination. Layer of bacteria in case of leguminous seeds allows the germinated seedlings to fix atmospheric nitrogen right from the start.

If the soil is pebbly and lacking in nutrients, it is worthwhile to add and mix some farmyard manure before sowing. Failing this, green leaves collected locally can be placed in continuous furrows where seeds are being sown.

The spacing between the furrows will depend on the spacing at which the trees are being planted. Trees are generally planted in a square design for all species. Actually, the design should change. In any case, introduction of shrubs as one of the desired components will influence the planting design. Thus, in order to accommodate shrubs, trees can be grown close in the row with a larger gap between rows. This pattern does not, however, reduce the number of trees per hectare below 1,600 (obtained in a square spacing of 2.5 m x 2.5 m). The same number of trees can be grown with a spacing of 1.3 m along the row and 4 m across or 1 m x 6 m across. Shrub lines can be 2-3 m away from the tree rows. Local experience indicates that the trees do not suffer from being too close to each other in a row as long as they have ample space and light between the rows. The shrubs will receive reasonable amount of light for growth and development. It is therefore advocated that spacing of trees be at 1 m x 6 m or 1.3 m x 4 m and the shrub rows 4-6 meters apart between the tree rows. The distance between shrub rows should, however, change if the land is sloping, the distance reducing with steeper slopes. Tree and shrub rows should be planted on the contour in order to maximize in situ moisture conservation.

The soil furrows should be at least 15 cm deep. This depth can be easily achieved by bullock ploughing if the soil is good. If the soil is hard, either manual digging or a heavy tractor-dozer operation is necessary. Attention to satisfactory soil working will make all the difference between success and failure in shrub planting.

If the shrub is leguminous, reasonable quantity (as recommended by growers), if available, of specific nodule bacteria should be added to the furrowed soil. If the legume is indigenous, the nodular bacteria will probably be present in the area making addition of nodules unnecessary.

Once the seeds have germinated, adequate supervision is essential. They will not need much help if a reasonable amount of rain falls. If it does not, some mortality will take place and fresh sowing may be necessary. Transplanting in the gaps of the germinated seedlings from the areas where they have grown profusely should be done. If the area produces too many weeds, which it is likely to in high rainfall zones, their removal, particularly of rank grasses is recommended. Top dressing, with nitrogenous fertilizers, once the shrubs have reached the seedling stage will boost their growth. But excessive weeding or heavy fertilization is not intended as it has to be kept in mind that shrubs are a low value product and cannot justify high inputs.

Among the species which can be best grown by sowing are Dodonaea viscosa, Carissa spp., Gymnosporia spp., Prosopis juliflora.

3.3 Propagation by Stem Cutting

There is a large number of species which can be grown from stem cuttings. Parts of the tree from which the stem should be cut for propagation are shrub-specific. In some shrubs, only the growing shoot tip is cut and planted. In others only mature stems are suitable. At times the mature stems tend to flower and fruit early with little vegetative growth: in such cases, younger cutting stock should be planted.

A few things have to be taken care of to make cuttings grow successfully. The propagating material should be taken from healthy and vigorous stock plants. The cuttings may be straight, of heel (a small piece of older wood retained at base) or of smaller (entire section of the branch of the older wood retained) types. The portion of the branch going in the soil should be at least three times as much as that which will be exposed. The exposed part should have at least 2 or 3 nodes. The cuttings should be prepared in dormant season, i.e. late fall, winter or early spring. Before planting, they should be immersed in water and the part that should go underground should be dipped in root hormones (IBA). If too many shoots come up, some should be removed leaving only a few. It is a useful practice to cover the tip of the branch cutting either with cowdung or clay so that the water can not penetrate the space between the bark and the woody portion of the cutting. Soil working and other practices are similar to those recommended for the sowing method. The species that are easily grown by cutting are Euphorbia, Jatropha, Erythrina, Glyricidia, Salix, Ipomoea, Opuntia, Hibiscus, Tamarix.

3.4 Propagation by Root Suckers

Propagation can also be done by root sucker growth. Separate shoots grow naturally from the adventitious buds on any part of the root or from near the region when a root is damaged. The shoots away from the main crown invade surrounding areas. After some seasons a single shrub can grow into a compact

shrubby patch. Rhus parviflora, Viburnum foetens and Clerodendron inerme (Plate 2) are well known shrubs naturally propagating in this way. The root sucker tendency may be used for artificial propagation. One method is to damage the side root system of the naturally occurring shrub by ploughing; this activates the root system to throw up shoots. Later the new shoots are severed with a part of the root and transplanted where necessary.

Good root suckering species which can be managed as shrubs

Agave sp.

Broussonetia papyrifera

Cassia siamea

Diospyros spp.

Garuga pinnata

Hardwickia binata

Rhus parviflora

Ziziphus spp.

3.5 Propagation by Transplanting

In some cases, transplanting of seedlings may have to be used to establish shrubs, but this method is very expensive and should not be normally practised. Bare rooted seedlings should be planted when it is raining heavily. The usual method of growing seedlings and transplanting by polybags, as is done for most trees, does not seem worthwhile for these low value shrubs.

3.6 Propagation by Stump

According to this method, seeds are germinated in nursery beds and the seedlings are allowed to grow for about a year, till the seedlings' collar reaches thumb size. Seedlings are uprooted a day before planting during the rains and converted into stumps by cleaning and pruning parts of the roots and shoot of each seedling. Each stump should have about 20 cm of tap root and 4-5 cm of shoot. All leaves and their side roots are removed from the stump. These stumps are then quickly planted in the field.

3.7 Propagation by Layering

Layering is done by bending a branch of the shrub into the ground and covering it partially with soil but leaving the terminal end out in the open in an upright position. This upright positioning of the terminal end is effected by bending it and keeping it in position with a wooden peg under the ground and if necessary by binding a wooden stake with the upright stem. Roots are likely to develop below the part under the soil of the terminal end and which become an independent tree when it is severed from the branch.

CHAPTER 4. SHRUB MANAGEMENT

The management of shrubs is an aspect which has received very little attention, therefore little is recorded. Since the local people use many shrub species for fuelwood, observers testify that most of the shrubs can take rough treatment. They can be properly managed, if a number of silvicultural practices which are now almost forgotten in forestry can be reintroduced. These practices include pruning for production of fuelwood and fodder (as opposed to pruning in teak to get a straight stem or pruning in fruit or flower plants to regulate and control vegetative growth, flowering and fruiting), topping and annual coppicing.

Pruning, as conceived here, is removal of aerial parts to induce more branching and collect products for use. The shock of cutting activates meristematic cells to produce more vegetative epicormic growth. The general principle is that pruning cuts should be clean, when close to a branch or bud; it should be done just before the active growth period begins. While it is true that shrub growth in a tropical country continues more or less throughout the year, the main growth period generally is in the spring to autumn period. For most species, the pruning time should be about a month before spring. Two seasons that should be particularly avoided are winter in frost holes and summer in arid regions as dormant buds likely to be activated by pruning cannot grow effectively in these seasons. In other climatic situations (i.e. in areas with moderate temperature and reasonable moisture throughout the year), pruning can be done any time of the year but growth is affected if it is done during the maximum growing season. There are certain species which can be pruned more than once a year. This is good for farmers, especially if the species yields fodder. An example is Leucaena leucocephala which, under proper supervision, is pruned twice a year in Jhansi in UP, in winter and again in the summer.

Gliricidia (Plate 3) is lopped or pruned continuously for green manure. Species which can be lopped or pruned every year for fuelwood are Carissa, Prosopis, Dodonaea, Vitex, Ipomoea, Lantana, etc. The species suitable for pruning for fodder and staking include Acacias, Leucaena, Calliandra, Sesbania.

In general, all cuts of stems over 25 cm in diameter should be treated with some waterproofing material, preferably possessing a fungicide property. Creosote is a good material for this treatment. This is an expensive operation and, unless essential, need not be done.

Topping or pollarding is a method by which the crown of the shrub is removed. This process, however, differs from the coppicing in that the removal is done at a certain height, thus leaving a longer part of the stem standing as a post in contrast to coppicing. There are species that stand pollarding but are killed by coppicing. There may be two reasons for this. One is that the latter do not have shoot primordia at the tree base, but have them at a certain height above the ground. Secondly, the stored food required for regrowth is not sufficient in the coppice stump. The pollard stump is longer and sufficient material for regrowth can be restored. Best examples are Morinda angustifolia, Acacia auriculiformis, Hardwickia binata, Jatropha

spp. Shrubs, however, are not topped generally. Either they are coppiced or they are pruned.

Coppicing involves cutting the tree at the base. Table 4.1 gives the list of the species of the shrubs which are good coppicers. Coppicing should be avoided during the height of the winter and summer. For most species the maximum coppicing yield is achieved if it is done one month before spring. A few precautions are necessary to get best results. The stem should be cut slanting so that water can drain. The cutting equipment should be sharp enough so that only a small gap is left between bark and the wood. The height of the stump should be at least 15 cm on the higher side of the stump slope.

Table 4.1

Fuelwood species with good coppicing ability

Botanical name	Coppicing power
Acacia auriculiformis	Poor
A. nilotica	Variable
A. senegal	Good
Albizia lebbek	V. good
Anogeissus latifolia	Excellent
A. pendula	Excellent
Cassia siamea	Good
Dalbergia sissoo	V. good
Erythrina suberosa	Good
Gliricidia sepium	V. good
Inga dulci	V. good
Lantana camara	Excellent
Pongamia pinnata	V. good
Prosopis juliflora	V. good
S. grandiflora	Good
Syzygium cumini	Good
Tamariz aphylla	Good
Zizyphus mauritiana	Good

All these species can be managed as shrub.

CHAPTER 5. CONCLUSIONS

The usefulness of shrubs as a life form to be encouraged along with tree crops in all afforestation programs of the country has been pointed out. Moreover, it has been stressed that attention to shrubs is lacking in the afforestation technologies now being promoted, which are incomplete, as trees produce a single canopy forest. Shrubs are more adaptable than trees, have more genera and species, giving the planter a wider choice. As many of them are hardy, unpalatable, spiny and can withstand hacking, they are easily propagated and need less maintenance. Though inexpensive to raise, their growth significantly adds to the plantation biomass.

Shrubs have a manifold contribution to make. Depending on the management pattern, shrubs planted on contours can be effective agents of moisture conservation, and as barriers to soil movements. They can act as live fences; fix nitrogen, supply fuel, fodder, small timber and green manure. In a country where, to poorer sections of the community, fuelwood is a foraging item, introduction of shoot cutting cycles can be of great help. In fact, as opposed to the trees, shrubs can sustain regular supply of fuelwood in the local context, assuming that transport of fuelwood from elsewhere to support local needs is an energy wasting procedure.

As is apparent from the next chapter, the information about many of the useful shrubs is not available (indicated by .. sign). In addition, lack of data will become more apparent when shrubs are introduced as a component of afforestation technology. The gaps in knowledge will be most noticed in the management techniques, in the symbiotic and antagonistic relationships between the shrub and the tree life forms (neglecting for the time being the relationships with the forbs), the financial and the economic cost benefit ratios, the effect that a thick mantle of shrubs will have on the zoological life and the reaction that the people will have to the introduction of the new technology. It would thus be quite appropriate to take up wide ranging research projects on different aspects of shrub life form.

CHAPTER 6. CHARACTERISTICS OF SOME IMPORTANT SHRUBS

Characteristics of eighty-one shrubs of India have been described. Information not readily available has been marked by two dots (..) sign.

Missing information sent by any reader will be gratefully accepted and acknowledged in next edition.

Name:	Botanical - Abrus precatorius Local - Ganchi, Rati
Family:	Leguminoseae - Papilioneae
Distribution:	Distributed throughout tropical India
Description:	A much branched winding climber with woody stem; leaves 5-17 jugate; flowers pale reddish to yellowish; pod oblong 3-5 seeded. Seeds two-third scarlet and the rest jet-black.
Uses:	Fuelwood; seeds used as weights by ancient goldsmiths. Roots and leaves used as medicine for cough, cold and colic, often eaten as raw vegetable.
Seeding time:	December-February
Seeds:	..
Germination:	..
Pretreatment of seeds:	..
Nursery method:	..
Planting method:	..
Growth:	Slow
Management method and yield:	Can be managed as a straggling shrub by repeated cutting and using the product as fuelwood; yield unreported.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical and sub-tropical; moist.
Altitude:	Below 1050 m
Soil:	Sandy loam, alluvial
Pests & Diseases:	..
Seed source:	West Bengal, Uttar Pradesh

.. Information not available

Name:	Botanical - Acacia jacquemontii Local - Ratabauli (Gujarati), Babul (Punjabi)
Family:	Leguminoseae
Distribution:	In Gujarat, Punjab, Haryana and Rajasthan States.
Description:	A bushy, thorny shrub with dark brown bark and long spines; flower heads light yellow in axillary clusters, pods flat.
Uses:	Leaves and seeds used as fodder, dried branches as brushwood fences; wood good fuel and yields good charcoal.
Seeding time:	..
Seeds:	..
Storage time:	..
Germination:	..
Pretreatment of seeds:	..
Nursery method:	..
Planting method:	..
Growth:	..
Management method and yield:	Coppices very well. Short rotation. Yield unreported.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical and sub-tropical; moist and arid.
Altitude:	Below 800 m
Soil:	Sandy
Pests & Diseases:	..
Seed source:	Punjab

Name:	Botanical - Acacia senegal Local - Goradio babul (Gujarati)
Family:	Leguminoseae
Distribution:	Haryana, Gujarat and Rajasthan
Description:	A small thorny deciduous shrub but can reach tree height; leaves bifurcate with stipular spines; flowers yellow, axillary spikes; pods straight, 5-6 seeds.
Uses:	Gum, roots for medicine; wood good for fuelwood and charcoal; seeds good fodder. Erosion control and soil rehabilitation.
Seeding time:	November
Seeds:	..
Storage time:	..
Germination:	..
Pretreatment of seeds:	Overnight soaking in cold water.
Nursery method:	In nursery beds, seeds should be kept moist to obtain good germination, which they commence in 4 days and complete in 8 days.
Planting method:	Planting by sowing in field or by transplanting in trenches or in V-ditches, on contour.
Growth:	Reported to attain 11 cm height in gravelly and 20 cm in sandy soil in first year.
Management method and yield:	The plantations can be managed by weeding in the first years. They can be pruned when they are at least 5-years old and have reached a height of 40 cm or more. Rotation 10 years for fuelwood. Yield can vary from 1-5 t/ha annually.
Locality factors of the area where the shrub can be grown:	
Climate:	Sub-tropical; rainfall ranging from 300-450 mm with long drought period.
Altitude:	Below 800 m.
Soil:	Sandy and clay
Pests & Diseases:	Browsing by goats, damage by white ants.
Seed source:	Gujarat

Name:	Botanical - Albizia amara Local - Chikram
Family:	Leguminoseae - Mimosoideae
Distribution:	South India, Orissa
Description:	A small tree with smooth, greenish bark; leaves small, linear; flowers long, yellow, fragant; pods 10-15 x 2-2.5 cm.
Uses:	Produces good fuelwood; dried leaves used as substitute for soap and as green manure; wood sometimes used for making cabinets; hard wood, used for making tool-handles.
Seeding time:	May-July
Seeds:	+ 1300 seeds/kg
Storage time:	5-6 months
Germination:	80-90%
Pretreatment of seeds:	..
Nursery method:	Seedlings can be grown in polypots.
Planting method:	About 30 cm tall saplings are placed in medium pits with enough humus and superphosphate. By direct sowing.
Growth:	Unreported.
Management method and yield:	By coppicing at short rotation, 3-5 years depending on growth. Yield unreported.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical; arid and semi-arid.
Altitude:	Below 800 m.
Soil:	Sandy loam, non saline
Pests & Diseases:	..
Seed source:	South India, Orissa.

Name:	Botanical - Anogeissus pendula Local - Dhau
Family:	Leguminoseae
Distribution:	Rajasthan, Madhya Pradesh, Gujarat, Haryana, Maharashtra
Description:	Bush or a tree (9-15 m).
Uses:	Wood good for handles; timber; fuelwood; yields Indian gum, leaves yield a dark dye.
Seeding time:	December-March
Seeds:	..
Storage time:	..
Germination:	Low
Pretreatment of seeds:	None
Nursery method:	Sown in nursery in June, kept on for 2 years before transplanting.
Planting method:	Usually transplanting or seeding; germination is slow.
Growth:	Slow in first few years; dies back every year till roots are mature enough to maintain shoot in dry period. It is reasonably fast at that stage.
Management method and yield:	It coppices, pollards and root suckers well, therefore management has a number of options depending on the objectives of management. Yield unreported.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical and sub-tropical; rainfall ranging from 500-700 mm.
Altitude:	Below 600 m.
Soil:	Shallow sands, lateritic, and clastic.
Pests & Diseases:	..
Seed source:	Rajasthan

Name:	**Botanical** - Balanites aegyptica (Plate 9) **Local** - Hingan
Family:	**Leguminoseae**
Distribution:	**Rajasthan, Bihar, Madhya Pradesh, Maharashtra**
Description:	**A small greyish-green tree, armed with axillary or extra-axillary thorns, hoary-tomentose; leaves 2-foliate, entire; flowers small, green in axillary cymes; fruit a large, fleshy, oily, 1-seeded drupes; deep tap root.**
Uses:	**Used as fuelwood (calorific value 4600 kc/kg) and fodder locally. Fruits used for washing clothes and also made into garlands; rich in edible carbohydrate, fixed oil (50%) and protein; a source of steroids.**
Seeding time:	**December-March**
Seeds:	**500-1500 seeds/kg**
Storage time:	**3-4 months**
Germination:	..
Pretreatment of seeds:	**Seeds passed through ruminants germinate well. Seeds are also soaked in hot water for 12-18 hours or scarified to overcome dormancy.**
Nursery method:	**Seedlings can be raised in polypots.**
Planting method:	**2 year old saplings should be planted in medium sized pits with bonemeal and humus. Can be grown by direct seeding and by cutting.**
Growth:	**Slow.**
Management method and yield:	**By pruning and trimming or by clearfelling. Yield unreported.**
Locality factors of the area where the shrub can be grown:	
Climate:	**Arid, semi-arid tropics; rainfall; over 600 mm.**
Altitude:	**Below 300 m.**
Soil:	**Lateritic and sandy soil.**
Pests & Diseases:	..
Seed source:	**Bihar, Madhya Pradesh, Rajasthan, Maharashtra.**

Name:	Botanical - Bauhinia variegata Local - Rakto-Kanchan, Khaiveeal, Borara
Family:	Leguminoseae-Caesalpinieae
Distribution:	Foothills of the Himalayas, Assam
Description:	A small tree that can be managed as shrub; leaves 2-lobed; flower in terminal raceme, large, showy; petals slightly unequal, pink or purple; pods long, flat, dehiscent.
Uses:	Provides good quality firewood. Young leaves and flower-buds sometime used as vegetables; bark used for tanning.
Seeding time:	April-June
Seeds:	+ 800 seeds/kg
Storage time:	4-5 months
Germination:	..
Pretreatment of seeds:	..
Nursery method:	Seedlings can be raised in small polypots. Sown in beds for making stumps.
Planting method:	In pits with superphosphate and humus. Also by stem planting.
Growth:	Slow in year 1-2, faster thereafter.
Management method and yield:	By pruning, trimming for intermediate fuelwood yields; by topping for fodder; coppicing at short rotation. Yield unreported.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical and sub-tropical; moist and wet.
Altitude:	Below 800 m.
Soil:	Deep sandy, sandy loam, clay.
Pests & Diseases:	..
Seed source:	Uttar Pradesh, Assam.

Name:	Botanical - Berberis lycium Local - Chatroi
Family:	Bereridaceae
Distribution:	Western Himalayas, Punjab, HP, UP and in Nilgiri hills at about 2000-3000 m.
Description:	About 1.5 m tall, thickly branched, spinous shrub; leaves narrow-oblanceolate, pedicels slender; racemes usually simple; flowers large, dull-yellow; berries ovoid, bluish violet.
Uses:	Can be used as contour hedge to arrest erosion. Stem used as fuelwood; root bark is rich in alkaloid berberine; dried berries are edible.
Seeding time:	May
Seeds:	..
Storage time:	..
Germination:	..
Pretreatment of seeds:	..
Nursery method:	Seedlings can be raised in polypots.
Planting method:	In pits with enough leaf-mould. Also by seeding.
Growth:	Unreported
Management method and yield:	By trimming, topping and coppicing at short rotation. Yield unreported.
Locality factors of the area where the shrub can be grown:	
Climate:	Temperate; moist and semi-arid.
Altitude:	1000-25000 m
Soil:	Sandy loam and skeletal.
Pests & Diseases:	..
Seed source:	Uttar Pradesh

Name:	Botanical - Bougainvilloea sp. Local - Bagan-villa
Family:	
Distribution:	Cultivated all over India.
Description:	Shrub or a climber armed with spines; leaves oval, cream coloured flowers decorated with decorative papery bracts.
Uses:	Flowering plant. Can be used as a hedge, for soil conservation and as a live fence hedge.
Seeding time:	Plant does not bear seeds. Propagation by cutting and grafting.
Seeds: Storage time: Germination: Pretreatment of seeds:	Does not arise
Nursery method:	15 cm long cuttings of new stems taken in spring, dipped in hormone rooting powder and inserted in nursery beds. Roots form in eight weeks when it can be transplanted.
Planting method:	By cutting planted in spring and in rains in upturned ploughed soil line in shallow pits.
Growth:	Slow in first year. Very fast in second year onwards. About 2 meters a year if the plant is pruned or cut back in spring.
Management method and yield:	By topping and pruning every year in early spring. Annual yield estimated under average conditions about 4 tons/ha.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical, sub-tropical and temperate; arid, semi-arid, moist and wet.
Altitude:	Below 2000 m.
Soil:	Sandy loam, clay
Pests & Diseases:	..
Seed source:	Seed not required as propagation is by cutting and grafting.

Name:	Botanical - Bridelia verrucosa Local - Local name not known
Family:	Euphorbiaceae
Distribution:	UP, Assam
Description:	Often a shrub with low spreading crown, leaves 8-16 cm, obovate or broad-elliptic; flowers small greenish yellow; fruit ovoid, black when ripe.
Uses:	Leaves lopped for fodder; fuelwood; fruit can be eaten.
Seeding time:	Flowers November-April; fruits November-April.
Seeds:	..
Storage time:	..
Germination:	..
Pretreatment of seeds:	Nil
Nursery method:	..
Planting method:	..
Growth:	Slow.
Management method and yield:	Coppices well and produces root suckers.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical; moist, semi-arid.
Altitude:	Below 1000 m.
Soil:	Sandy loam and clay
Pests & Diseases:	..
Seed source:	Assam, UP

Name:	Botanical - Buddleia paniculata Local - Bhimsenopate
Family:	Loganiaceae
Distribution:	In sub-Himalayan regions of UP, Punjab, West Bengal.
Description:	Tall shrub; leaves subsessile, ovate-oblong, sinuate-dentate, woolly beneath, stipulates very narrow; panicles interrupted; corolla wooly dull white.
Uses:	..
Seeding time:	April-June.
Seeds:	20,000 seeds/kg
Storage time:	1-2 months
Germination:	..
Pretreatment of seeds:	..
Nursery method:	Seedlings can be raised in normal seed-beds; branch cuttings get rooted very easily.
Planting method:	Seedlings in small pits with plenty of humus. Also by branch cutting and by direct seeding.
Growth:	Unreported.
Management method and yield:	By trimming and topping. Yield unreported.
Locality factors of the area where the shrub can be grown:	
Climate:	Sub-tropical and temperate; moist and wet.
Altitude:	Below 2000 m.
Soil:	Sandy-rocky soil with plenty of humus
Pests & Diseases:	..
Seed source:	Uttar Pradesh.

Name:	Botanical - Cajanus cajan, (Cajanus indicus) Local - Arhar
Family:	Leguminoseae (Papilionoideae)
Distribution:	Cultivated throughout India for beans.
Description:	An erect woody shrub, generally grown as an annual, but is a short term perennial; leaves pinnately 3 foliate with resinous glands; flowers generally on axillary and terminal racemes, yellow with purple veins or diffuse red, standard orbicular keel, petals free; pods generally flattish, constricted, pubescent; seeds, 4-6 in a pod, slightly compressed, blotched or speckled.
Uses:	Cotyledons used as pulse, as cattle-feed, stems as fuelwood.
Seeding time:	September-October
Seeds:	16000 seeds/kg
Storage time:	One year
Germination:	80%
Pretreatment of seeds:	Not required
Nursery method:	Not required as seeds sown directly in field.
Planting method:	Direct sowing at a spacing of 30 x 30 cm during June or July. Usually grown as a mixed crop with Jua (Sorghum spp.), bajra (Pennisetum typhoides).
Growth:	It grows to about 2-3 m in 5-6 months.
Management method and yield:	Annual clearfelling followed by resowing. Can be managed as a perennial if cut at heights above 0.15 m. The yield can reach about 2 tonnes of woody stocks per ha. per growing season.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical, sub-tropical; hot moist conditions, rainfall 500-2500 mm.
Altitude:	Below 1000 m.
Soil:	Rich to fairly poor soils.

Pests & Diseases: The most common pests attacking Cajanus are the gram caterpillar (Heliothis obsoleta), gram plume moth (Exclastis atomasa, W.) and gram pod fly (Agromysa oblusa M.). The most common disease of Cajanus is wilt caused by fungus, Fusarium udum Butl. Controllable.

Seed source: Throughout India.

Name:	Botanical - Calotropis gigantea (Plate 10) Local - Akanda
Family:	Asclepiadaceae
Distribution:	In arid to moist parts of all regions of Indian plains.
Description:	A stout hairy tomentose shrub, rarely arboresecent; latex milky, leaves opposite, large, clasping the base; flowers in axillary paniculate cyme, light purple or lilac or even white; fruits a pair of folicles, 7-10 cm long; root stout tap root.
Uses:	Wood is soft and is a good fuel. Stem bark yields a fibre used for making fishing nets; root bark used against dysentery and skin disease. Latex used as insecticide.
Seeding time:	February-June
Seeds:	10,000 or more seeds/kg
Storage time:	..
Germination:	..
Pretreatment of seeds:	..
Nursery method:	..
Planting method:	..
Growth:	..
Management method and yield:	Unreported.
Locality factors of the area where the shrub can be grown:	
Climate:	Grows well in hot semi-arid areas with rainfall over 200 mm.
Altitude:	Below 100 m.
Soil:	Sandy and sandy loam.
Pests & Diseases:	..
Seed source:	Rajasthan, Gujarat

Name:	Botanical - Capparis decidua (Syn: C. aphylla) Local - Kurrel, Karer
Family:	Capparaceae
Distribution:	Punjab, Haryana, UP Grujarat, Rajasthan, MP and Deccan peninsula.
Description:	A densely greenish branching shrub with scanty, small caducous leaves found only on young shoots; flowers red, in many flowered corymbs; fruit a pink red berry globose. Stout tap root (Plate 11).
Uses:	Fuelwood; small timber for tool handles; fruits edible; different parts of the plant have medicinal value.
Seeding time:	May-June
Seeds:	17,100 seeds/kg
Storage time:	..
Germination:	92%
Pretreatment of seeds:	..
Nursery method:	..
Planting method:	..
Growth:	Rapid
Management method and yield:	Reproduces by root suckers. Can be managed by coppicing as the plant coppices easily. Yield unreported.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical, dry
Altitude:	Plains
Soil:	Sand, sandy loams, clastic
Pests & Diseases:	Nothing serious.
Seed source:	Kajasthan

Name:	Botanical - Capparis horrida Local - Asaria, Banai
Family:	Capparaceae
Distribution:	Throughout India
Description:	Medium climbing shrub, armed with stipulary thorns; young stem and leaves with rusty pubescence; leaves broadly ovate; flowers solitary, axillary, large, showy white, filaments purple; fruit a berry, subglobose.
Uses:	Leaves eaten by sheep and goats; stems used as fuelwood.
Seeding time:	August-September
Seeds:	..
Storage time:	..
Germination:	..
Pretreatment of seeds:	..
Nursery method:	Seedlings raised in polypots.
Planting method:	Planting of 1 year old seedlings in pits.
Growth:	Slow
Management method and yield:	By coppicing, by trimming, pruning and topping. Yield unreported.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical, hot, semi-arid to arid.
Altitude:	Below 1,000 m
Soil:	Rocky, sandy and sandy loam
Pests & Diseases:	..
Seed source:	Throughout India

Name:	Botanical - Capparis spinosa Local - Kabra
Family:	Capparaceae
Distribution:	Hilly areas of Deccan peninsula, Rajasthan and Punjab
Description:	A much branched shrub with trailing branches, leaves broadly ovate to orbicular; flowers solitary, axillary, white; filaments purple; fruit a fleshy berry, red inside when ripe.
Uses:	Fuelwood; flower buds and young fruits used as condiments; leaves and ripe fruits eaten by goats and sheep; decoction of root bark used as expectorant and diuretic.
Seeding time:	December-February
Seeds:	..
Storage time:	..
Germination:	..
Pretreatment of seeds:	..
Nursery method:	Seedlings raised in polypots.
Planting method:	Planting of 4-5 months old seedling in the pits dug in the planting area.
Growth:	Slow
Management method and yield:	By pruning, trimming, topping and coppicing. Yield unreported.
Locality factors of the area where the shrub can be grown:	
Climate:	Arid and semi-arid and tropics; rainfall; over 300 mm.
Altitude:	Below 1000 m
Soil:	Sand, sandy loams.
Pests & Diseases:	..
Seed source:	Punjab, Peninsular India and Rajasthan.

Name:	Botanical - Carissa carandas Local - Karamcha, Karanda, Kendakeri
Family:	Apocynaceae
Distribution:	UP, AP, Haryana, Punjab, Maharashtra, Tamil Nadu
Description:	Large, thickly branched, spinous shrub; leaves, coriaceous, opposite, shining above, tips rounded; flowers white; fruits ellipsoid, + 2 cm long, deep brown on ripening, sour.
Uses:	Fruits used for making pickles, jam, etc., leaf decoction used as medicine; goats browse on leaves; timber used for tool handles; stems used as fuelwood. Suitable for live fencing.
Seeding time:	July-August
Seeds:	About 2,000 seeds/kg
Storage time:	3-4 months
Germination:	70-80%
Pretreatment of seeds:	Not required
Nursery method:	Seeds can be sown in polypots and seedlings will be ready for planting in 5-6 months.
Planting method:	Naked root seedlings can be planted in freshly prepared pits, along with sufficient humus; close sowing directly in ploughed contour lines in rains.
Growth:	Slow.
Management method and yield:	Annual pruning for fuelwood collection. Fruit collection for pickles. Yield of fuelwood about 2-3 tons/ha annually.
Locality factors of the area where the shrub can be grown:	
Climate:	Arid tropical areas with a rainfall of 300-600 mm.
Altitude:	Below 300 m
Soil:	Lateritic and alluvial soil
Pests & Diseases:	..
Seed source:	Throughout India.

Name:	Botanical - Carissa spinarum Local - Karanda, Auka Kuli
Family:	Apocynaceae
Distribution:	In Bihar, UP, AP, Maharashtra, Tamil Nadu
Description:	Small (about 1-2 m), suberect, much branched, spiny with milky latex; leaves coriaceous, opposite, shining above, flowers white; berry sub-globose, + 0.6 cm long, sour.
Uses:	Fruits edible; leaves browsed on by goats; stem and branches used fuelwood; can be used as soil retaining contour hedge.
Seeding time:	July-August
Seeds:	About 2,000 seeds/kg
Storage time:	3-4 months
Germination:	80-90%
Pretreatment of seeds:	Not required
Nursery method:	Seeds can be sown in polypots and seedlings will be ready by the next rainy season.
Planting method:	One year old seedlings are planted in small pits. Can be grown by sowing in rains in ploughed contour lines.
Growth:	Slow in years 1 and 2. Faster from year 3.
Management method and yield:	The plants, grown as contour hedge, can be trimmed and pruned annually for collection of fuelwood; yield can be about 2-2.5 tons of dry matter per ha annually.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical, arid with rainfall 300-600 mm.
Altitude:	Below 300 m
Soil:	Lateritic and alluvial soils
Pests & Diseases:	..
Seed source:	Throughout India.

Name:	Botanical - Cassia auriculata (Plate 7) Local - Tarab
Family:	Leguminoseae - Caesalpinioideae
Distribution:	Gujarat, Rajasthan, Tamil Nadu, Maharashtra, UP, MP
Description:	A much branched handsome shrub; leaflets 1-2m with hairy fringes; stipules large, foliaceous, persistent; flowers large, yellow; pods 6-10x1.25 cm flat with 6-10 seeds.
Uses:	Bark used for tanning; stem very commonly used as fuel; for clothing barren tracts, as contour hedge for soil and moisture retention and leaves as green manure.
Seeding time:	January-March
Seeds:	About 1,200 seeds/kg
Storage time:	..
Germination:	..
Pretreatment of seeds:	..
Nursery method:	Seedlings easily raised by sowing in normal seed beds.
Planting method:	Seedlings planted in freshly prepared small pits. Can be grown by close sowing in ploughed contour beds 5m apart as a low canopy shrub layer under an overhead Acacia nilotica crop. Suitable for contour hedge planting for soil retention.
Growth:	Rapid from year 1.
Management method and yield:	Annual coppicing will be successful as evidenced by people cutting them annually for fuelwood collection. Dry fuelwood yield estimated under average conditions from 5m. apart hedges is 2-3 tons/ha annually.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical, arid, semi-arid and moist.
Altitude:	Below 200 m
Soil:	Alluvial, latritic and black clay soil.
Pests & Diseases:	..
Seed source:	Madhya Pradesh, Gujarat, Tamil Nadu and Rajasthan.

Name:	Botanical - Cassia glauca Local - Introduced plant: no local name
Family:	Leguminoseae - Caesalpinioideae
Distribution:	Orissa, Bihar, West Bengal
Description:	A medium shrub, leaves paripinnate; leaflets glaucous, terminal and subterminal, much branched racemes; flowers in bracts reflexed, corolla bright yellow; pod long, linear, flat and thin.
Uses:	Fuelwood
Seeding time:	October-January
Seeds:	..
Storage time:	2-3 months
Germination:	..
Pretreatment of seeds:	..
Nursery methods:	By sowing seeds in polypots
Planting method:	Seedlings generally planted in freshly prepared small pits at 30 cm spacing.
Growth:	Unreported
Management method and yield:	Annual coppicing is likely to be successful. Yield unreported.
Locality factors of the area where the shrub can be grown:	
Climate:	Moist and wet with rainfall over 800 mm
Altitude:	Below 200 m
Soil:	Alluvial
Pests and diseases:	..
Seed source:	Orissa, Bihar, West Bengal

Name:	Botanical - Cassia occidentalis Local - Kalkasunda
Family:	Leguminoseae-Caesalpinioideae
Distribution:	NE India, Assam, West Bengal, Orissa plains
Description:	A much branched under-shrub; leaves paripinnate with 3-5 pairs of ovate-oblong leaflets; flowers in terminal and subterminal branched corymbs, yellow; pods long, slightly compressed and impressed between seeds.
Uses:	Stems used as fuel by poor people. Seeds and leaves used in the treatment of skin diseases and roots in snake bite and as purgative. Leaves as green manure.
Seeding time:	December-January
Seeds:	2,000 seeds/kg
Storage time:	3-4 months
Germination:	85-95%
Pretreatment of seeds:	Not required
Nursery method:	Seedlings are very easily raised in normal seed beds
Planting method:	Seedlings planted in the pits dug at 30x30cm interval. Can be raised by direct sowing also.
Growth:	Unreported
Management method and yield:	Annual coppicing likely to be successful. Yield unreported.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical, moist and wet with rainfall over 800 mm.
Altitude:	Below 300 m
Soil:	Alluvial
Pests and diseases:	..
Seed source:	West Bengal

Name:	Botanical - Cleistanthus collinus Local - Karada, Carrar
Family:	Euphorbiaceae
Distribution:	West Bengal, Orissa, Bihar, UP, Maharashtra, MP, AP, Tamil Nadu
Description:	A monoecious shrub to a small tree with spreading branches, leaves alternate, glabrous beneath; flowers in axillary clusters, minute, green; milky capsule 3-lobed; seeds globose.
Uses:	Can be used as a contour hedge. Stem provides excellent fuelwood and wood; bark, leaves and fuel green fruits used for tanning; wood suitable for paper pulp.
Seeding time:	March-April
Seeds:	8,000-9,000 seeds/kg
Storage time:	4-5 months
Germination:	..
Pretreatment of seeds:	..
Nursery method:	Seedlings can be raised in polypots. Seeds are sown in beds and the seedlings pricked out into polypots when 3 cm high.
Planting method:	By planting seedlings in pits with bonemeal and humus. Can be grown by sowing in ploughed lines.
Growth:	Unreported
Management method and yield:	Pruning, topping annually and coppicing at short rotation. Yield unreported.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical, semi-arid, moist and wet
Altitude:	Below 600 m
Soil:	Lateritic, sandy loams
Pests and diseases:	..
Seed source:	Bihar, Orissa, Madhya Pradesh and Penninsular India.

Name:	Botanical - Clerodendron inerme (Plate 2) Local - Ban-jai, Bat-raj
Family:	Verbenaceae
Distribution:	In wet and moist areas of West Bengal, Orissa, Kerala (near sea shores).
Description:	A densely branched shrub with long, slender straggling branches; leaves opposite, obovate with rounded tips, entire, thick; flowers axillary and terminally cymose; flowers white with a long coralla tube; calyx in fruit closely attached to base of berry.
Uses:	Stems used as fuel; long and slender branches used for making local fishing instruments; a good soil binder; also grown along the fences.
Seeding time:	December-February
Seeds:	+ 1000
Storage time:	4-6 months
Germination:	80%
Pretreatment of seeds:	..
Nursery method:	Seedlings can be raised in polypots.
Planting method:	Seedlings planted closely in freshly prepared small holes. By direct seeding. By root suckering.
Growth:	Unreported
Management method and yield:	..
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical, moist
Altitude:	Below 300 m
Soil:	Muddy saline areas near sea
Pests and diseases:	..
Seed source:	West Bengal, Orissa, Kerala

Name:	Botanical - Clerodendron viscosum (Plate 12) (= C. infortunatum) Local - Bhant, Ghentu
Family:	Verbenaceae
Distribution:	Eastern states and high rainfall areas
Description:	An underbrush with perennial base and annual stems; slightly over 1 m tall; leaves large, ovate, cordate, serrate, rough; bracts red, corolla tube white, limbs fringed with pink, sickly scented flowers; berry globose, black.
Uses:	Stem used as fuelwood. Root bark used to relieve stomach-ache, leaf extract used against worm and lice
Seeding time:	September-October
Seeds:	+ 5,000 seeds/kg
Storage time:	8-9 months
Germination:	..
Pretreatment of seeds:	..
Nursery method:	Seedlings can be raised in normal shaded nursery beds
Planting method:	In freshly prepared small pits with little leaf mould. By direct seeding also.
Growth:	Unreported
Management method and yield:	..
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical, moist and wet
Altitude:	Below 500 m
Soil:	Sandy-loam
Pests and diseases:	..
Seed source:	Throughout India
Locality factors of the area where the shrub can be grown:	

Name:	Botanical - Coffea bengalensis Local - Mirthelo (Assamese)
Family:	Rubiaceae
Distribution:	Assam, West Bengal
Description:	A deciduous shrub; leaves variable, often elliptic or broadly ovate; flowers slender, white, fragrant, axillary or at the ends of small branchlets; fruits drupe, subglobose; seeds grooved.
Uses:	Fuelwood; contour hedge planting for soil and moisture conservation in hilly terrain.
Seeding time:	October-December
Seeds:	..
Storage time:	..
Germination:	..
Pretreatment of seeds:	..
Nursery method:	..
Planting method:	..
Growth:	..
Management method and yield:	..
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical; moist and wet
Altitude:	1000-2000m
Soil:	Sandy loam
Pests and diseases:	..
Seed source:	West Bengal

Name:	Botanical - Colebrookia oppositifolia Local - Pansra, Binda
Family:	Labiatae
Distribution:	In the Himalayas, generally between 500-1250m
Description:	Leaves opposite, large, white tomentose; flowers in terminal panicled spikes; fruits nutlets usually only one, hairy, oboroid.
Uses:	Used as fuelwood. Pasted leaves cure wounds and bruises; gun-powder charcoal prepared from its wood.
Seeding time:	February-March
Seeds:	10,000 seeds/kg
Storage time:	4-5 months
Germination:	..
Pretreatment of seeds:	..
Nursery method:	Seedlings can be raised in normal shaded seed beds; shoot-cuttings produce better saplings.
Planting method:	4-5 months old seedling may be planted in pits. Direct seeding and shoot cuttings are successful.
Growth:	Unreported
Management method and yield:	By side trimming and by pruning. Yield unreported
Locality factors of the area where the shrub can be grown:	
Climate:	Wet, sub-tropical mountains; moist and wet
Altitude:	About 500-1250m
Soil:	Sandy loam
Pests and diseases:	..
Seed source:	West Bengal, Assam, Meghalaya

Name:	Botanical - Combretum decandrum Local - Namarkeng (Assamese)
Family:	Combretaceae
Distribution:	Assam, West Bengal and NE states ascending to 500m elevation
Description:	A large straggling shrubby climber; leaves opposite, simple, elliptic to lanceolate; flower greenish white in dense spikes; fruit with wings
Uses:	As hedge for soil conservation; as fuelwood. Bark chewed as substitute for betel nut.
Seeding time:	March-April
Seeds:	.. seeds/kg
Storage time:	..
Germination:	..
Pretreatment of seeds:	..
Nursery method:	..
Planting method:	..
Growth:	..
Management method and yield:	Can be managed by pruning or coppicing every year and the products used as fuelwood. If planted on contour, they will grow in spite of regular cutting and act as a soil trap. Dry fuel yield is estimated at 4-6 tons/ha of fuelwood from dense hedges grown at 5 m intervals.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical, sub-tropical, moist and wet
Altitude:	Below 500m
Soil:	Alluvial and lateritic
Pests and diseases:	..
Seed source:	Assam, West Bengal

Name:	Botanical - Coriaria nepalensis Local - Masuri
Family:	Coriarieae
Distribution:	Temperate Himalayas, very common near Mussourie, Uttar Pradesh
Description:	A large shrub or small tree; branchlets quadrangular; leaves opposite, 3-7 nerved ovate-oblong or lanceolate; flower racemes solitary or in clusters; fruit black.
Uses:	Leaves medicinal; ripe berries eaten, good for clothing landslips.
Seeding time:	July-October
Seeds:	
Storage time:	..
Germination:	..
Pretreatment of seeds:	..
Nursery method:	..
Planting method:	..
Growth:	..
Management method and yield:	..
Locality factors of the area where the shrub can be grown:	
Climate:	Temperate; semi-arid to moist
Altitude:	1000-2000m
Soil:	Sandy loam and skeletal
Pests and diseases:	..
Seed source:	Uttar Pradesh

Name:	Botanical - Cotoneaster bacillaris Local - Reush, Reus
Family:	Rosaceae
Distribution:	In north-west Himalayas between 1500-3000 m elevation in moist cool places
Description:	A large shrub
Uses:	Fodder for goats and sheep
Seeding time:	..
Seeds:	..
Storage time:	..
Germination:	..
Pretreatment of seeds:	..
Nursery method:	..
Planting method:	Direct seeding
Growth:	Rapid
Management method and yield:	..
Locality factors of the area where the shrub can be grown:	
Climate:	Temperate; moist
Altitude:	1500-3000m
Soil:	Sandy loam and skeletal
Pests and diseases:	..
Seed source:	Himachal, Pradesh, Jammu and Kashmir

Name:	Botanical - Crotolaria juncea Local - Sanai, kidney bean
Family:	Leguminoseae - Papilionoideae
Distribution:	Mainly in East and South India
Description:	A shrub 1-2m high; linear-oblong simple leaves covered with silky hairs on both surfaces; flowers yellow in terminal racemes; sessile pods with persistent silky hairs; seeds brown.
Uses:	Yields good fibre (sun hemp), portion remaining after fibre extraction used as fuel.
Seeding time:	February-March
Seeds:	10-15 numbers in a pod
Storage time:	..
Germination:	About 90%
Pretreatment of seeds:	Nil
Nursery method:	Not necessary as seeds can be directly sown in the field
Planting method:	Seeds are broadcast in the field.
Growth:	Grows rapidly. Fruits in about 6 months.
Management method and yield:	As an undershrub. Clearfelled annually and seeds re-broadcast in the area. Yield of dry fuelwood about 3 tons/ha.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical, semi-arid to wet with rainfall 700-2500mm
Altitude:	0-1000m
Soil:	All types of soil including poor soil but excluding water-logged areas.
Pests and diseases:	Many disease organisms are found on sunhemp but are controllable
Seed source:	Assam, West Bengal, UP, AP, Tamil Nadu

Name:	Botanical - Daphne cannabina Local - Satpura, Setburwa
Family:	Thymelaeaceae
Distribution:	Found in eastern Himalayas
Description:	An evergreen shrub with smooth grey bark; leaves 5-10 cm long; flowers scented, white; fruit a berry, orange when young, ruby when ripe.
Uses:	Fuelwood. Bark fibre for handmade paper.
Seeding time:	May-June and December-January
Seeds:	..
Storage time:	..
Germination:	..
Pretreatment of seeds:	..
Nursery method:	..
Planting method:	..
Growth:	..
Management method and yield:	..
Locality factors of the area where the shrub can be grown:	
Climate:	Temperate, subtropical, wet and moist
Altitude:	1500-3000m
Soil:	Sandy loam and skeletal
Pests and diseases:	..
Seed source:	West Bengal

Name:	Botanical - Debregesia hypoleuca Local - Sansaru, Siaru
Family:	Urticaceae
Distribution:	Western Himalayas at 1000-1500 m elevation
Description:	A large shrub or a small tree (up to 5 m height)
Uses:	Leaves provide fodder for sheep; fruits are edible; stem good as fuelwood. Can be grown as a hedge on contour, as a soil trap.
Seeding time:	..
Seeds:	..
Storage time:	..
Germination:	..
Pretreatment of seeds:	..
Nursery method:	..
Planting method:	..
Growth:	..
Management method and yield:	..
Locality factors of the area where the shrub can be grown:	
Climate:	Subtropical temperature; semi-arid and moist
Altitude:	1000-1500m
Soil:	Sandy loam and loam
Pests and diseases:	..
Seed source:	Uttar Pradesh

Name:	Botanical - Desmodium gyroides Local - ..
Family:	Capparaceae
Distribution:	Eastern India plains
Description:	A large much branched shrub up to 4 m tall; densely pubescent; leaves 3-foliolate, stipules free, acuminate; leaflets subcoriaceous, oblong, entire, terminal one large; flowers in terminal dense panicles, large, showy; pods indistinctly jointed, loosely pubescent, dehiscing in a continuous line along the ventral suture.
Uses:	A good fodder plant; helps in improving poor soil.
Seeding time:	October-November
Seeds:	+ 2,500 seeds/kg
Storage time:	7-8 months
Germination:	..
Pretreatment of seeds:	..
Nursery method:	Seedlings can be raised in shaded normal nursery beds and in polypots.
Planting method:	Seedlings in fresh prepared small holes; by direct seeding also in ploughed soil.
Growth:	Unreported
Management method and yield:	By heavy pruning and by trimming for fuel, by lopping for fodder. Yield unreported.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical, sub-tropical; moist
Altitude:	Below 1000 m
Soil:	Arid and alkaline but not saline soils
Pests and diseases:	..
Seed source:	Assam, West Bengal

Name:	Botanical - Dodonaea viscosa Local -
Family:	Sapindaceae
Distribution:	All over India
Description:	Spreading, dense, erect multi-stemmed shrub. Leaves variable in shape, linear to obovate or spatulate. Sessile or stalked, bright green, leathery, flowers inconspicuous, greenish male and female on separate plants; fruit a leathery capsule.
Uses:	Fuel (caloric value 4,592 kcal/kg). For soil conservation on degraded sites.
Seeding time:	..
Seeds:	100,000 seeds/kg
Storage time:	..
Germination:	Very high, survival if watered or rain follows
Pretreatment of seeds:	By scarification by nicking or by boiling water treatment.
Nursery method:	Sowing in polypots.
Planting method:	By cuttings; also by sowing directly in the field.
Growth:	Unreported
Management method and yield:	By coppicing annually. Sensitive to fire. Yield of dry fuelwood estimated 4-5 tons/ha annually.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical and sub-tropical; arid to semi-arid.
Altitude:	Below 1000m
Soil:	Sandy, loamy, lateritic and stony
Pests and diseases:	No serious pests.
Seed source:	Punjab

Name:	Botanical - Duranta repens (Plate 4) Local - Pigeon Berry
Family:	Verbenaceae
Distribution:	Cultivated throughout India as a hedge plant.
Description:	An evergreen shrub with drooping branches armed with spines. The branches are quadrangular with oval leaves; flowers blue in panicle or loose racemes; berries glossy, orange and globose.
Uses:	Impenetrable hedge. Plant not browsed by cattle. Good fuelwood. Wood can be used for turnery work.
Seeding time:	Flowers and fruits throughout the year.
Seeds:	..
Storage time:	..
Germination:	..
Pretreatment of seeds:	..
Nursery method:	..
Planting method:	Planting by seeds or by cutting; planting during rains.
Growth:	..
Management method and yield:	..
Locality factors of the area where the shrub can be grown:	
Climate:	Sub-tropical and tropical; semi-arid and moist
Altitude:	Below 1000m
Soil:	Alluvial, lateritic
Pests and diseases:	..
Seed source:	Bihar, Uttar Pradesh

Name:	Botanical - Ervatamia coronaria (= Tabernaemontana coronaria)(Plate 13) Local - Tagar
Family:	Apocynaceae
Distribution:	Foothills of Himalayas from Garhwal to Arunachal, Pradesh
Description:	A small, much branched shrub with milky latex; leaves oblong, acuminate, entire; flowers in short terminal cymes, white; pods oblong, 3-ribbed.
Uses:	Can be used as hedge to arrest soil erosion. Stem is used as fuelwood; an ornamental shrub; seeds used in dye preparation; flowers made into garlands.
Seeding time:	June-August
Seeds:	..
Storage time:	6-8 months
Germination:	..
Pretreatment of seeds:	..
Nursery method:	Seedlings can be raised in normal seed beds but cuttings produce better saplings.
Planting method:	Seedlings in pits with bonemeal and humus. By planting cuttings in upturned ploughed lines or in pits.
Growth:	Unreported
Management method and yield:	By pruning and short rotation coppicing. Rotation can be 1-2 years. Yield unreported.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical and sub-tropical; moist and wet
Altitude:	Below 1000m
Soil:	Sandy loam, clay
Pests and diseases:	..
Seed source:	West Bengal, Assam

Name:	Botanical - Erythrina suberosa Local - Madar
Family:	Leguminoesae
Distribution:	Throughout dry forests of Indian plains and foothills
Description:	A moderate sized deciduous tree can be managed as a shrub, branches armed with conical prickles; leaves pinnately 3-foliate; flowers bright scarlet; pods tapering at both ends, 4-6 seeded; seeds black.
Uses:	Fuelwood; tree can be managed as large shrub; good live fence; timber used as ladles, sieve frames, small containers. Quality of leaf fodder variable.
Seeding time:	June
Seeds:	..
Storage time:	..
Germination:	..
Pretreatment of seeds:	..
Nursery method:	By sowing in nursery beds or directly in polypots.
Planting method:	It can be raised by branch cuttings, direct sowing or by planting out nursery raised seedlings.
Growth:	..
Management method and yield:	It can be managed as a large shrub by coppicing and pollarding which it does vigorously. Yield unreported.
Locality factors of the area where the shrub can be grown:	
Climate:	Sub tropical; moist; semi-arid
Altitude:	Up to 800m
Soil:	Black clay, alluvial
Pests and diseases:	..
Seed source:	Assam, Madhya Pradesh, Maharashtra, Uttar Pradesh

Name:	Botanical - Euphorbia royleana (Plate 14) Local - Mansha
Family:	Euphorbiaceae
Distribution:	Gujarat, Rajasthan, UP, Maharashtra
Description:	Erect, glabrous, armed with prickles, cactoid shrub; stems 5-7 angled, produces ovate-oblong leaves in moist season; flowers small, green. Capsule 0.6 in diameter; stout tap roots.
Uses:	Milky latex used as anthelmentic; chopped leaves and young stem is a fish poison. Dried stems used as fuelwood. Also used as torches. Can be used as live fences and as contour hedges for soil conservation.
Seeding time:	June-October
Seeds:	..
Storage time:	2-3 months
Germination:	..
Pretreatment of seeds:	..
Nursery method:	Stem cutting gets rooted very easily.
Planting method:	Stem cuttings are immersed in water for stopping latex exudation and planted directly in field in freshly prepared small pits or in ploughed lines with added sand and humus in 1:1 proportion.
Growth:	Unreported
Management method and yield:	Cuttings closely planted as very effective hedges. Hedges topped and trimmed annually for fuelwood. Yield unreported but estimated at 3-4 dry ton/ha from 2000 m. of hedge line.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical, arid
Altitude:	Below 200m
Soil:	Sandy and sandy loam latritic and saline
Pests and diseases:	..
Seed source:	Rajasthan, Uttar Pradesh, Gujarat, Maharasthra

Name:	Botanical - Eurya japonica Local - Baunra, Gonte
Family:	Ternstromiaceae
Distribution:	Eastern Himalayas
Description:	An evergreen shrub with oblong-lanceolate leaves; flowers white, small; fruit globose, size of a peppercorn.
Uses:	Fuelwood; leaves used as green manure in Sikkim.
Seeding time:	November-December
Seeds:	..
Storage time:	..
Germination:	..
Pretreatment of seeds:	..
Nursery method:	..
Planting method:	Propagation is by cuttings taken from the tips of the growing shoots.
Growth:	..
Management method and yield:	The plants can be pollarded and kept low so that the leaves are regularly cropped. Yield unreported.
Locality factors of the area where the shrub can be grown:	
Climate:	Sub-tropical and temperate; set, moist.
Altitude:	1000-2200m
Soil:	Mountain soil
Pests and diseases:	..
Seed source:	West Bengal, Sikkim

Name:	Botanical - Flacourtia indica Local - Bench, bhanber
Family:	Flacourtiacea
Distribution:	Most of drier parts of India.
Description:	A shrub or small tree armed with axillary and branched stem thorns; leaves red, when young, ovate; petiole 0.5-0.8 cm long; flowers greenish yellow, usually racemes; fruit red; edible seeds 8-16.
Uses:	For agricultural implements; fuel; fruits edible; leaves lopped for fodder. Suitable for live hedges.
Seeding times:	March-July
Seed:	..
Storage time:	..
Germination:	..
Pretreatment of seeds:	..
Nursery method:	..
Planting method:	..
Growth:	Very slow. Reported annual girth increment 0.5-0.8 cm. In Tamil Nadu, coppice shoot reached 3.4 m height and 9.4 cm girth in 15 years, corresponding to mean annual girth increment of only 0.63 cm.
Management method and yield:	It coppices well. Yield unreported.
Locality factors of the area where the shrub can be grown:	
Climate:	Subtropical; dry-moist.
Altitude:	Below 1,200 m
Soil:	All types including skeletal and black cotton
Pests and diseases:	Some defoliators and sap suckers but controllable
Seed source:	Uttar Pradesh

Name:	Botanical - Flueggea microcarpa Local - Khaukura (Khasi)
Family:	Euphorbiaceae
Distribution:	Assam, north-east India, West Bengal, Himalayas (up to 1,800 m)
Description:	A large unarmed shrub or small tree; leaves deciduous, alternate, elliptic-ovate; flowers dioecious, minute, axillary; fruit fleshy.
Uses:	Wood used for agricultural implements, stem for fuelwood.
Seeding times:	September-November
Seed:	..
Storage time:	..
Germination:	..
Pretreatment of seeds:	..
Nursery method:	..
Planting method:	..
Growth:	
Management method and yield:	
Locality factors of the area where the shrub can be grown:	
Climate:	Sub-tropical and temperate; wet and moist
Altitude:	1,000-1,800 m
Soil:	Sandy loam, loam and skeletal
Pests and diseases:	..
Seed source:	Assam

Name:	Botanical - Glycosmis pentaphylla Local - Bon-nimbu, Ashhora, Danton
Family:	Rutaceae
Distribution:	Northeast India, Eastern India, Himalayan foothills.
Description:	A low, gregarious shrub, leaves imparipinnate with 1-5 leaflets; lamina membranous with characteristic small flowers in axillary and terminal panicles, dirty white; fruits globose, fleshy, berry-like.
Uses:	A good hedge plant. Fruits edible; fuelwood; leaf decoction used against fever, liver complaints and as vermifuge; leaves used for packing fruits; twigs used as toothpicks.
Seeding times:	Throughout the year.
Seed:	20,000 seeds/kg
Storage time:	..
Germination:	..
Pretreatment of seeds:	..
Nursery method:	Seedlings can be grown in polypots.
Planting method:	Seedlings in freshly prepared pits, added with little humus, can tolerate shade. Success or otherwise of sowing and planting of branch cutting unreported.
Growth:	Rapid
Management method and yield:	By side trimming and pruning. Yield unreported.
Locality factors of the area where the shrub can be grown:	
Climate:	Sub tropical-tropical; wet
Altitude:	Below 800 m
Soil:	Sandy loam, clay
Pests and diseases:	..
Seed source:	Uttar Pradesh, West Bengal, Assam

Name:	Botanical - Grewia tiliifolia Local - Dhamin
Family:	Tiliaceae
Distribution:	Plains of UP, Bihar, Orissa, AP, Tamil Nadu, Karnataka, Maharashtra
Description:	A medium sized tree but can be managed as a shrub; leaves alternate, obliquely ovate, rhomboid, cordate, entire, abruptly short pointed; flowers in axillary clustered cymes (shorter than petiole) without any involucre; fruit red, drupe, fleshy, dry.
Uses:	Fruits edible; leaves used as good fodder; branches provide good firewood, timber used for agricultural implements and sports goods.
Seeding times:	August-September.
Seed:	6,000 (with pulp), 19,400 (freshly pulped) seeds/kg
Storage time:	Viability low (upto 4 months)
Germination:	80%
Pretreatment of seeds:	None
Nursery method:	Seeds are sown in polypots, require 15-20 days for germination, ready for planting in the field by 3-4 months. For stumps, the seedling is kept in nursery for 1 more year.
Planting method:	By naked root, polypot raised seedling, by stump planting, by shoot cutting.
Growth:	The mean annual girth increment under average conditions is reported 4.2 cm. One year old coppice shoots attain an average height of 2.5 m.
Management method and yield:	The tree can be managed by coppice system with a short rotation. Yield unreported.
Locality factors of the area where the shrub can be grown:	
Climate:	Arid to semi-arid tropical climate.
Altitude:	Below 300 m.
Soil:	Lateritic and alluvial soils.

Pests and diseases:	Several insects cause damage by defoliating trees. Several fungi cause mottled sap rot, mottled spongy rot, white spongy rot and brownish heart rot. They are controllable.
Seed source:	Bihar, Orissa, Madhya Pradesh, Uttar Pradesh.

Name:	Botanical - Gymnosporia spinosa Local - Not known
Family:	Celastraceae
Distribution:	Throughout the drier parts of India
Description:	A tall thorny shrub
Uses:	Leaf fodder of poor quality. Good fuelwood. Leaf, stem, bark and leaves used for medicine. Can be used as contour dense hedge for soil conservation.
Seeding times:	..
Seed:	..
Storage time:	..
Germination:	..
Pretreatment of seeds:	..
Nursery method:	..
Planting method:	Direct seeding in upturned plough lines
Growth:	Unreported
Management method and yield:	The shrub can be pruned, topped and coppiced annually. Yield is estimated at 2-3 tons/ha if grown as a hedge at 5 m interval.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical and sub-tropical; arid and semi-arid.
Altitude:	Sea level to 1,000 m.
Soil:	Lateritic and black
Pests and diseases:	..
Seed source:	Maharashtra, Madhya Pradesh, Andhra Pradesh, Karnataka.

Name:	Botanical - Hibiscus subdariffa Local - 1. Vegetable type: (Tak-dhenras) 2. Fibre type: Lal-ambari
Family:	Malvaceae
Distribution:	In most parts of Indian plains.
Description:	An annual (upto 2 m) with purplish stem, with branch, leaves alternate, much variable, generally palmately 3-5 lobed or entire; flowers solitary-axillary, showy, yellow, epicalyx fleshy (edible), red in vegetable type and generally less fleshy and green in fibre type; fruit and ovate capsule covered with persistent calyx and epicalyx.
Uses:	Fleshy epicalyx used as vegetable and for the preparation of pickles and drinks (Sudan tea); a jute like fibre is extracted from bark and the inner xylem core used as fuel.
Seeding times:	October-December.
Seed:	Over 2,000 seeds/kg.
Storage time:	5-7 months.
Germination:	80-90%
Pretreatment of seeds:	None required.
Nursery method:	Not necessary
Planting method:	Directly broadcast in the field during monsoon.
Growth:	..
Management method and yield:	Clearfelled annually and seeds re-broadcast. Yield of dry fuelwood about 2 tons/ha.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical, sub-tropical; arid to wet.
Altitude:	Below 650 m
Soil:	Organic soils, sandy soils and sand.
Pests and diseases:	..
Seed source:	Throughout India.

Name:	Botanical - Holarrhena antidysenterica Local - Kurchi
Family:	Apocynaceae
Distribution:	Bihar, Orissa, UP, West Bengal
Description:	A small deciduous tree/large shrub with milky juice, opposite leaves; cream or white slightly scented flower; fruit of 2 distinct follicles; numerous seeds 1.2 cm long.
Uses:	Fuelwood, wood for carving, turning furniture. Bark for medicine.
Seeding times:	Flowers May-June; fruits cold season.
Seed:	..
Storage time:	Viability is low after 1 year.
Germination:	Very high percentage.
Pretreatment of seeds:	Nil
Nursery method:	By direct sowing in beds or in polypots, weeding and watering.
Planting method:	By direct sowing and by planting. Natural reproduction is also abundant.
Growth:	Attains 10-15 cm height after sowing at the end of one year. Subsequently growth more rapid, mean annual girth increment being 2.0-2.3 cm.
Management method and yield:	Can be managed by natural regeneration and annual pruning and debranching for fuelwood. Yield unreported.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical, sub tropical; wet, moist and semi arid.
Altitude:	Upto 1,200 m.
Soil:	Alluvial, lateritic, black soil.
Pests and diseases:	..
Seed source:	West Bengal, Bihar, Orissa, Uttar Pradesh.

Name:	Botanical - Holmskioldia sanguinea Local - Kapni
Family:	Verbenaceae
Distribution:	In Himalayan foothills east of Sutlej.
Description:	A large straggling shrub, leaves opposite; flowers with red-orange silvar-shaped membraneous calyx; fruit drupe; seeds oblong.
Uses:	Fuelwood; plant eaten by sheep and goat.
Seeding times:	In winter.
Seed:	..
Storage time:	..
Germination:	..
Pretreatment of seeds:	..
Nursery method:	..
Planting method:	Propagated by layering, cuttings or seeds. Can be grown with little care and does best in full sunshine.
Growth:	..
Management method and yield:	Can be pruned after flowering annually for intermediate fuelwood yield. Yield unreported.
Locality factors of the area where the shrub can be grown:	
Climate:	Subtropical; wet, moist.
Altitude:	Below 1,000 m.
Soil:	Valley loamy soils.
Pests and diseases:	..
Seed source:	West Bengal, Himachal Pradesh, Uttar Pradesh.

Name:	Botanical - Indigofera oblongifolia Local - Jhungi, Vilayata jhojun
Family:	Leguminoseae
Distribution:	Found throughout Indian plains even on poorest soils.
Description:	A woody branched undershrub attaining heights of 1-2 m. Leaves argenteo-canescent; flowers tiny, bright red with hairy corolla; pods glaucous.
Uses:	Good fodder for sheep. Roots, in particular, and other parts used as medicine. Leaves for green manure.
Seeding times:	..
Seed:	..
Storage time:	..
Germination:	..
Pretreatment of seeds:	..
Nursery method:	..
Planting method:	By direct seeding.
Growth:	Unreported
Management method and yield:	Unreported
Locality factors of the area where the shrub can be grown:	
Climate:	Subtropical and tropical; arid and semi arid.
Altitude:	Below 1,000 m.
Soil:	Alluvial, lateritic and skeletal.
Pests and diseases:	..
Seed source:	Uttar Pradesh

Name:	Botanical - Inga dulcis Local - Dekhani babul, Kachalora Bankribel, Kichimichi
Family:	Leguminoseae - Papiolionoideae
Distribution:	In most parts of moist Indian plains.
Description:	Small, 2-pinnate; stipules small, generally spinescent; floral heads in panicle, yellowish pods, twisted.
Uses:	Good quality fuel. As hedge. Arills edible.
Seeding times:	August-September
Seed:	About 1,800 seeds/kg
Storage time:	9-10 months
Germination:	90%
Pretreatment of seeds:	..
Nursery method:	Sowing in polypots
Planting method:	Sowing in pits with humus. Also by transplanting polypot seedlings.
Growth:	Unreported.
Management method and yield:	By annual trimming and pruning. Yield unreported.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical; wet, moist.
Altitude:	Below 500 m
Soil:	Sandy loam, lateritic
Pests and diseases:	..
Seed source:	Assam, West Bengal, Kerala.

Name:	Botanical - Ipomoea carnea (Syn.I. fistulosa) (Plate 15) Local - Dhal Kalmi
Family:	Convolvulaceae
Distribution:	In most of the Indian plains.
Description:	A straggling shrub with long, slender branches with milky juice; leaves simple, ovate oblong, cordate, acuminate; flowers in long peduncled fascicle, large purplish; fruit capsule; seeds silky.
Uses:	As contour hedge for soil and moisture conservation purpose. As live fence. Stems used as fuel. Leaves toxic for livestock, but a good green manure.
Seeding times:	Through the year except in winter.
Seed:	..
Storage time:	..
Germination:	..
Pretreatment of seeds:	..
Nursery method:	Propagated by stem cuttings, which are planted directly in the field.
Planting method:	Planting of about 8-10 cm long cutting in the planting area during monsoon months at 0.5 m spacing in line.
Growth:	Slow in year 1, followed by rapid growth.
Management method and yield:	The management is by simple pollarding annually at a height of 2 m. Can be pruned as well. Under rainfed conditions, a broader crop 1.6 km in length, gave, in 6 cuttings, 30 tons of green matter in one year.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical; rainfall from 800 mw-2,500 mw
Altitude:	0-1,500 m
Soil:	Degraded soil, waterlogged soil.
Pests and diseases:	..
Seed source:	Not relevant as cuttings are best propagating materials.

Name:	Botanical - Ixora arborea Local - Kotagandhal
Family:	Rubiaceae
Distribution:	Found throughout Indian plains
Description:	A small, much branched tree or shrub. Leaves opposite, oblong, coriaceous, glaucous; flowers in large corymbose terminal cymes small numerous; berries black, globose; seeds plano convex.
Uses:	Poor fodder for buffaloes. Good fuelwood; twigs used for torches. Fruits and roots used for local medicine.
Seeding times:	..
Seed:	..
Storage time:	..
Germination:	..
Pretreatment of seeds:	..
Nursery method:	..
Planting method:	Direct sowing or planting of cuttings.
Growth:	..
Management method and yield:	By topping. Yield unreported.
Locality factors of the area where the shrub can be grown:	
Climate:	Subtropical; semi arid-moist.
Altitude:	Below 500 m.
Soil:	Alluvial, lateritic, black clay.
Pests and diseases:	..
Seed source:	Maharashtra, Madhya Pradesh, Orissa.

Name:	Botanical - Jatropha curcas (Plate 16) Local - Bag-bherenda, Sada-bherenda
Family:	Euphorbiacea
Distribution:	Native of tropical America, occurring throughout India.
Description:	A tall (3-4 m) and sparsely branched, soft-wooded shrub with watery latex, leaves alternate, palmately 3 or 5-lobed, flowers in dense umbellate cymes, yellowish-white, fruits slightly over 1 cm, 3-lobed, breaks into three 2-valved cocci. Seeds ovoid-oblong, dull brownish black; root system bushy.
Uses:	Can be used as live fence in combination with other species; yields oil; seeds are rat poison when ground with palm oil; leaves reported to have insecticidal properties.
Seeding times:	Sets fruit in winter when it is leafless.
Seed:	Each seed 0.5-0.7 gms. Average seed yield of a bush 4.6 kg.
Storage time:	..
Germination:	..
Pretreatment of seeds:	Soaking in water overnight.
Nursery method:	Raised directly in the field by sowing.
Planting method:	Propagated easily by branch cutting or by dibbling of seed at a spacing of 0.5 in a line.
Growth:	Grows rapidly.
Management method and yield:	Can be cut and lopped to any desired height. No special management practices required for maintaining a live hedge. Yield unreported.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical and sub-tropical; from wet to desert conditions.
Altitude:	Below 1,000 m.
Soil:	Clay, sandy soils, soils with low fertility.

Pests and diseases: ..

Seed source: West Bengal, Bihar, Orissa, Uttar Pradesh.

Name:	Botanical - Justicia adathoda Local - Bakas; Vasaka
Family:	Acanthaceae
Distribution:	In Assam, West Bengal, Bihar, Uttar Pradesh, Himachal/Pradesh, Orissa, Kerala, Karnataka
Description:	Much branched bushy shrub with foetid smell; leaves broadly ovate-lanceolate; flowers in terminal and sub-terminal dense spikes with large green bracts and bracteoles, corolla white 2-lipped, curved, with brown markings; fruit capsule, compressed, 4 seeded.
Uses:	Leaf decoction is an effective expectorant; leaves used as insect repellant in storage of food grains; plant of medicinal importance. As contour hedge, it is useful in soil reclamation programs; leaf as green manure; used in landscaping; wood good as fuel.
Seeding times:	June-August.
Seed:	Over 5,000 seeds/kg.
Storage time:	2-3 months
Germination:	..
Pretreatment of seeds:	None required.
Nursery method:	Easily grown from stem cuttings and becomes ready for transplanting in 3-4 months.
Planting method:	Pre-sprouted stem cuttings in freshly prepared shallow pits with little humus. Stem cuttings can be directly put in the field at 30 cm x 3 m (between rows) spacing to grow contour hedge.
Growth:	Unreported.
Management method and yield:	Can be grown as an undershrub and managed by coppicing with annual rotation. Yield unreported.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical, subtropical; moist and wet.
Altitude:	Below 1,000 m.

Soil:	Sandy, sandy loam and clayey soil.
Pests and diseases:	..
Seed source:	Assam, West Bengal, Uttar Pradesh, Himachel Pradesh

Name:	Botanical - Lantana camara Local - Guya gandha, bhut-bharasa
Family:	Verbenaceae
Distribution:	Throughout India upto 800 m elevation.
Description:	A shrub, branches forming dense thickets, very prickly; leaves simple, scabrid, foetid; flowers in penduncled ovoid heads (capitat), colour changes with age; fruits small, globose, black on ripening, 2-seeded.
Uses:	Stem used as fuel; paper pulp; bark used as astringent against leprous and other obstinate ulcers; leaves used as a substitute for tea, occasionally as green manure; improves fertility of exhaused soil.
Seeding times:	Throughout the year.
Seed:	2,000 seeds/kg
Storage time:	..
Germination:	90%
Pretreatment of seeds:	..
Nursery method:	Normal shaded seed-beds or polypots.
Planting method:	In freshly prepared small pits or by direct seeding.
Growth:	Unreported.
Management method and yield:	By coppicing annually. Yield of dry fuelwood may be around 4 t/ha per year.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical and sub-tropical; semi-arid, moist and wet.
Altitude:	Below 800 m.
Soil:	All soils except very saline.
Pests and diseases:	None serious.
Seed source:	Throughout India.

Name:	Botanical - Lawsonia alba (Syn. L. inermis) Local - Mehndi, Mehedi
Family:	Lythraceae
Distribution:	Cultivated and semi-wild throughout moist and wet parts of Indian plains.
Description:	Large, erect, much branched, glabrous shrub, leaves opposite, ovate-lanceolate, entire flowers in terminal large paniculate cymes, small, dull white, strongly scented; fruits capsule, globose, with numerous seeds.
Uses:	Used extensively as hedge plant. Used as fuelwood. A reddish-brown dye obtained from leaves used by ladies for festive occasions; flowers yield "Hina attar" of perfumery.
Seeding times:	November-January.
Seed:	..
Storage time:	6-8 months
Germination:	..
Pretreatment of seeds:	Soaked in water from 20-25 days with frequent changes of water for sprouting.
Nursery method:	Sowing, cutting and layering produce good saplings.
Planting method:	Cuttings or seedlings (after root and shoot pruning). Generally grown along the fences, by planting in small pits or in upturned ploughlines.
Growth:	Unreported.
Management method and yield:	By side pruning and trimming and by coppicing to obtain fuelwood; yield unreported; but harvested stems, minus the leaves removed by beating, can produce fuel upto 0.5-0.8 t/ha from 3 year old plants.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical and sub-tropical; moist and wet.
Altitude:	Below 500 m.
Soil:	Sandy loam, lateritic and black soils, tolerates slight alkalinity.

Pests and diseases: ..

Seed source: AU over Indian plains.

Name:	Botanical - Mallotus philippinensis Local - Akus, Kamala, Rohini
Family:	Euphorbiaceae
Distribution:	Assam, West Bengal, Uttar Pradesh, Bihar, Himachel Pradesh
Description:	A much branched small tree (Max. 10 m) which can be managed as shrub; leaves ovate or rhomboid, acute or acuminate; young stem covered with rusty-yellow glandular hairs and permanently with small red glands; male racemes clustered at the tips of branches; female racemes stout; capsule 3-lobed, densely covered with red glands.
Uses:	Provides good fuelwood and 'Kamala' dye.
Seeding times:	February-March.
Seed:	1,500 seeds/kg
Storage time:	Loses viability fast with time.
Germination:	Often uncertain.
Pretreatment of seeds:	Nil
Nursery method:	Grown by sowing in polypots.
Planting method:	4-5 months old seedlings are planted in small pits, previously supplied with humus. Can be grown by direct sowing in ploughed soil or in small trenches.
Growth:	Unreported.
Management method and yield:	Annual pruning is a likely management practice. Yield unreported.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical and sub-tropical; moist and wet.
Altitude:	Below 1,000 m.
Soil:	Sandy, sandy loam and loam
Pests and diseases:	Root fungus and heartwood borer. None serious.
Seed source:	Assam, West Bengal, Uttar Pradesh.

Name:	Botanical - Manilkara hexandra (Syn: Mimusops hexandra) Local - Khirni
Family:	
Distribution:	
Description:	A small tree; leaves oblanceolate or elliptic-obovate, emerginate; flowers few in axillary clusters, small, white, petals with 2-fid ligules; berry ellipsoid, 1.25 cm. long.
Uses:	Seedlings used as root-stock for sapota; fruits edible; branches used for making walking sticks; wood used for making tool-handles, agricultural implements, etc.; leaves cattle fodder.
Seeding times:	April-June.
Seed:	± 400 seeds/kg
Storage time:	1-3 months.
Germination:	..
Pretreatment of seeds:	..
Nursery method:	Seedlings can be raised in polypots.
Planting method:	In small pits with humus and bonemeals. Also by sowing in rains in upturned ploughlines. Being a light demander, cannot be grown under shade.
Growth:	..
Management method and yield:	..
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical; semi-arid and moist.
Altitude:	Below 500 m.
Soil:	Sandy loam and clayey.
Pests and diseases:	..
Seed source:	..

Name:	Botanical - Mimosa himalayana
Family:	Leguminoseae - Mimosoideae
Distribution:	Assam and subtropical Himalayas
Description:	A straggling prickly shrub; young branches red, beset with short recurved prickles; compound, pinnae opposite, 4-10 pairs; flowers red to white; pod linear-oblong.
Uses:	Fuelwood; can be used to stabilize landslips and to act as soil trap when planted as contour hedge. Can be used as live fence.
Seeding times:	November-January.
Seed:	..
Storage time:	..
Germination:	..
Pretreatment of seeds:	..
Nursery method:	..
Planting method:	..
Growth:	
Management method and yield:	
Locality factors of the area where the shrub can be grown:	
Climate:	Subtropical and temperate; wet, moist and semi-arid.
Altitude:	Below 1,800 m.
Soil:	Clay-sandy loam.
Pests and diseases:	..
Seed source:	Uttar Pradesh.

Name:	Botanical - Morinda angustifolia Local - Daruharidra, Haldi-kung; Asho
Family:	Rubiaceae
Distribution:	Assam, Andaman Islands, Uttar Pradesh
Description:	A large shrub; leaves broadly elliptic or oblanceolate; stipules acute; flowers in axillary, peduncled, compact heads with coherent calyx; corolla white; globose multiple fruit.
Uses:	Stems provide fuelwood; root bark provides the yellow 'Hardi' dye; leaves used for rearing silk-worm; fruit pulp used for cleaning hairs.
Seeding times:	October-January.
Seed:	± 2,000 seeds/kg
Storage time:	5-8 months.
Germination:	..
Pretreatment of seeds:	..
Nursery method:	Seedlings can be raised in polypots.
Planting method:	Seedlings in small pits with humus and bonemeal.
Growth:	..
Management method and yield:	..
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical; wet and moist.
Altitude:	1,000-2,000 m.
Soil:	Sandy, sandy loam.
Pests and diseases:	..
Seed source:	Assam, Andaman Islands, Uttar Pradesh.

Name:	Botanical - Murraya koenigii Local - Basanfa, curry-pata, kathnim
Family:	Rutaceae
Distribution:	Found throughout Indian plains.
Description:	An unarmed, medium to large, spreading shrub; leaves imparipinnate with a characteristic aromatic smell; leaflets 10-29 oblique; flower in axillary and terminal, much branched, white; fruit berry-like.
Uses:	Can be used as contour hedge plant to arrest soil erosion; fuelwood; leaves used in curries and also yields aromatic volatile oil used as a fixative in soap perfumery; wood used for making agricultural implements.
Seeding times:	June-July.
Seed:	About 4,600 seeds/kg
Storage time:	3-4 months.
Germination:	..
Pretreatment of seeds:	..
Nursery method:	Seedlings can be grown in polypots.
Planting method:	Seedlings are planted in pits. Direct seeding also can be done. Seeds germinate freely under shade; therefore can be used for enriching degraded forests.
Growth:	Rapid.
Management method and yield:	Side pruning and trimming for fuelwood collection and deleafing for curry making. Yield unreported.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical and sub-tropical; moist and wet.
Altitude:	Below 1,500 m.
Soil:	Loam and sandy-loam.
Pests and diseases:	Several species of insects feed on sap, twigs and shoots and damage leaves by defoliation, leaf mining and rolling. They are all controllable.
Seed source:	South India, Bengal, Assam, Punjab, Haryana.

Name:	Botanical - Nyctanthes arbor-tristis Local - Harsinghar, Seoli
Family:	Oleaceae
Distribution:	Sub-Himalayan region, Bihar-Chotanagpur, Rajasthan, Madhya Pradesh, Andhra Pradesh
Description:	A small deciduous tree/large shrub with quadrangular branches and greenish white rough bark; leaves opposite; flowers sweet scented, white with orange corolla tube; fruit capsule; seeds exalbuminous.
Uses:	Soil conservation; fuelwood; corolla tubes as orange-dyes; bark as tanning material; leaf fodder poor quality, not browsed.
Seeding times:	Flowers August-October; fruits cold season.
Seed:	..
Storage time:	..
Germination:	..
Pretreatment of seeds:	..
Nursery method:	..
Planting method:	Direct seeding and cutting.
Growth:	..
Management method and yield:	It coppices easily. It can be managed by annual coppicing or by pruning. As it tolerates shade, the shrub can be grown as an under crop to an overhead tree canopy. Yield unreported.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical; moist semi-acid.
Altitude:	Below 1,000 m.
Soil:	Sandy loam, lateritic.
Pests and diseases:	A powdery mildew attacks foliage but does not do much damage.
Seed source:	West Bengal, Bihar, Uttar Pradesh.

Name:	Botanical - Opuntia dillenii Local - Nag-phana, Phani-mansha
Family:	Cactaceae
Distribution:	All arid areas of Indian plains upto 800 m elevation.
Description:	A leafless, much branched shrub; stems modified into flat or rounded phyloclades, nodes modified in aerioles with numerous acropetally borne spines; flowers large, showy yellow; fruits berry, deep purplish red on ripening; seeds numerous, black.
Uses:	Dried stem is a source of fuel for the poor. Generally grown as a hedge plant; fruits edible, baked fruit relieves whooping cough; a syrup prepared from the ripe fruit increases bile secretion.
Seeding times:	June-September.
Seed:	± 10,000 seeds/kg
Storage time:	4-6 months.
Germination:	..
Pretreatment of seeds:	..
Nursery method:	Seeds should be placed on sandbeds prepared in small earthen pots; stem cuttings give much better result.
Planting method:	Pieces of phyloclades can be placed directly in freshly prepared pits or in ploughed lines.
Growth:	Unreported.
Management method and yield:	By trimming, pruning, topping hedges. Yield unreported.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical; arid and semi-arid.
Altitude:	Below 800 m.
Soil:	All soils except clay and saline soils.
Pests and diseases:	Unreported.
Seed source:	Throughout India.

Name:	Botanical - Parkinsonia aculeata Local - Bilati Kikar
Family:	Leguminoseae - Caesalpinioideae
Distribution:	Throughout the arid plains.
Description:	A large spinous shrub or small tree with slender semipendulous branches; main rachis modified into a rachillum long, flattened with very small leaflets; paripinate; flowers in short axillary racemes; sepals green, united; petals spreading, yellow.
Uses:	Branches lopped for fodder; provides firewood; planted along road-sides and in parks. Can be grown as a hedge.
Seeding times:	September-December.
Seed:	± 1,200 seeds/kg.
Storage time:	
Germination:	80-90%
Pretreatment of seeds:	Soaked in water for 3-4 days or in warm water for one day.
Nursery method:	Seedlings can be raised in polypots.
Planting method:	In freshly prepared pits with humus and bonemeals. By direct seeding also. By branch cutting.
Growth:	Shoot cuttings average 1 m a year in length and 1.5 cm in diameter.
Management method and yield:	By drastic pruning, topping, by lopping for fodder, by clearfelling and resowing or planting of cutting for regeneration. Yield unreported.
Locality factors of the area where the shrub can be grown:	
Climate:	Sub-tropical, tropical; dry, moist and wet.
Altitude:	Below 500 m.
Soil:	All soils including saline soils.
Pests and diseases:	..
Seed source:	Throughout India.

Name:	Botanical - Punica granatum Local - Darimba, dalim
Family:	Lythraceae
Distribution:	Common in bouldery, dry ravines in Himalayas upto about 1800m.
Description:	A shrub/small tree with dark grey bark; leaves opposite, clustered; flowers sessile, three-flowered cymes bright red; fruit (in wild state) globose; seeds long angled with a ruby colored aril filled with juice.
Uses:	Fuelwood; fruits eaten, bark astringent used as medicine and tanning, can be grown as hedge.
Seeding time:	Flowers April-May; fruits July-September.
Seeds:	
Germination:	..
Pretreatment of seeds:	..
Nursery method:	Hard wood cuttings 25-50 cm long from the previous season's growth are taken. They are planted in nursery beds leaving only one or two buds and transplanted next year.
Planting method:	By seeds, by stem cutting and by seedlings.
Growth:	Rapid
Management method and yield:	..
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical and sub-tropical; moist, semi arid.
Altitude:	Below 2000 m
Soil:	Sandy loam
Pests & Diseases:	Die back of twigs; dry rot of pomegranate fruits. Controllable
Seed source:	West Bengal, Karnataka

Name:	Botanical - Randia dumetorum (Syn: R. spinosa) Local - Menphal, Madan
Family:	Rubiaceae
Distribution:	In sub-Himalayan tracts and many parts of the Indian peninsula.
Description:	A large shrub/small tree with straight axillary thorns; leaves mostly clustered on short branchlets, obovate; flowers solitary terminal on short-shoots, white, turns yellow with age; berry globose, crowned with calyx.
Uses:	Wood used as small timber; provides fuelwood (calorific value 4707 kcal/kg); fruits edible and antidysenteric; leaves as fodder; can be used as contour hedge to arrest erosion and as live fence.
Seeding time:	August-January
Seeds:	
Storage time:	..
Germination:	..
Pretreatment of seeds:	..
Nursery method:	Seedling can be raised by polypots.
Planting method:	Seedlings in small pits along with humus and bonemeal. Also by direct seeding.
Growth:	Reported mean annual girth increment 1.5-2.2 cm
Management method and yield:	By pruning by topping and by cutting part of the shrub and by promoting root sucker regeneration. Yield unreported.
Locality factors of the area where the shrub can be grown:	
Temperature:	Subtropical and tropical; dry, moist and wet.
Rainfall:	
Altitude:	Below 1000 m
Soil:	Loam, sandy loam
Pests & Diseases:	..
Seed source:	Sikkim, Uttar Pradesh, West Bengal

Name:	Botanical - Rhamnus virgatus Local - ..
Family:	Rhamnaceae
Distribution:	Middle and upper hills of eastern Himalayas
Description:	A deciduous shrub or small tree, generally with a stout spine at the forks of the branches; leaves generally sub-opposite; flowers 4-merous in dense axillary fascicles; fruit 0.3 cm diameter, globose.
Uses:	Fuelwood; wood for agricultural implements; fruit purgative.
Seeding time:	Flowers May-June; fruits July-October
Seeds:	..
Storage time:	..
Germination:	..
Pretreatment of seeds:	..
Nursery method:	..
Planting method:	..
Growth:	..
Management method and yield:	..
Locality factors of the area where the shrub can be grown:	
Climate:	Temperate; moist, semi arid.
Altitude:	1000-3000 m.
Soil:	Sandy and stony
Pests & Diseases:	..
Seed source:	Assam

Name:	Botanical - Rhus parviflora Local - Khag-bhalayo
Family:	Anacardiaceae
Distribution:	In Himalayas at about 600-2100 m elevation and Pachmari hills in Madhya Pradesh.
Description:	A small deciduous tree, branches and leaf beneath softly pubescent; leaves imparipinnate, panicles large, terminal; flowers minute, white; drupes very small, compressed globose.
Uses:	Fruits edible; stem provides firewood. Useful for stabilizing bare and unstable hillsides.
Seeding time:	October-November
Seeds:	92,000 seeds/kg
Storage time:	..
Germination:	..
Pretreatment of seeds:	..
Nursery method:	Seed depulped by drying and rubbing against each other and sown. Seedlings can be raised in polypots.
Planting method:	Seedlings in pits with humus. By direct seeding.
Growth:	Unreported.
Management method and yield:	By trimming, topping and coppicing at 1 year rotation. Also by cutting a part of the shrub roots thus promoting root sucker regeneration. Yield per year can be about 2-3 tons from the species growing as an undershrub.
Locality factors of the area where the shrub can be grown:	
Climate:	Sub-tropical and temperate, moist
Altitude:	600-2100 m.
Soil:	Sandy loam, and skeletal
Pests & Diseases:	..
Seed source:	Uttar Pradesh.

Name:	Botanical - Rosa moschata Local - Gulab
Family:	Rosaceae
Distribution:	In the Himalayan mountains, between 1000-2000 m.
Description:	A large thorny climbing shrub; prickles stout, recurved; leaves compound with scattered prickles beneath; flowers white, sweet scented; fruit oboroid, dark brown.
Uses:	Helps in soil conservation as it grows in rock surfaces.
Seeding time:	Flower May-June; fruits June-July
Number of seeds/kg:	..
Storage time:	..
Germination:	..
Pretreatment of seeds:	..
Nursery method:	..
Planting method:	..
Growth:	..
Management method and yield:	Can be heavily pruned annually. Estimated annual dry fuelwood yield of a dense shrub layer is 4 tons/ha.
Locality factors of the area where the shrub can be grown:	
Climate:	Sub-tropical and temperate; moist, semi-arid.
Altitude:	1000-2000 m.
Soil:	Rocks, eroded ravines.
Pests & Diseases:	..
Seed source:	Assam, West Bengal, Uttar Pradesh, Himachel Pradesh.

Name:	Botanical - Salvadora persica Local -
Family:	Salvadoraceae
Distribution:	Gujarat, Rajasthan, Punjab, Haryana
Description:	A much branched shrub or a small tree
Uses:	Used as camel fodder. Seed cake for fat extraction. Root barks as medicine. As a wind breaker in farms.
Seeding time:	..
Seeds:	..
Storage time:	..
Germination:	..
Pretreatment of seeds:	Not required
Nursery method:	In polypots.
Planting method:	Direct seeding. Slow growth. 3 year old nursery seedling.
Growth:	Coppice growth slow
Management method and yield:	By coppicing. Yield low mean annual increment.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical; acid to desert
Altitude:	Plains
Soil:	Sandy loam and saline.
Pests & Diseases:	Defoliating larvae of beetles and a number of fungi damaging leaves; controllable.
Seed source:	Gujarat, Rajasthan, Punjab, Haryana

Name:	Botanical - Sesbania bispinosa (Syn. S cannabina) Local - Dhaincha
Family:	Leguminoseae
Distribution:	Cultivated in Indian plains.
Description:	A softwood; leaves paripinnate. Flower pale yellow in racemes. Pods 6-9 inches.
Uses:	Effective wind breaker; contour hedge; gum from seeds; leaves make good cattle fodder, green manure; stems as fuelwood, (calorific value 4500 kcal/kg), for a paper pulp; fixes nitrogen thus improving soil; excellent for suppressing weeds, even Imperata cylindrica.
Seeding time:	October to February.
Seeds:	
Storage time:	One year
Germination:	80%
Pretreatment of seeds:	None required
Nursery method:	Nil
Planting method:	Close sowing (4000 stems per ha.) in the field or broadcasting.
Growth:	It is a quick growing shrub which can produce fuelwood in 6 months. Two harvests a year are possible.
Management method and yield:	Clearfelling annually and sometimes twice a year. The plant attains maturity in 5-7 months. In good soils, it attains height of 3-5 m and mid-length diamater of 1.5 to 5.0 cm. A crop may yield upto 7-10 bone-dry tons per ha per year.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical, sub-tropical; moist, wet.
Altitude:	0-1200 m
Soil:	Adapted to difficult soil, grows in saline and alkaline and wet to water logged soil.
Pests & Diseases:	..
Seed source:	West Bengal, Bihar, Uttar Pradesh, Orissa.

Name:	Botanical - Streblus asper Local - Siora, Karchanua
Family:	Urticaceae
Distribution:	In the sub-Himalayan region ascending to 450 m and in peninsular India upto 600 m.
Description:	A small evergreen tree or rigid shrub with milky juice; leaves alternate; irregularly toothed; flowers dioecious, male in short-peduncled heads, female pendunculate single or few together in leaf axils; fruit one-seeded yellow berry.
Uses:	Fuel; wood for yokes; twigs make toothbrushes; its milky juice is medicinal; fruit edible; good as hedge.
Seeding time:	Flowers January-March; fruits May-July
Seeds:	
Storage time:	..
Germination:	..
Pretreatment of seeds:	..
Nursery method:	..
Planting method:	..
Growth:	..
Management method and yield:	Coppices very well. Can be annually pruned or coppiced for fuelwood production. Estimated yield 2-4 tons/ha annually.
Locality factors of the area where the shrub can be grown:	
Climate:	Subtropical, tropical; Semi arid, moist.
Altitude:	Upto 100 m.
Soil:	Sandy, alluvial, lateritic.
Pests & Diseases:	..
Seed source:	West Bengal, Bihar, Uttar Pradesh.

Name:	Botanical - Tamarix aphylla Local - Lal-Jhau
Family:	Tamaricaceae
Distribution:	South west Punjab, Haryana, Rajasthan and North west Uttar Pradesh.
Description:	A small tree similar to T. dioica but with drooping reddish branches; leaves small, sheathing; foliage more grey than T. dioica; flowers pink; fruit and capsule.
Uses:	Suitable for wind-break and shelter-belt plantations; twigs used for making baskets; wood used in making agricultural implements. A good garden plant. Stems fairly good as fuelwood.
Seeding time:	October-March.
Seeds:	..
Storage time:	4-6 months
Germination:	..
Pretreatment of seeds:	..
Nursery method:	By sprouting root and shoots of stem cuttings in poly pots.
Planting method:	By planting 40 cm. long healthy green branch cuttings or seedlings in small pits with superphosphate and green manure. By planting cuttings as a dense hedge in cultivated lines.
Growth:	Unreported.
Management method and yield:	Can be managed by coppicing at 8 years rotation. Yield unreported.
Locality factors of the area where the shrub can be grown:	
Altitude:	Below 200 m.
Soil:	Sandy-clay soil which can retain water for a longer period of the year; tolerates salty soils, poor quality water and drought.
Pests & Diseases:	..
Seed source:	Uttar Pradesh, Haryana, Punjab, Rajasthan and Gujarat.

Name:	Botanical - Tamarix dioica Local - Lal Jhau
Family:	Tamaricaceae
Distribution:	Throughout coastal India.
Description:	A gregarious shrub, sometimes arborescent; leaves scaly, sheathing and clasping the stem; plants dioecious; flowers in short, dense spikes, pink; stamens 5; capsules oblong.
Uses:	Stem provides good fuelwood. Twigs used for making baskets, wood for making persian wheels. Very useful as windbreak to arrest march of shifting sands.
Seeding time:	October-April
Seeds:	..
Storage time:	..
Germination:	..
Pretreatment of seeds:	..
Nursery method:	See T. aphylla. Seedlings may be raised in poly pots.
Planting method:	Same as T. aphylla.
Growth:	Under favourable conditions reaching annual girth increment of 11.38 cm.
Management method and yield:	Same as T. aphylla.
Locality factors of the area where the shrub can be grown:	Same as T. aphylla
Seed source:	West Bengal (mainly Sundarban)

Name:	Botanical - Tecoma undulata Local - Rugtnora
Family:	Bignoniaceae
Distribution:	Rajasthan, Uttar Pradesh, Haryana, Maharashtra
Description:	A shrub or a small tree; leaves narrowly oblong ± 15 cm long, entire-undulate; corymbs terminating in stout lateral branches; flowers red; capsules slightly curved; seeds narrow, winged.
Uses:	Fuelwood; can be used as a hedge plant; wood useful for making small furniture, carving and for agricultural implements.
Seeding time:	May-August
Seeds:	..
Storage time:	..
Germination:	..
Pretreatment of seeds:	..
Nursery method:	Seedlings may be raised in shaded seedbeds; cuttings treated with root hormones (IAA) produce better results.
Planting method:	In pits with enough humus and bone-meal.
Growth:	Unreported.
Management method and yield:	Pruning, trimming, topping. Yield unreported.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical and sub-tropical semi-arid to moist.
Altitude:	Below 700 m.
Soil:	Sandy loam
Pests & Diseases:	..
Seed source:	Rajasthan.

Name:	Botanical - Thevetia peruviana (Syn. T. nereifolia) Local - Kokla phul, Pile Kuner
Family:	Asclepadiaceae
Distribution:	Cultivated throughout India in gardens.
Description:	A large evergreen shrub to a small tree, glabrous, latex milky; leaves long, narrow 1-nerved; flowers in terminal few-flowered cymes, large, yellow or white on pink campanulates; fruit a slightly compressed two-lobed drupe with stony endocarp.
Uses:	Kernel rich source of cardiac glycosides - useful in heart disease; glycosides also present in bark, flowers and roots; a common garden plant; provides fuelwood.
Seeding time:	Throughout the year.
Seeds:	25-30 seeds/kg
Storage time:	0-7 months
Germination:	70-80%
Pretreatment of seeds:	Lightly breaking the endocarp.
Nursery method:	Seedling can be raised in poly-pot.
Planting method:	Seedlings in freshly prepared small pits with humus. It can be grown also from seeds and cuttings.
Growth:	Rapid.
Management method and yield:	Trimming, lopping and topping annually. Yield unreported.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical and sub-tropical; moist and wet.
Altitude:	Below 1200 m.
Soil:	Comfortable in well drained shady loam.
Pests and diseases:	A viral disease showing severe mining and curling of the leaves has been reported. No insect has yet been identified.
Seed source:	Throughout India.

Name:	Botanical - Trema politoria Local - Banharria
Family:	Urticaceae
Distribution:	In dry places in subtropical Himalayas and throughout north India.
Description:	A shrub or small tree with smooth bark and rough branches; leaves acuminate serrulate, trinerved at the base; cymes compact; fruit drupe, globose.
Uses:	Fuel; leaves for fodder; bark strong fibre; soil binder.
Seeding time:	Flowers April-June; fruits October-November
Seeds:	..
Storage time:	..
Germination:	..
Pretreatment of seeds:	..
Nursery method:	..
Planting method:	Direct sowing; by stump planting.
Growth:	Rapid
Management method and yield:	..
Locality factors of the area where the shrub can be grown:	
Climate:	Subtropical; semi arid and moist.
Altitude:	Upto 1000 m.
Soil:	Sandy and alluvial.
Pests & Diseases:	Defoliators. Controllable.
Seed source:	West Bengal, Punjab, Uttar Pradesh, Bihar

Name:	Botanical - Viburnum foetens Local -
Family:	Caprifoliaceae
Distribution:	Western Himalaya.
Description:	A shrub with stout branches, leaves 6 cm by 3.5 cm, elliptic-oblong, pubescent beneath, lateral nerves closely parallel; flowers light rosy, small; fruit drupe ellipsoid.
Uses:	As contour hedges for soil conservation in mountain slopes.
Seeding time:	Flowers April-May; fruits May-July
Seeds:	..
Storage time:	..
Germination:	..
Pretreatment of seeds:	..
Nursery method:	..
Planting method:	Planting by seeds or by cutting, planting during rains.
Growth:	Unreported
Management method and yield:	..
Locality factors of the area where the shrub can be grown:	
Climate:	Temperate; moist
Altitude:	Over 2000 m
Soil:	Organic and mountainous
Pests & Diseases:	..
Seed source:	Himachal Pradesh

Name:	Botanical - Vitex negundo Local - Sambhalu, Nishinda
Family:	Verbenaceae
Distribution:	Common in many parts of India below 1500 m elevation.
Description:	A tall, much branched shrub with quadrangular tomentose branchlets; leaves palmately compound with 3-5 leaflets, aromatic; flowers blueish-purple in much branched panicle; fruits a succulent drupe; roots strong and deep.
Uses:	Used as live fences (not browsed by cattle). Can be used as a contour hedge in sandy arid areas for soil retention and moisture conservation. Stem used as firewood. Roots and leaves used in local medicine, branches and twigs for basket-making.
Seeding time:	Throughout the year
Seeds:	5-6 mm in diameter invested at the base with enlarged calyx.
Storage time:	3 weeks
Germination:	..
Nursery method:	Hard wood cuttings are planted in nursery bed or in polythene tubes in May-June. After 2 months transferred to the field.
Planting method:	Cuttings may be planted directly in the field with 80% success.
Growth:	It grows fairly rapidly.
Management method and yield:	Can be managed by coppicing with a rotation of 2 years. Likely yield is 1 kg annually in 6 metres of live plants in live fences, yields about 0.3 tons/ha of air-dry fuelwood when it is planted on contour 5 m apart.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical and sub-tropical; moist, wet with rainfall ranging from 600-2000 mm.

Altitude:	0-1500 m
Soil:	Degraded soil, sandy soil
Pests & Diseases:	Fungus Cercospora agarwalli has been noticed on leaves. Larvae of a number of insect-pests defoliate, mine and fold the leaves. Controllable.
Seed source:	Uttar Pradesh, Bihar, West Bengal, Sikkim, Punjab, Haryana.

Name:	Botanical - Woodfordia fruticosa (Syn: W. floribunda) Local - Dawi, thawi, santha, dhaula
Family:	Lythraceae
Distribution:	In Himalayan foothills upto 1500 m
Description:	A shrub 1-3 m high with long, slender branches; leaves opposite, lanceolate; flowers in axillary, short paniculate cymes; corolla tubular, scarlet; capsules ellipsoid, membranous; seeds brown, minute, smooth.
Uses:	Very useful for landslip reclamation as soil improver; poorman's fuelwood; ornamental shrub; gum used as a substitute of Tragacanth; flowers yield yellow and red dye; bark and leaves used for tanning.
Seeding time:	June-July
Seeds:	..
Storage time:	..
Germination:	..
Pretreatment of seeds:	..
Nursery method:	..
Planting method:	..
Growth:	..
Management method and yield:	It coppices well. Can be managed on a short rotation of 3-5 years. yield unreported.
Locality factors of the area where the shrub can be grown:	
Temperature:	Tropical; Semi-arid, moist
Rainfall:	
Altitude:	Below 1500 m
Soil:	Sandy loams, lateritic
Pests & Diseases:	..
Seed source:	Bihar, Orissa, West Bengal, Uttar Pradesh, Tamil Nadu.

Name:	Botanical - Zizyphus mauritiana, (Syn. Z. jujuba) (Plate 17) Local - Ber, Bar Koli Boyer
Family:	Rhamnaceae
Distribution:	Throughout India
Description:	A small tree with stout and curved spinous stipule; leaves short, ovate-oblong, palmi-nerved; flowers stoutly pedicellate in small axillary clusters, green; fruits round or elongated drupes with fleshy mesocarp, sweet or sour.
Uses:	Fruits edible; branches provide good fuelwood; leaves good fodder.
Seeding time:	January-March
Seeds:	700-900 seeds/kg
Storage time:	One year
Germination:	70-80%
Pretreatment of seeds:	Treatment with giberralic acid after stratification in flats of sand and kept exposed to weather through the winter.
Nursery method:	Seedling can be raised easily by sowing in polypots, but bud grafts are now more popular; stumps made from 1 year old seedlings also successful and beneficial. Rooting may be obtained by air layering with IBA and NAA.
Planting method:	At the onset of rain, sapling can be planted in small pits, previously added with superphosphate and humus. Can be also raised by direct sowing or pre-treated seeds, and by stump-planting. Propagation by cuttings has been tried without success.
Growth:	Mean annual girth increment 2.6 cm.-4 cm.
Management method and yield:	Topping, trimming and pruning can be done annually. If fruits are not one of the products, it can be managed by coppicing at 5-years' rotation. Fuelwood yield under average conditions through trimming and pruning is 2-3 tons/ha./year.
Locality factors of the area where the shrub can be grown:	

Climate:	Tropical with rainfall of over 600 mm.
Altitude:	Below 1000 m
Soil:	Sand, sandy loam, clayey loam, clay.
Pests & Diseases:	Nothing serious
Seed source:	UP, Rajasthan

Name:	Botanical - Zizyphus nummularia Local - Jharber
Family:	Rhamnaceae
Distribution:	Punjab, Rajasthan and dry parts of peninsular India.
Description:	A shrub with constantly zigzag and slender branches; stipules curved spinous; leaves small, mostly orbicular, palminerved, greyly-pubesent above; flowers minute, green in axillary cluster; pental margins reflexed; fruits very small, with fleshy mesocarp.
Uses:	Fruits edible; bark used for tanning; suitable for wind-break and shelter-belts; can be used as lac host; good fuelwood; leaves provide fodder for goats.
Seeding time:	November-February
Seeds:	2000 seeds/kg
Storage time:	4-6 months
Germination:	60%
Pretreatment of seeds:	Same as Z. mauritiana
Nursery method:	Same as Z. mauritiana
Planting method:	By sowing, by stumping and by transplanting in small pits with a little of superphosphate and humus.
Growth:	
Management method and yield:	Same as Z. mauritiana.
Locality factors of the area where the shrub can be grown:	
Climate:	Tropical, arid and semi arid rainfall over 200 mm.
Altitude:	Below 200 m.
Soil:	Sandy, sandy loams
Pests & Diseases:	No serious pests and diseases.
Seed source:	Punjab, Haryana, Rajasthan

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Plate 1. Shrub sinusae, with branches close to ground, preventing raindrop erosion.

Plate 2. Root sucker spread of Clerodendron inerme on Kerala coast preventing beach erosion.

Plate 3. Live fence of Glyricidia sepium lopped and pollarded annually for green manure and fuel.

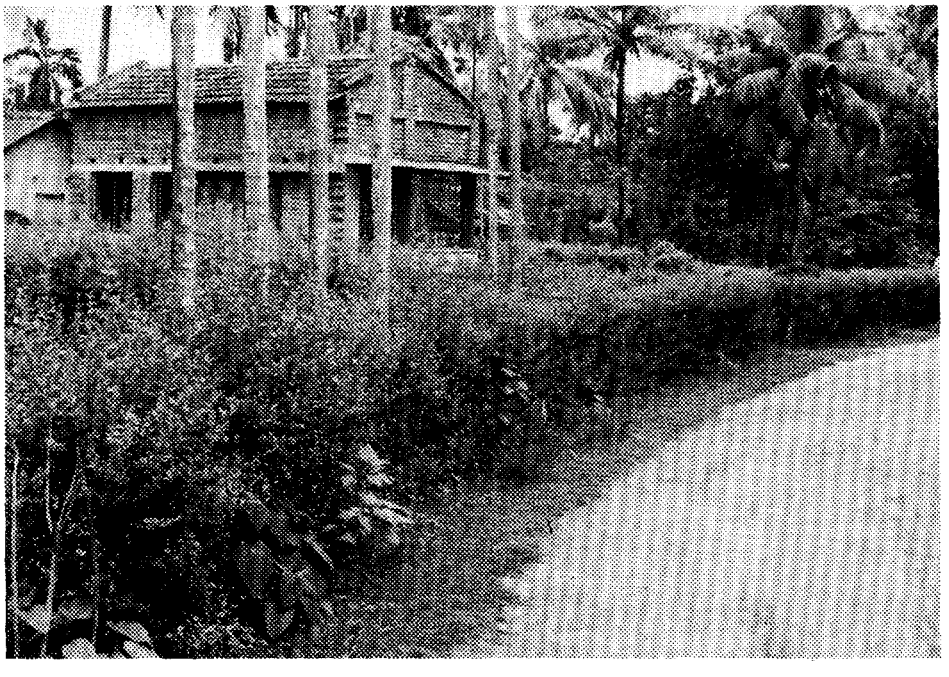

Plate 4. Duranta sp. live fence.

Plate 5. Ipomoea carnea live fence on soil inundated by rain.

Plate 6. Jatropha curcus live fence grown from cuttings.

Plate 7.
Cassia auriculata's abundant pods.

Plate 8. Acacia trees subject to erosion as they have no shrub, grass, or forb layer.

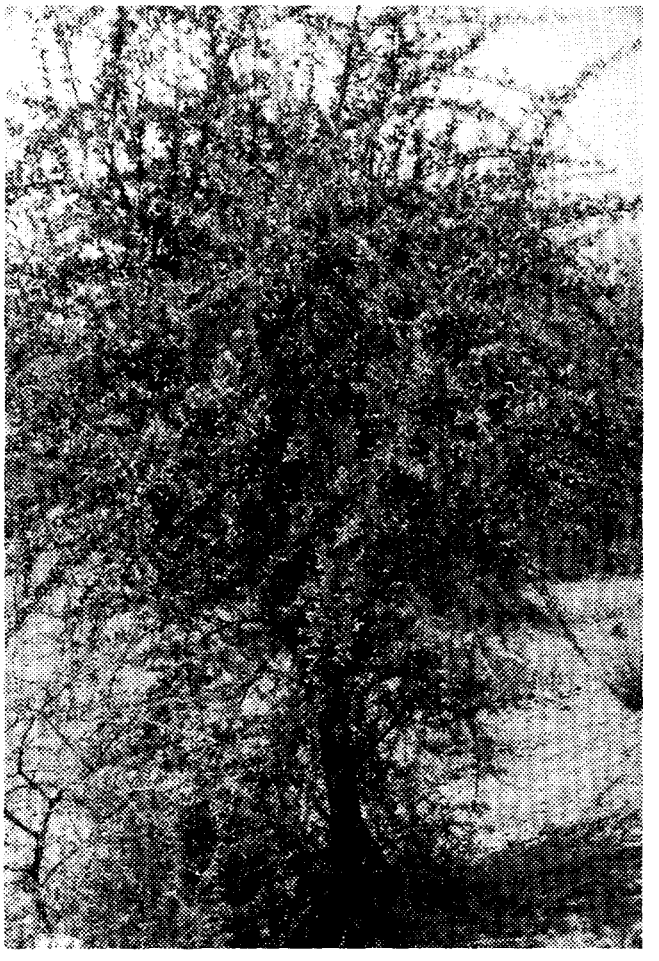

Plate 9.
Balanites aegyptica.

Plate 10.
Calotropis gigantea.

Plate 11.
Capparis decidua.

Plate 12.
Clerodendron viscosum.

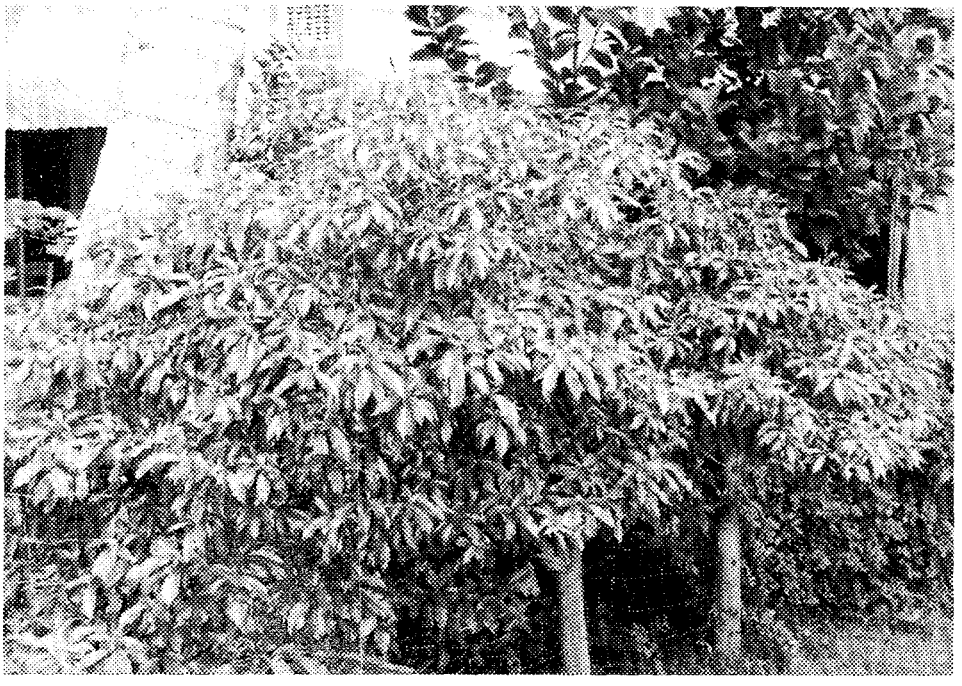

Plate 13. Ervatamia coronaria.

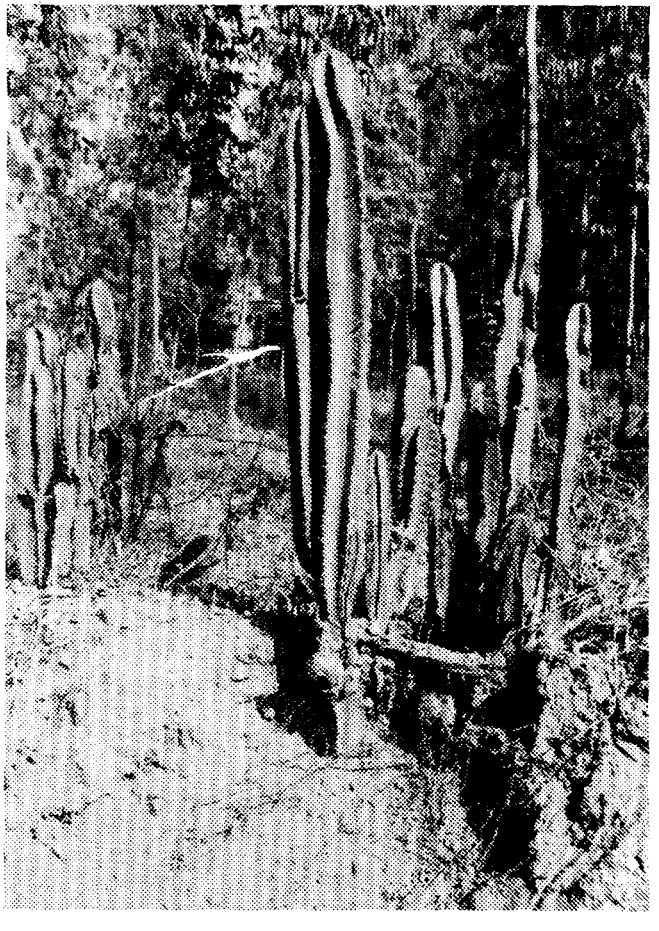

Plate 14.
Euphorbia sp.'s stout tap root.

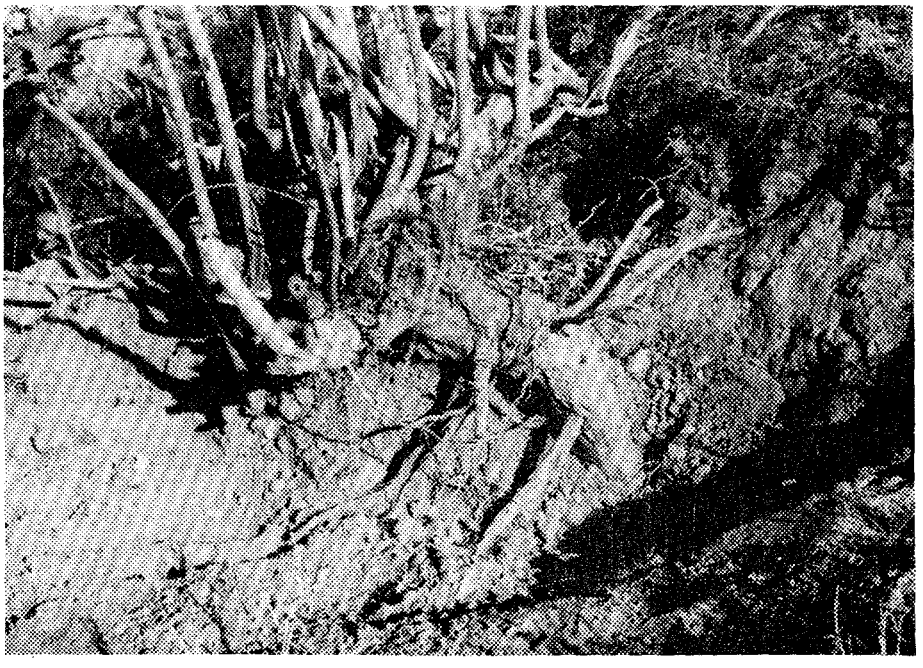

Plate 15. Ipomoea carnea's root system.

Plate 16. Jatropha curcus.

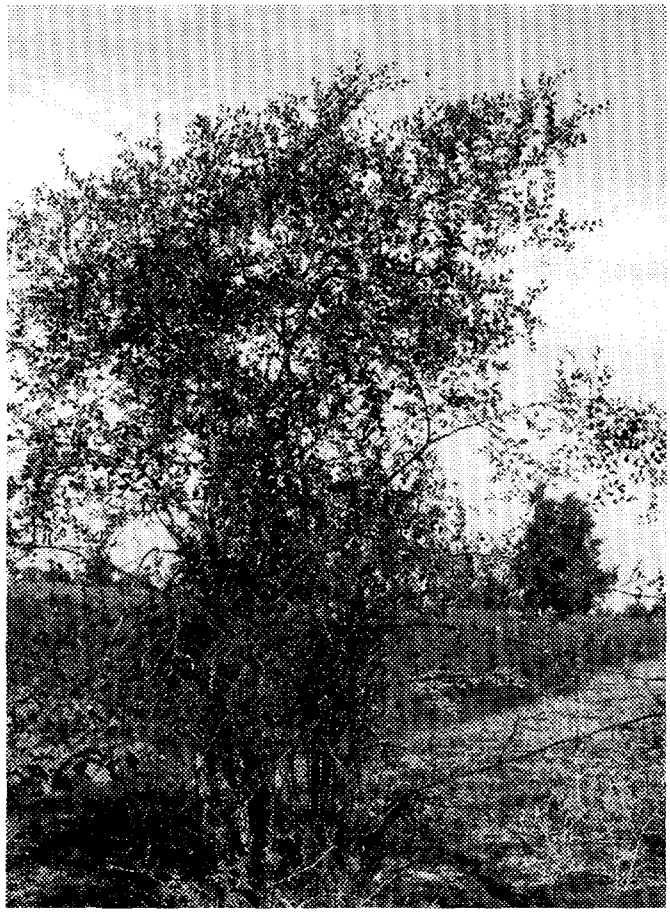

Plate 17. Zizyphus mauritiana.

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