Chapter 2
Natural Sources of Fibre

Introduction

A detailed study of five fibre-yielding plants (Table 2.1) was undertaken. The observations dealing with the morphological and distributional features of various species, details of fibre and its extraction, and final products made out of different fibres have been described in the following sections.

Description of Plants

The plant morphology of the selected species varies from trees to perennial succulents (Plates 2.1 and 2.2). The literature is full of detailed morphological and taxonomical features (Osmaston 1927, Naithani 1984, Samant 1987) and varied uses (Anonymous 1970, 1988). Thus, only a brief de-

Table 2.1: Some Features of Selected Fibre-yielding Plants

Plant species	Family	Growth form / Propagation / Parts Used for Fibre Extraction
Cannabis sativa Linn	*Cannabinaceae*	Tall annual herb/seed/ stem
Girardiana heterophylla Decne	*Urticaceae*	Annual herb/ seed and rhizome/stem
Grewia oppositifolia Roxb. ex Mast	*Tiliaceae*	Moderate semi-deciduous tree/seed/branch (bark)
Agave sisalana Perr	*Amaryllidaceae*	Perennial succulent/bulbils and suckers/leaves
Daphne papyracea Wall. ex Steud	*Thymelaeaceae*	Evergreen perennial shrub/seed/leaves and stem

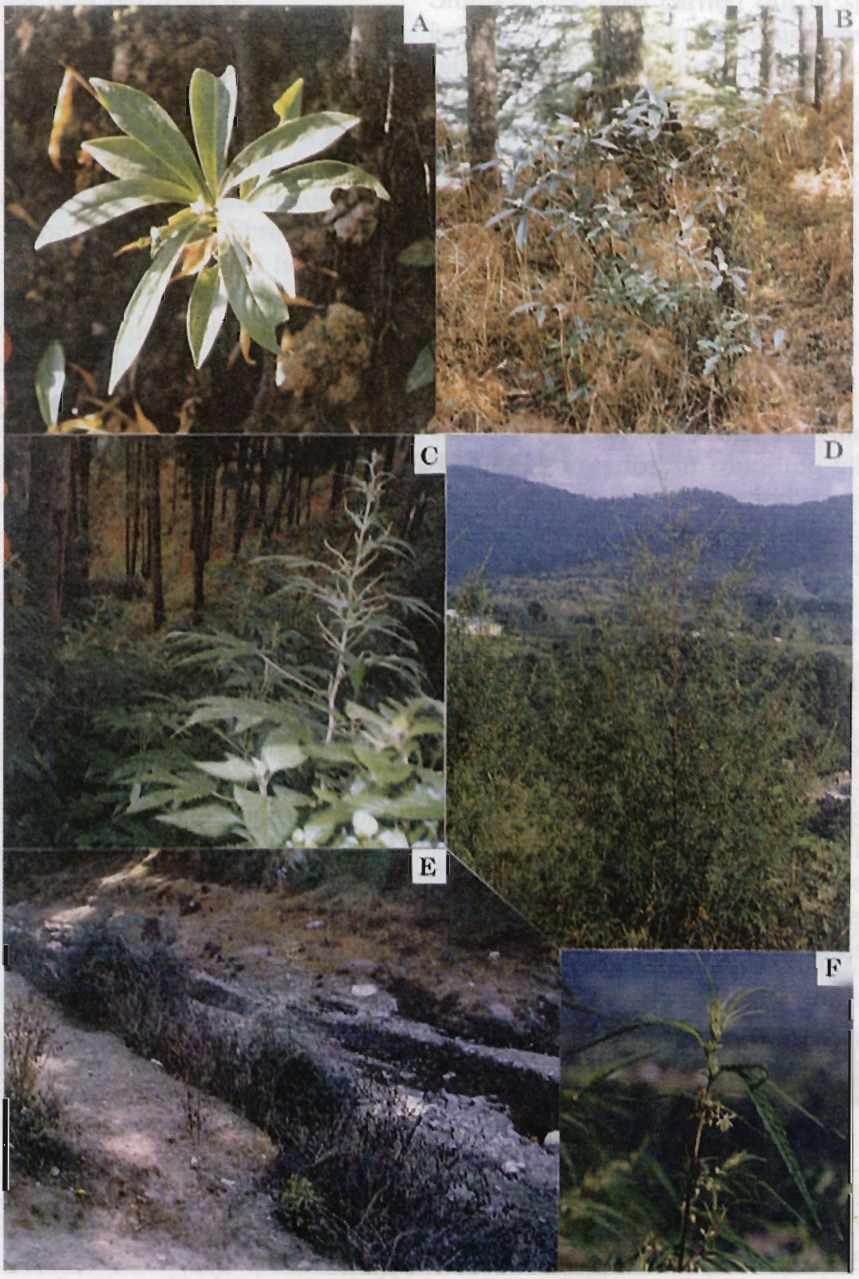

Plate 2.1: Fibre plants and their habitats
A) Close-up of *Daphne papyracea* with white flowers
B) *Daphne* in the understory of a *Cedrus deodara* forest
C) *Giraridana heterophylla* along water channels in a *Cedrus deodara* forest
D) Wild population of *Cannabis sativa*
E) *Girardiana* population along a stream channel and (F) A flowering shoot of *Cannabis*

Plate 2.2: A) Trees of *Grewia oppositifolia*
B) Drying of pooled stalks harvested from trees after fodder removal

scription has been presented in the following text as ready reference.

Cannabis sativa

This monotype genus is widely distributed (especially in the temperate and tropical countries) and is considered to be a native of Western and Central Asia. It is a tall herb, sometimes growing up to 4.88m. In the Jataganga catchment, shoot height and diameter (at base) of female plants vary from 275 to 305cm and 8.4 to 16.8mm, respectively. Twenty-day old seedlings attain a height of about 38cm with a 5mm diameter and about 10 leaves. The plant is dioecious in nature with a tap root system but occasionally monoecious plants have also been observed. The long stem is angular and bears divided palmate leaves. Flowers are usually yellowish cream in colour but have also been reported to be greenish. Male flowers are borne in long drooping panicles and female flowers in short axillary spikes. The fruit is an ovate seed-like achene.

Girardiana heterophylla

This is a perennial herb of temperate and subtropical Himalayan regions. It is a robust herb that grows to a height of up to nine feet. In the Jataganga catchment, shoot height and diameter at the base vary from 208 to 242cm and 15.5 to 21.2mm, respectively. The peculiar feature of this plant is that its stem is armed with stinging hairs that are present in abundance. The leaves are large-lobed and coarsely dentate or serrate. The plants are often found growing gregariously.

Grewia oppositifolia

This moderately-sized tree is widely distributed from the plains of Punjab to Bengal and up to an altitude of 2,134m in the Himalayas from Jammu and Kashmir to the Central Himalayas and Nepal (Brandis 1906). This tree is an essential component of age-old agroforestry practices of the Central Himalayan villages. Rough leaves are ovate, acuminate, and serrate. Pale yellow flowers occur in leaf cymes that are opposite the leaves. Fruits are black, drooping, and edible.

Agave sisalana

This genus is a native of Central America but is also found growing in East Africa and Asia. It was introduced in India during the 15th century but has become completely naturalised now. The plant has a short stem that bears a number of green, thick fleshy leaves. *Agave* flowers once during its lifetime. Its flowering stem arises from the centre of the plant as a thick pole that grows to a height of about six metres. The entire plant dies after bearing fruit.

Daphne papyracea

This plant is a common undergrowth in the broad-leaved forests that grow between 3,658 and 5,000m in the Central Himalayan region. The plant grows to a height of up to 2.44m. The leaves are obtuse.

Uses

These fibre-yielding plants also have various direct uses, other than providing raw material for fibre products. There are several by-products that are generated during the fibre extraction processes. Therefore, these plants play an important role in the functioning of village ecosystems. The various uses of the species have been summarised below.

Cannabis sativa

This plant is preferred by villagers for its multiple uses (Figure 2.1). However, cultivation of *Cannabis* is prohibited in many parts of India because of its abuse in the production of narcotic drugs. Uses of fibre, by-products, after fibre extraction, and the seed are summarised in Table 2.2. The woody portion that remains after the extraction of fibre is used to some extent as a fuel supplement in the kitchen (Plate 2.3). In February 1997, the market rate for seeds was Rs 18 per kg in Jataganga catchment. However, at district headquarters (e.g., Pithoragarh), it was Rs 30 per kg during November-December and Rs 25 per kg during January-February.

Girardiana heterophylla

This wild plant is only used for making ropes because of its stinging hair. However, sometimes the tender shoots and leaves have been used as vegetables by poor people. Contributions of fibre products in various aspects of village life are shown in Figure 2.2, and summarised in Table 2.3.

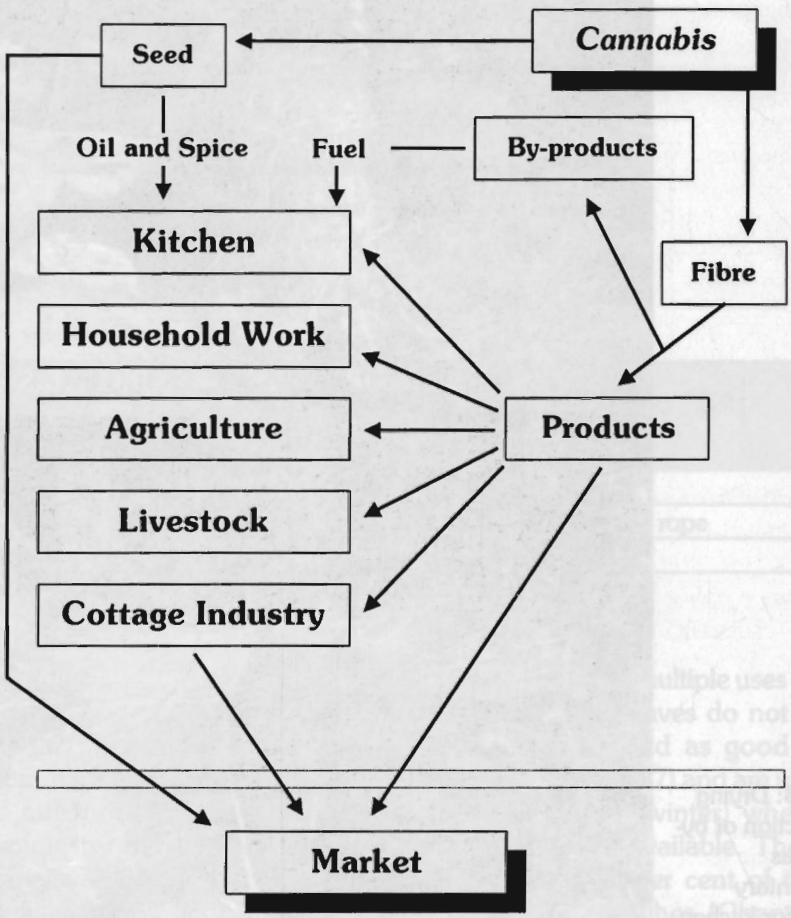

Figure 2.1: Different Uses of *Cannabis*

Table 2.2: Different Uses of the *Cannabis* Plant Seed, Fibre and Allied By-products		
Product	**Local name**	**Use**
1. Fibre	Taga	Binding material for a mat produced locally
2. Fibre	*Dhaga*	Weaving of local cloth
3. Fibre	*Dhaga*	Making different types of rope
4. Wood	*Laakar*	Firewood
5. Seed	*Bhang*	Spice, Dish (*Chutney*), Oil (also used to adulterate *Ghee)*

Plate 2.3: Drying and collection of by-products as supplementary firewood for kitchen activities

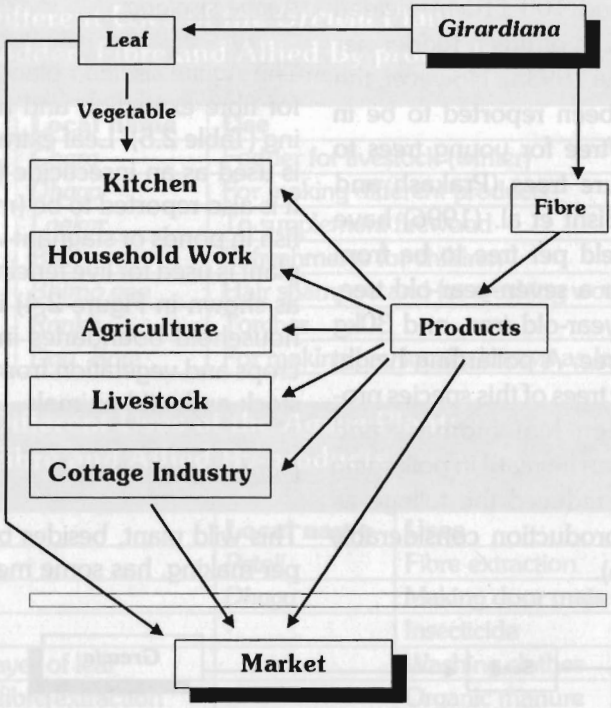

Figure 2.2: Different Uses of *Girardiana*

Table 2.3: Different Uses of the *Girardiana* Plant Fibre and Allied By-products

Product	Local name	Use
1. Fibre	*Dhaga*	For making different types of rope
2. Leaves	*Paat*	Used as vegetables

Grewia oppositifolia

Various uses of this plant are shown in Figure 2.3 and summarised in Table 2.4. In a study carried out to gauge the farmers' choice of agroforestry tree species in the subtropical Himalayas, 94 per cent of farmers in the low hills and 84 per cent in the mid-hills expressed the first preference for *Grewia* because of its multiple uses (Anonymous 1987). Since leaves do not contain tannin, they are rated as good fodder (Laurie 1945, Negi 1977) and are used during the lean period (winter) when other green fodder is not available. The leaves constitute about 70 per cent of the total fresh weight of branches (Chandra and Sharma 1977). Trees with girths of from 40-

50cm, 70-80cm, and 100-110cm yielded 3.5, 10.5, and 20.1kg of green fodder per tree (Lata and Verma 1993a). However, the general yield has been reported to be in the range of 12kg/tree for young trees to 30kg/tree for mature trees (Prakash and Hockking 1986). Bisht et al. (1996) have reported fodder yield per tree to be from five to seven kg for a seven-year-old tree, 11-15kg for a 15-year-old tree, and 30kg for a 25-year-old tree. A pollarding height of 0.5 and 1.5m for trees of this species produced higher green leaf biomass and fuelwood; a further an increase in pollarding height (i.e., 2.0m) reduced the foliage as well as fuelwood production considerably (Anonymous 1995).

Agave sisalana

The *Agave sisalana* plant is primarily used for fibre extraction and as biological fencing (Table 2.5). Leaf extract, in liquid form, is used as an insecticide (mainly for fleas). It is also reported to be (mis)used for killing fish in ponds or stagnant waters. The whole plant is used for live fencing (i.e., biofencing as shown in Figure 2.4) in crop fields and household boundaries in order to protect crops and vegetation from free grazing livestock and wild animals.

Daphne papyracea

This wild plant, besides being used for paper-making, has some medicinal properties

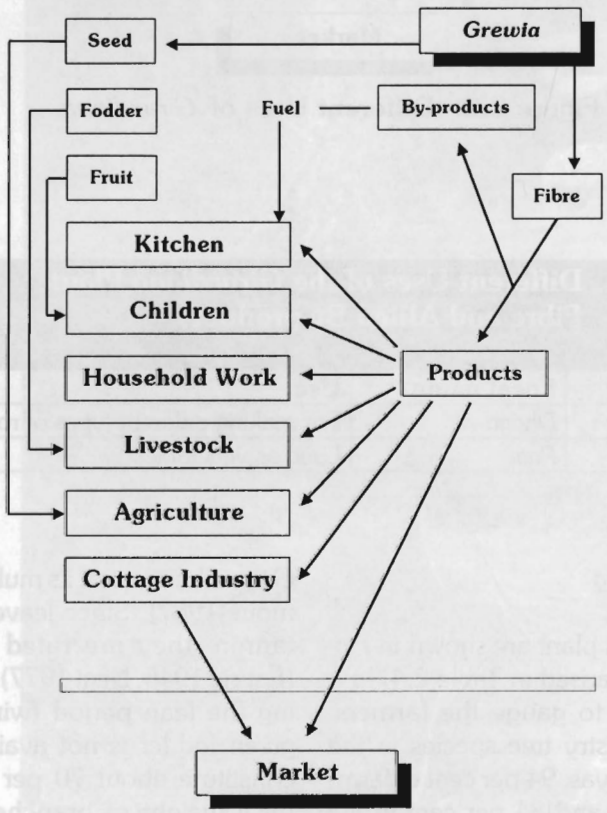

Figure 2.3: Different Uses of *Grewia*

Table 2.4: Different Uses of the *Grewia* Plant Fodder, Fibre and Allied By-products

Product	Local name	Use
1. Leaves	*Chara*	Fodder for livestock (winter)
2. Fibre	*Dhaga*	For making different products
3. Wood	*Laakar*	To supplement firewood
4. Seeds	*Bien*	Refreshments for children
5. Fresh bark	*Bhimo gao*	Hair shampoo and for washing woollen clothes
6. Dry sticks	*Rankh*	Torches
7. Tree	*Dau, Bote*	For making hay locally known as *loota*

Table 2.5: Different Uses of the *Agave* Plant: Fibre and Allied By-products

Product	Local name	Uses
1. Leaves	*Pateli*	Fibre extraction
2. Fibre	*Dhaga*	Making door mats and ropes
3. Leaf extract		Insecticide
4. Outer green layer of leaf		Washing clothes
5. Residue after fibre extraction		Organic manure
6. Flower stem	*Laakar*	Stakes for climbers
7. Whole plant	*Gher*	Biological fencing

that include bringing about relief from stomach-ache (root extract in water) and for healing fractured bones (bark) (Table 2.6).

Fibres and Their Extraction

The fibrous properties and extraction methods have been compiled from various sources, and these include secondary literature and methods adopted by village practitioners.

Table 2.6: Uses of *Daphne* Plant

Product	Local name	Uses
1. Bark	*Chhao*	Fibre extraction
2. Bark	-do-	Treatment of bone fractures
3. Root	*Jar*	Treatment of stomach-ache

Cannabis sativa

In the Central Himalayan region, *Cannabis* occurs abundantly in the wild during the rainy season; however, only cultivated plants are used for fibre extraction. Preparation of crop fields begins before the rainy season sets in (May-June) and the fields being ploughed twice. Sowing is carried out after mid-June and is followed by levelling the crop fields. The weight of 10 seeds stored at room temperature for eight months was 0.23g $\pm$ 0.01 and the rate of germination was almost 100 per cent. The crop requires intensive weeding between July and August. The vegetative growth occurs up to August followed by flowering and fruiting in September. Male plants flower a little earlier than the female plants

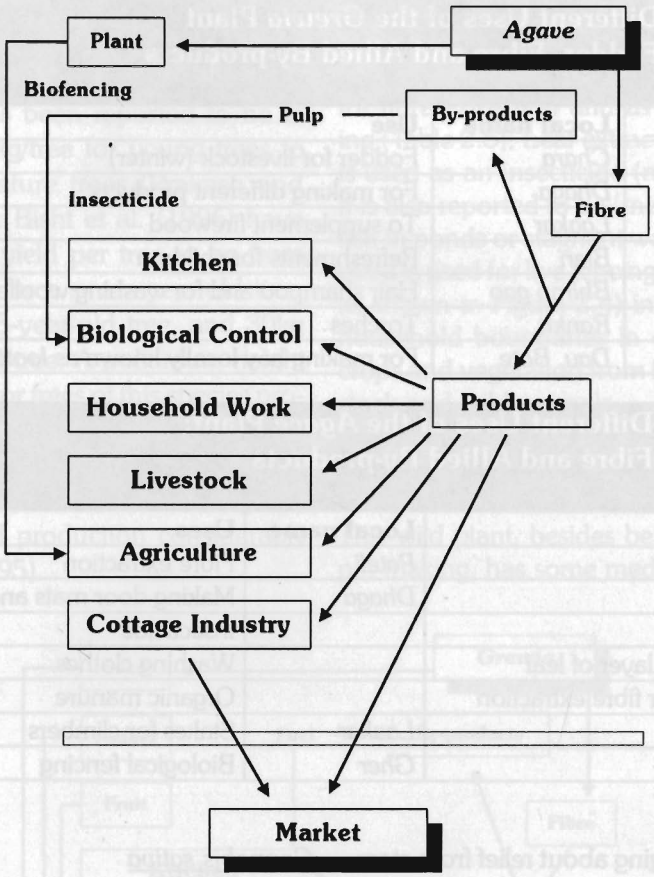

Figure 2.4: Different Uses of *Agave*

and their contribution to total plants in a unit area is about 50 per cent (according to the villagers). Male plants are easily distinguishable and only these are harvested.

The harvested male plants are spread on roof tops and allowed to ret in rain water; they require only a small quantity of water for the process. If the rain is irregular, the harvested plants are processed with surface water. The plants are subjected to retting for three to four days, followed by the extraction of fibre and drying.

The female plants stand in the fields until the seeds mature, up to about the end of October. Seeds are collected after harvesting the plants and the stems are left in the field for 15-20 days to dry in the sun. The stems are then stacked in bundles of 60 to 120 plants (Plate 2.4). The bundles are submerged in running water channels or *khal*(s) or moistened with tap water and left for retting (Plate 2.5) depending on the availability of time between various agricultural activities. The duration of retting depends upon the climate of the place. It normally takes three-four days to complete the process. The fibre is then separated from the retted stalks by hand. The scutched fibre is finally cleaned and separated into finer strands.

Plate 2.4: Use of solar energy for drying
A) *Cannabis* stems before retting
B) Extracted fibre (hanging) and by-products (on the ground)

Plate 2.5: Different methods of retting for *Cannabis* fibre
A) In running water
B) In *khal*
C) With tap water

The fibre is strong, lustrous, and durable. Commercial fibre is 40-80 inches long. The fineness of its staple is less than that of linen, though its tensile strength is appreciably greater. The fibre is made up of a mixture of cellulose and ligno-cellulose. Chemical analysis indicates that the cellulose content is about 78 per cent. The tips of the fibre are bluntly rounded. The fibre is usually straw-white but can vary in colour from pale yellow to deep grey. It is strong and the villagers consider it to be the most durable among all the natural fibres that are of plant origin. Notably, the fibre from female plants is stronger and longer than that from male plants (298cm *vs* 132cm, respectively). The fibre obtained from five stalks of different lengths (90-282cm) yielded 31.4g of dry fibre and the time for extraction was about two minutes. The diameter of single thread obtained from fibre is recorded to be about five mm.

Girardiana heterophylla

Three species of genus *Girardiana* are found in India and only one of them, *G. palmata,* is systematically cultivated in the Nilgiri hills in the Western Ghats. No systematic cultivation (such as that of hemp) of the species exists in the Central Himalayan region and fibre is extracted only from naturally growing plants of *G. heterophylla*. The plant occurs abundantly in the wild, over the moist areas along water channels, and on nutrient rich soils in the vicinity of human habitations. The shoots appear during April from underground rhizomes. Vegetative growth occurs up until August, followed by flowering and fruiting in August-September. The plant above ground perishes in December-January. Seed collection is carried out from December-February. In an experiment performed at the G.B. Pant Institute of Himalayan Environment and Development's Katarmal Nursery in Kosi, the seed germination rate (seeds sown 6 months after collection) was only about 17 per cent.

The fibre lies in the inner bark of the stalk, and fibre extraction is not a common practice among the villagers because of the stinging hair on its leaves and stem. The artisans of a particular caste within the village extract fibre from this species. The stem yields a fibre, which is said to rival the best fibres in strength. Harvesting of stems is carried out from September through February according to the time available, but mostly just after the rains are over. The main process involved in the extraction of the fibre is retting in water as in the case of *Cannabis*. The harvested stems are submerged in running water channels for two to three days for retting and then the fibre is peeled away (Plate 2.6).

The fibres contain about 90 per cent cellulose and resemble flax in length and firmness but are softer, more open, and downy. The density and tensile strength of the fibre are higher than those of flax, but the resistance to slipping is lower. Tests carried out in Darjeeling show that the fibre can be spun into long filaments. The strength of wet specimens of bleached filament is higher than that of air-dried specimens. The fibre is soft and flexible. The colour is usually straw-white but may vary from pale brown to pale yellow.

Grewia oppositifolia

The density of seedlings in an area is subject to thinning and depends on local needs/ requirements. The young shoots, i.e, current year's growth, appear in April and the vegetative growth continues up to the month of August. The leaves fall in March-

Plate 2.6: Fibre extraction from *Girardiana*
A) Retting in a running water channel
B) Collection of retted stalks

April. The blossoms and fruit appear along with the vegetative growth.

The species is propagated by seeds that are collected in the period from October to January and the number of seeds per kg varies between 10,000-15,000 (Lata and Verma 1993a). The seeds exhibit dormancy due to the hard seed coat. Seeds sown in July (eight months after collection) took longer (19 days) to begin germinating. Further, the germination percentage is often unsatisfactory (only about 28%) (Lata and Verma 1993b). However, quick (nine days) and better (about 50%) germination takes place when seeds are soaked in hot water for 24 hours. In an experiment at the GBPIHED nursery at Kosi, seeds sown in the first week of August (about eight months after collection) had slightly higher germination rates than (50%) those collected in Kullu (46%); especially when the seeds were soaked in cold water for 24 hours and rubbed with wire mesh for 10 minutes. Commencement of germination was also fast (only eight days). The height

(based on 36 seedlings) of a two-month old seedling was slightly lower for those seeds collected from Kullu provenance (7.5cm with 5.2 leaves per seedling) than for those from the Kosi provenance (7.7cm with 5.1 leaves per seedling). Lata (1996) has reported 82.7g per seedling dry matter production for a one-year old seedling, of which the root accounted for about 38 per cent, and leaves and stem for about 31 per cent each. Seven-year old trees of *Grewia* growing at the institute's nursery in Kosi, grew to a height of 7.5±1m and a girth of 47±7cm (based on 5 plants). Further, this tree is a strong light demander and requires full sunlight for optimal growth. Species can also withstand frost and this has further increased the importance of this species for farmers.

During winter (November to February), the current years' shoots are harvested to obtain leaves as green fodder. The sticks (after leaf collection) are left out for shade drying until the second week of March. Shade dried sticks are then spread in the open for sun drying for two to three days. These sticks are then pooled into bundles of 30-40 sticks per bundle. The bundles are kept submerged under water for about four to six weeks in a channel by making a pool (locally known as *khal)*. Stones are kept on each bundle to keep the bundles submerged. The retting time depends on the thickness of sticks and the prevailing temperature in the area. The *Grewia* sticks take the longest to ret in water than any other species. A sort of slimy microbial growth seems to be necessary for the process of retting to be complete (Bisht et al. 1996). The fibre is extracted from retted stalks manually by peeling off the bark gently and pounding it with a mallet to remove the dead outer bark. Finally, it is washed in water. The fibre is usually white or light brown in colour. The newly extracted fibre is dried in the sun. Using local skills and a combination of various 'ties and knots', different products are fabricated to meet the domestic and market demands.

The bark yields a fibre that contains 72 per cent cellulose. In an experiment, five stalks (with minimum diameters of 2.5cm and of different lengths - 55, 90, 101, 106, 125cm) yielded a total of about 48g dry weight of fibre. The time taken to extract fibre was about 2.5 minutes. The fibre was pounded by a mallet for 7.5 minutes in order to dislodge the outer bark and then washed with water for about one minute.

Agave sisalana

By and large, cultivation practices have not been observed in the case of this species in the Central Himalayan region except in a few locations near Dehradun in Garhwal region and near Bhowali and Bageshwar in Kumaon region by voluntary organizations. The mature leaves are scraped by hand to remove the green matter from the fibrous layer.

The fibre consists of strands or filaments usually three to five inches long. The fibrous substance consists of 73-78 per cent of a lignified form of cellulose. The fibre is white or pale yellowish in colour; it is strong and coarse.

Daphne papyracea

This is an evergreen shrub with continued leaf drop (multiple events). Leaf drop takes place throughout the year, whereas leaf flushing occurs during February-March and September-October (multiple events) (Singh and Singh 1984). The plant bears white odourless flowers from December to February and fruit maturation occurs from April to June. The fleshy fruits are brown-

ish red in colour. The number of individual plants per ha varied in different *Quercus* forests (2,134 plants/ha in *Quercus floribunda*, 33 plants/ha in *Q. lanuginosa*, 1,455 plants/ha in *Q. leucotrichophora*, 6,875 plants/ha in mixed *Quercus* forests) (Saxena and Singh 1982). Its bark is the source of commercial cellulose, but it is found in only small quantities (about 22%).

The bark can be peeled off easily. The bark is sun dried and, after scraping off the epidermis, it is cooked in water that has been rendered alkaline with wood ash. The inner fibrous parts are softened by this treatment. The cooked parts are beaten into a pulp and cast out on perforated sheets to make paper.

Fibre Products

The fibre obtained from different species is spun manually into threads using various tools (Plates 2.7 and 2.8). Use of hands and feet is essential because the tools of the trade are incomplete. A description of various fibre products of different species has been presented below.

Cannabis sativa

The fibre of this plant is primarily used for making different types of rope for household activities and/or in cottage industries. The various products that are prepared with different combinations of fibre threads are shown in Table 2.7 and Plate 2.9.

Girardiana heterophylla

In the Himalayas, unlike in other places, the fibre is extracted for local use and is used mainly for household work, usually for making various ropes (particularly for livestock related jobs). At the level of small cottage industries, it is used for making fishing nets (presently confined to one location only, Plate 2.10). Different types of ropes, identical to those made of the *Cannabis* fibre, are made using various combinations of threads (Table 2.8).

Grewia oppositifolia

This fibre is used mainly for making ropes for household activities. The method of making ropes (varying combinations of threads) depends on the specific purpose for which the rope is to be used. Ropes are used for livestock care, to a great extent, and are available in the local markets of the region (Table 2.9).

Agave sisalana

The various products traditionally made of *agave* fibre and their specific use in village life are shown in Table 2.10 and Plate 2.10. Other commercial products have also been tried out by some organizations.

Daphne papyracea

In this region, this plant fibre was earlier used to make paper (locally known as *Kagaj*) and for preparing horoscopes.

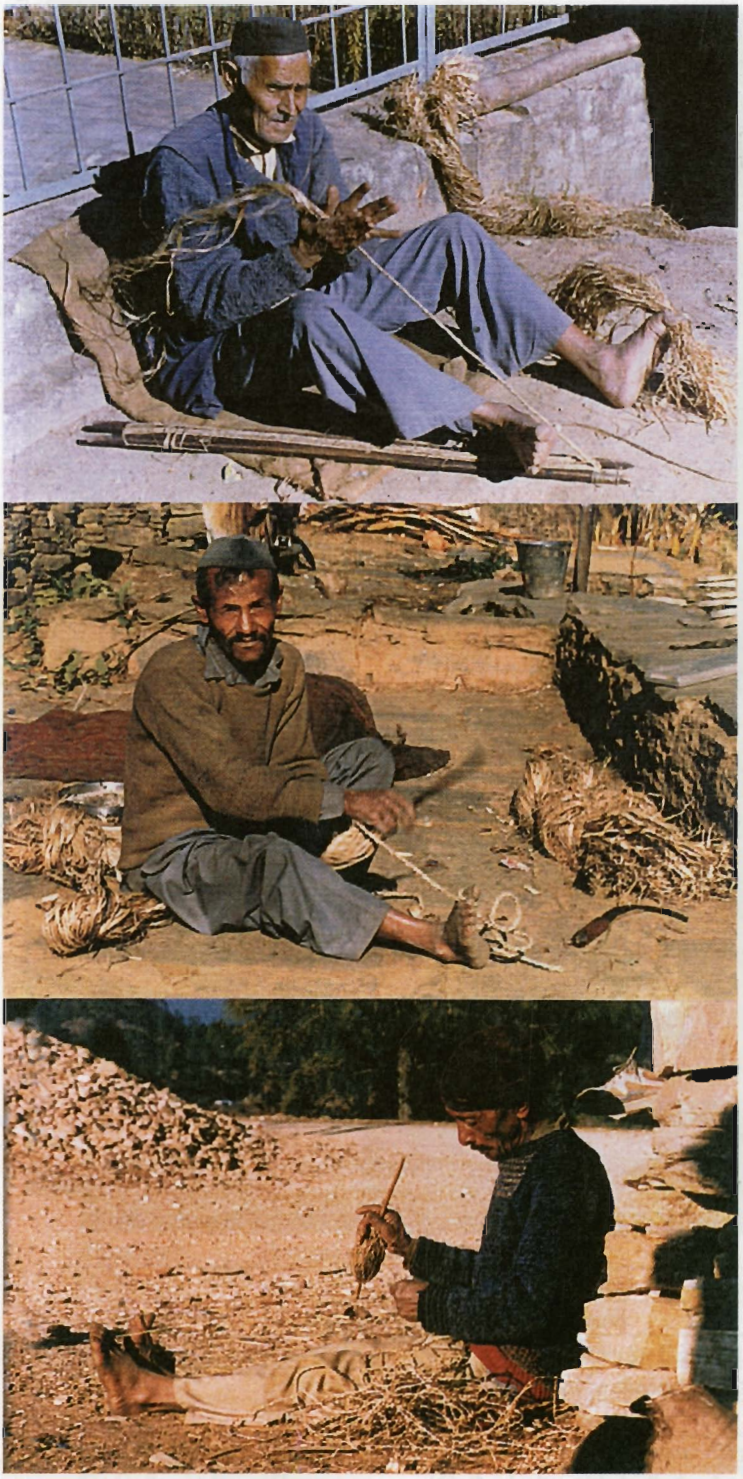

Plate 2.7: Spinning fibre threads with various tools — a special feature is the use of feet and hands

Plate 2.8: Fibre, various tools and usage for spinning fibre threads and weaving cloth

Table 2.7: Final Products of *Cannabis* Fibre

Product	Local name	Specific Use
1. Net	*Jao*	To collect fodder and leaf litter
2. Rope	*Jyor*	To carry firewood and fodder
3. Rope	*Gayan*	To tether animals
4. Rope	*Barr*	To pluck firewood
5. Rope	*Jutora, Haroon, Nara*	To yoke bullocks to the plough
6. Carry bag	*Seenk*	To carry utensils
7. Cloth	*Kuthla*	To carry and store food grain
8. Cloth	*Budla*	To carry fodder and matting
9. Mask	*Muhao*	Masks for cattle while performing agricultural work
10. Collar Belt	*Daon*	To tie collar bells on bullocks
11. Basket	*Jali*	To pick mangoes and other fruit

Table 2.8: Final Products of *Girardiana* Fibre

Product	Local name	Specific use
1. Net	*Fatyao*	Small fishing nets
2. Net	*Jal*	Large fishing nets
3. Rope	*Jyor*	To carry firewood
4. Rope	*Gayan*	To tether animals in cattle sheds
5. Rope	*Jutora*	To yoke bullocks to the plough

Table 2.9: Final Products of *Grewia* Fibre

Product	Local name	Specific Use
1. Rope	*Jyor*	To carry firewood
2. Rope	*Gayan*	To tether animals in cattle sheds
3. Rope	*Jutora*	To yoke bullocks to the plough
4. Mask	*Muhao*	Masks for cattle during agricultural activities
5. Net	*Jao*	To store vegetables and carry utensils
6. Carrier bag	*Seenk*	To store vegetables and carry utensils

Table 2.10: Final Products of *Agave* Fibre

Product	Local name	Specific Use
1. Rope	*Jyor*	To carry firewood and fodder
2. Rope	*Gayan*	To tether animals
3. Rope	*Haroon*	To yoke bullocks to the plough
4. Mask	*Muhao*	Masks for cattle during agricultural activities
5. Net	*Jal*	To carry fodder
6. Carry bag	*Seenk*	To store vegetables and carry utensils
7. Collar belt	*Daon*	Collar belts with bells for bullocks

Plate 2.9: Various ropes and their usage
A) *Seenk* B) *Jutora* C) *Muhao* and thread D) *Jao* E) *Jyora*

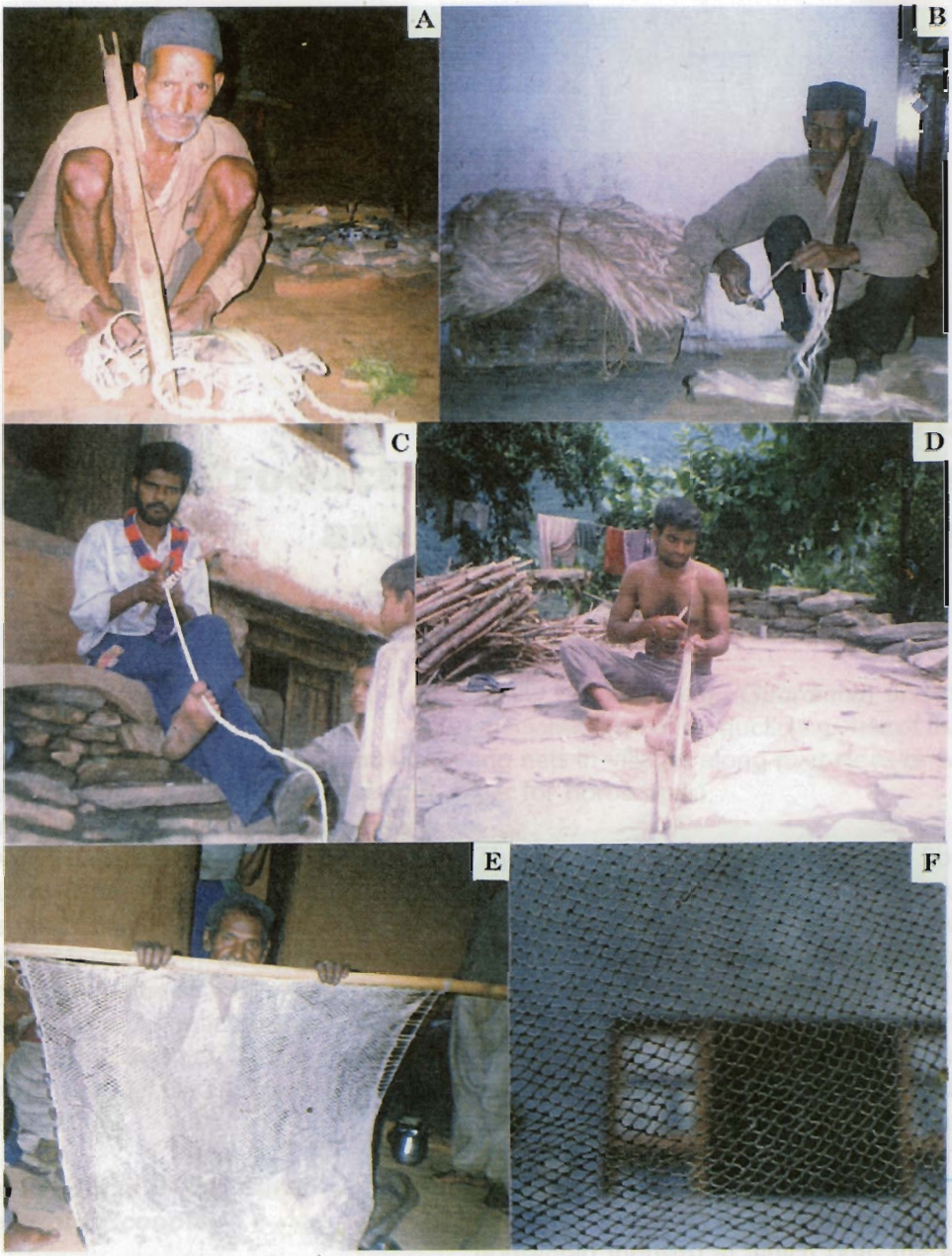

Plate 2.10: Ropes and fibres of *Agave*
A,B,C) Artisans with scutched fibre, ropes, and tools
D) An artisan making a fishing net from Girardiana fibre
E) A ready-made fishing net
F) Close-up of net