OUR LAND OUR LIFE

(A practical course of agriculture and environmental education)

Class 8

Uttarakhand Seva Nidhi Paryavaran Shiksha Sansthan
Almora

THIS WORK BOOK BELONGS TO

Student's name	: ....
Class	: ....
Year	: ....
Team number	: ....
Name of school	: ....
Name of principal	: ....
Name of environmental education teacher	: ....
Name of study village	: ....
Name of block	: ....
Name of district	: ....

OUR LAND
OUR LIFE

Class Eight

A practical course of agriculture and environmental education for classes six to ten in the Schools of Uttarakhand

2012

Uttarakhand Seva Nidhi Paryavaran Shiksha Sansthan,
Almora, Uttarakhand

Conception : Sri Madhav Ashish
Mirtola Ashram

Course design : M. G. Jackson

Workbook writing : M. G. Jackson, G. P. Pande, Suman Pande

Support : Lalit Pande, Krishan Singh Suyal, Deevan Nagarkoti, Anuradha Pande, Anjali Punera, Satish Datt Pande, Shri Kant Joshi, Naveen Chandra Kabadval; Mirtola Ashram, Gandhi Intermediate College and Uttarakhand Seva Nidhi Paryavaran Shiksha Sansthan

Illustrations : Chandra Shekhar Tiwari, Dhruv Joshi, Deepa Balsavar, Nita Gangopadhyaya, Deepa Pant, Kevin Maddison, Mohammad Salim, G.P. Pande

Additional Support : J.S. Gill, Sri Dev Ashish, Anil Bordia, J.C. Pant, G.K. Arora, Mahesh Chandra Pant

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Review committee for fifth edition (6th to 8th class portion) : Trilochan, O.P. Borhai, Umesh Chamola, G.P. Ranakoti, S.K. Gaur, Satish Kumar Pandey, Kanchan Dewrarhi, Ramendra Kumar Ojha, Dhara Dutt Sharma, J.K. Joshi, C.M. Joshi, Sarop Singh Mehara, Narendra Singh Gusain, Kalika Prasad Semwal, S.S. Chauhan, Om Prakash Gairola, K.P.S. Saroha, D.S. Samant, Rajnish Mani Pande, Gajendra Singh Sikarwar, Kailash Chandra Pande, Shaukin Singh Yadav, Rishipal Singh.

Foreward

This set of five workbooks constitutes a single, continuous course to be offered to students of classes 6-10. It is being published in English for the benefit of those outside the state of Uttarakhand who do not know Hindi. As explained in the brief account of the history of the course that follows, it has not yet been possible to introduce the full five year course for lack of space in the prevailing school curriculum, but only the 6th to 8th class portion.

Using these workbooks as a general model, it should be possible to design similar courses for any region of the country.

We hope to receive comments from readers of this English version. The course is an on-going experiment, and efforts are continually being made to improve it as we go along.

Almora
January, 2012

Lalit Pande
Director
Uttarakhand Seva Nidhi
Paryavaran Shiksha Sansthan
Almora (Uttarakhand)

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COURSE HISTORY

This course is the outcome of the collaboration between 1986 and 2000 of the Mirtola Ashram, Dhauladevi Block, District Almora, the Uttarakhand Environmental Education Centre, Almora, the Gandhi Intermediate College, Panwanaula, Dhauladevi Block, District Almora, the Department of Education, Government of Uttar Pradesh (Uttarakhand after 2000) and the Department of Education, Ministry of Human Resources Development, Government of India, New Delhi.

The idea of an environmental education course in the schools and intermediate colleges of the hill region of Uttar Pradesh was endorsed by the National Planning Commission's Task Force on Hill Development and by the Departments of Education, Governments of India and Uttar Pradesh in 1986. The Uttarakhand Environmental Education Centre (UEEC) offered to implement the course.

The initial version of the course was designed for students of classes nine and ten. In 1987 it was offered in the Gandhi Intermediate College, Panuwanaula. Between 1988 and 1992 forty more schools and intermediate colleges volunteered to participate in the project. Five-day, in-service teacher-training camps were held every year in June at the Gandhi Intermediate College. Later, in 1998, these camps were transferred to the USNPSS training center in Almora.

In 1991-92 a major stocktaking was done by all the participants with the result that the course was recast as a five-year course for classes six to ten. A slot in the junior high school (classes six to eight) curriculum was found and the revised course was taken up by junior high schools, high schools and intermediate colleges. By 2002 the combined number of all these had increased to 1000. No slot however, could be found for the ninth and tenth class part of the revised course, and the sixth to eight class part was revised to make a self-contained course. A course for the plains region of the state was made. These courses were introduced from July 2002 as an optional subject in all schools and intermediate colleges in the State in a phased manner, as rapidly as teachers could be trained. The major responsibility for the administration of the course (the printing of workbooks, in-service teacher training and examinations) was taken over by the Department of Education from the UEEC in that year. Master trainers in the District Institutes of Education and Training were trained by UEEC staff in 2002.

In 2008 the course was expanded by incorporating subject matter had earlier featured in the agriculture course, and the hill and plains versions were merged. This revised course was made a compulsory part of the curriculum in 2009.

TO TEACHERS AND PARENTS

The modernisation of our country has brought us many benefits. Compared to 50 years ago we are healthier and better educated today. Roads and telephones make travel and communications easier and faster. There are many manufactured goods in the market to make life easier and more enjoyable. Farming is more productive where there is irrigation and food production has increased greatly.

Along with these benefits we now realise that many serious problems have arisen. Factories, cars, trucks and buses are causing severe air pollution in our cities. The wastes from our factories and cities are polluting our waterways. Both air and water pollution are causing many new diseases and aggravating old ones.

In the rural areas of our country forests are rapidly disappearing resulting in a lack of fuelwood and fodder, and giving rise to soil erosion. In hill areas the loss of forests also causes water sources to dry up. In addition to deforestation and soil erosion, the fertility of our soil is decreasing where modern agricultural practices have been taken up. Wells in the plains are going dry due to the excessive pumping of ground water to irrigate crops. Pesticides are polluting our soils, ground water and food, which adversely affects our health.

The increasing awareness of these problems leads us to the conclusion that modernisation in its present from cannot be sustained. If our environment – our air, water, land and forests – is harmed there can be no real modernisation or development. We must find solutions to these problems and apply them in our daily lives and livelihood pursuits.

Most of us are not fully aware of these problems; they hardly existed when we were children. Nor do we understand how our own actions give rise to them. In this course children are made aware of these environmental problems and helped to acquire the knowledge and skills that are needed to solve them.

This school programme also provides an opportunity for parents to learn along with their children. Further, parents have an indispensable role to play in the course; indeed, the course can only be effective if parents contribute some time and effort to helping their children learn. In many cases parents can share their traditional knowledge and skills; these are being forgotten but they can help us solve many of our current environmental problems.

As teachers we too have much to learn about environmental problems and how children and parents can be helped to deal with them. Indeed, learning about the environment is a collaborative effort of teachers, students and parents. All are equal partners in this learning process.

The name of this course is 'Our Land, Our Life' and it deals with the problem of land and forest degradation, with ways of rehabilitating them, and with managing them for high and at the same time sustainable production. Our main natural assets in Uttarakhand are land and forests, and our development will depend primarily on managing them well. Most of our children will remain in the village and it is our duty to ensure that they have the motivation and the means (knowledge and skills) to make a comfortable and secure future for themselves.

Some of our children will, of course, leave their village or the state to earn their living. For them too this course of is valuable. Everywhere in our country, and indeed in the world, environmental education in some form or other is now a part of the school curriculum. Increasingly, a knowledge of environmental problems and their solutions is required for employment. The nature of environmental problems and the means of solving them vary with location but the principles are the same everywhere, North, South, in the city and in the village. The challenge is similar to that of language education: language differs in different parts of the country, but in all schools learners are expected to be proficient in their regional language (i.e., in reading, writing and speaking).

In this course children do much of their learning outside the classroom. They study the village first-hand, collecting information and data, analysing it, and experimenting with new ways of land, forest, crop, water and animal management. The table of contents of this workbook indicates the variety of topics they study. They work in small teams and they will ask you, their parents, for help and information. You may also help them by questioning them about what they are doing and why. As teachers you will teach them the concepts they will need and guide them in their work. Encourage them to ask you questions. You are partners with them and their parents in this learning exercise.

We hope everyone – parents, teachers and children – will enjoy this course. Send us your suggestions, through your school principal, for improving the course in the future.

SUGGESTIONS TO TEACHERS FOR CONDUCTING THE COURSE

This course extends over five years, classes six to ten. The subject matter topics of the course are: land, water, trees, crops, compost, animals, fodder, fuelwood, people and ecosystem. Students gain knowledge, concepts and skills, step-by-step as the course proceeds.

The village ecosystem is the central theme of the course. Subordinate themes are: species diversity, species adaptation, sustainability, community and carrying capacity. The village community an integral part of the village ecosystem. Students learn these concepts through practical work.

The contents of the course are presented in a workbook format. As more emphasis is given to the exercises they are placed before the boxes.

The objective of, and procedure for, each exercise is explained at the beginning of the exercise. Notes for the teacher are also given in some exercises where it seems necessary. Most exercises are accompanied by one or more boxes. Boxes explain concepts, give detailed directions for doing the exercise, give necessary background information, and clarify concepts through stories.

A village is the laboratory in this course. Students undertake a thorough and systematic quantitative and qualitative study of a particular village over a period of five years. Therefore at the beginning of class six a study village is to be selected, in which, students will work continuously for five years (classes six to ten). Every new batch of students entering class six will be assigned a new study village. About one-fourth of the exercises will be done in the study village; the rest will be done in the school campus or classroom. In class eight, Exercises 26, 27, 34, 35 and 36 must be done in the village.

A block of four periods (about one-half day) will be needed for village visits. This will have to be arranged with the headmaster/principal. Before starting the course it will be necessary for you to visit the study village to meet the residents and explain the course to them and to request them to provide their help and support. Without their participation the course cannot be carried out effectively. Their participation will take the form of helping students with their investigations and sharing local, traditional knowledge with them. By participating in the course the residents will learn about their village from a different point of view.

For doing practical work the class should be divided into about ten teams of two to five students each. The purpose of forming teams is: to help students learn team work; to obtain several estimates of each parameter; to ensure that all students participate; and to make the class easier to manage. The averages of the estimates of a given parameter from the several teams can be calculated in the classroom after the village visit.

Teachers are urged to adopt a discussion mode in conducting the course. Students already know many things about their local environment. The role of the teacher is that of a discussion leader, helping to bring out what students know, to express their opinion/ideas, and to provide the concepts that are necessary for discussing facts/opinions in meaningful ways.

There are important differences between high and low altitude villages in land, water, trees and crops. In the boxes examples from both have been included. Students in all schools should study all the boxes, even if the examples are from a different altitude zone than their own village. The mountains and plains of Uttarakhand are interconnected and all students should learn about their entire state.

At the beginning of the year prepare an annual calendar of the course, indicating the month for doing each exercise. Some exercises can only be done at definite times of the year. For example, the exercises on measuring fodder consumption and milk yield are season bound.

Date: ....

Code : Tree 6
Month : April

EXERCISE 25

PROJECT FOR RESTORING TREES TO OUR VILLAGE ECOSYSTEM 2. PLANTATION PLAN

INTRODUCTION

This exercise is a continuation of the project that we began in Exercise 24. In this exercise we will make a plan of our selected site. The plan will specify how many seedlings of fodder, fuelwood and stemwood types are to be planted, where and when.

PROCEDURE

1. The project area is to be divided into three parts, one for fodder production, one for fuelwood and one for stemwood. Decide on this division in a class discussion with your teacher. Mark these separate areas in your project-area map (Exercise 24). From the map estimate the approximate area of each of these and write the figures in column 2 of Table 25-2. From now on we will call these three separate areas 'management blocks'. Thus we will have a 'fodder block', a 'fuelwood block' and a 'stem-wood block'.

2. Note the types of trees already growing, in each block, their ages and condition. How will you manage them? Remember from Box 24-2 restoration of trees requires not only planting tree seedlings, but also the proper management of whatever trees are growing there at present. After you have thought about this, and discussed with your team members, your teacher will arrange for a class discussion to finalise one management plan for each block. These plans will then be followed by all teams. Describe these plans on next page.

FOR THE TEACHER

Take up Box 25-1 after this exercise.

Fodder block :

Fuelwood block :

Stem-wood block :

3. Refer to the selection of types of trees you made in Exercise 8. Discuss this selection with the residents of your study village – that is, with the members of your assigned family. After considering their suggestions, finalise one list in a class discussion. Write the names of the selected types in Table 25-1.

Table 25-1. Final list of selected types of trees for our project area

Block	Type of tree	Reason(s) for selecting this type
Fodder		
Fuelwood		
Stem-wood		

4. Calculate the total number of seedlings to be planted in each block, using Table 25-2.

Table 25-2. Numbers of total seedlings to be planted in each block of the project area

Block (1)	Area of block 'ares' (2)	Number of seedlings per 'are' (3)	Number of seedlings in block (4)
Fodder			
Fuelwood			
Stemwood			

5. Next with the help of Table 25-3, calculate the required number of seedlings of each type of tree. The total of all types in one block in Table 25-3 (column 4) should equal the total for the block as calculated in Table 25-2 (column 4).

6. In Table 25-3 you have calculated the numbers of seedlings of each type required to plant in your project area. However, you will have to produce more than these numbers because:

   a. Some seedlings will die in the nursery, and some may turn out to be weak or deformed.

   b. Some seedlings will die after being transplanted. You will have to do gap-filling the following year.

   Using Table 26-4, calculate the total numbers of tree seedlings that your team team will have to raise for initial planting and for gap-filling one year later. Transfer column 3 of Table 25-3 to the corresponing line in Table 25-4

Table 25-3. Numbers of seedlings of each type of tree required

Block (1)	Type of tree (2)	Number of seedlings required (3)	Total number of seedlings in the block (4)
Fodder			
Fuelwood			
Stemwood			

Teacher's signature:....................

Date:....................

BOX 25-1

THE MAHILA MANGAL DAL OF TANGSA VILLAGE

The forests of villages along the Alakananda River in Chamoli District of Garhwal region are badly degraded. In Tangsa village, for example, most of the forest area had no trees left some 20 years ago. In a large area on the north side of the village there had been repeated large landslides. Two decades ago the women of Tangsa had to bring much of their fodder from the distant reserve forest. They would leave home at seven in the morning and return only at two in the afternoon.

Now that picture has changed. Some parts of the forest have been enclosed with walls. The protected areas inside the walls are now producing several times more grass fodder than previously. Now the families have a good supply of dry grass for dry season feeding near their houses. Fodder and fuelwood trees are growing inside the enclosures. In a few more years these trees will provide fuelwood, and also green tree-leaf fodder for dry season feeding. And these supplies will also be close to home, thus saving the women's time. How did all this happen?

The women of Tangsa village organised themselves into a Mahila Mangal Dal. With the help from the Dasholi Gram Swarajya Mandal they enclosed, one by one, six patches of the forest with stone walls. They then planted seedlings of *banj, Manipur banj, bhimal, kwaral, kharik, shahtut, siris, bakain, rita, timil, toon, pangar* and bamboo *(bans)*. Trees of other species like *gauthi, charchar, khagsu, pian, anwla, mahwa* and *mehal* are appearing naturally due to protection. To give the planted seedlings a good start, the women put compost in the pits, even though they did not have enough for their fields. The survival rate of the planted seedlings is about 80 percent.

The men and women of the village made the protective walls themselves, but were paid wages with money provided by the Dasholi Gram Swarajya Mandal. Everyone who worked, man or woman, received equal wages. In one day each person was required to build a one-metre length of wall to earn his/her day's wage. The records of who worked were kept by the Mahila Mangal Dal. Wages were distributed every month at a meeting of the Mahila Mangal Dal.

The enclosed areas are managed by the Mahila Mangal Dal. Constant *chowkidari* (watch) is organized on the *mawas* system in which each family in turn carries out *chowkidari* duty for one day. When the grass is ready to cut, the Mahila Mangal Dal decides at a meeting the days for cutting. On these days one member from each family can cut one headload. Each family thus gets an equal share of the available dry grass. Two families do not own any animals. Even then they each get a share. They sell their shares to other families. Anyone entering the enclosures at any time other than on grass cutting days, or in anyway damages the enclosures, is punished with a fine.

In addition to fodder and fuelwood species of trees, the people of Tangsa have planted about 5,000 fruit trees – citrus, lime, pear, walnut and others. Some of these they have planted around their houses. Others they have planted in the cultivated fields around the landslide site. These field are no longer ploughed. By changing from cultivated crops to fruit trees (with grass underneath the trees) they hope to reduce the risk of further landslides. About 100 fruit trees have started yielding.

Today Tangsa village is both greener and more productive. Life there is a little easier. All this is due to the initiative and co-operative spirit of its women. We all can learn a great deal from their experience.

This story has been adapted from the report entitled "Experience of Dasoli Gram Swaraj Mandal in Social and Agro Forestry with Community Participation" written by C.P. Bhatt. This report is the outcome of a seminar organized in Gopeshwar, District Chamoli between 12th and 17th December 1992.

Date: ....

Code : Compost 1
Month : May

EXERCISE 26

BIOMASS RECYCLING : AN INVENTORY

INTRODUCTION

In Box 4-1 and Exercise 5 we learned that for a healthy and productive ecosystem, we should try to recycle all the biomass produced in the system back to the soil. Biomass means tissues of all organisms of plants, animals, microorganisms and decomposers. In this exercise we will make an inventory of all the different types of biomass produced in our study village ecosystem and enquire what happens to it. Most of the biomass produced in our village ecosystem is plant tissues (primary biomass), and for convenience we will talk only about primary biomass.

Before beginning this exercise let us remember the different ways that plant biomass may be recycled.

1. As mulch (Boxes 11-1'The principles of organic farming' and 18-1 'When it rains') This is the most natural way of recycling biomass – it is the way recycling is done in a natural ecosystem. The mulch decomposes and feeds the soil and then the crops we grow in the soil. Aside from this, mulch protects the soil surface from direct rainfall and from excessive heat and cold. Mulch acts like clothes for the human body.

2. As compost Biomass may be converted into compost by putting it directly into a compost pile or feeding it to animals first and then putting the dung and urine in the compost pile (Box 26-2 'How to make good compost'). Human waste, produced from the food biomass we eat, can also be made into compost.

3. As fuelwood Let us also recall that it is usually necessary to burn some biomass (e.g., fuelwood) in our *chulhas*. In this case the energy of the burned biomass is not returned to the soil. Of course we must return the ash from this biomass to the soil either directly or by putting it in a compost pile (Box 26-2). Remember that the

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FOR THE TEACHER

Take up Box 26-1 before and Boxe 26-2 and 26-3 after this exercise.

decomposers that live in the soil require energy as well as minerals. We must not burn any biomass in our village ecosystem except that needed for our *chulhas*.

PROCEDURE

1. Meet the members of your assigned family and ask them to tell you all the forms of primary biomass produced by their land (crops, grasses, tree leaves, wood, etc.) and what they do with it. Enter this information in Table 26-1. Remember biomass comes in the form of human food, animal food, material suitable for mulching and composting. Note that some biomass may be sold and thus leave the ecosystem.

   The land, animals and people of one family may be considered a small ecosystem, and recycling may be within this ecosystem. All the land, animals and people of all families in the village make up the village ecosystem.

2. Now, in Table 26-2 note down for all items in Table 26-1 that are not fully recycled and the reasons why they are not recycled, after discussion with the members of your assigned family. Two common reasons are:

   i. Biomass is sold: for example, in the case of paddy straw, the money obtained by selling it to the paper factory is valued more than he benefit from using it as mulch.

   ii. Biomass is burnt in field: for example, in case of sugarcane trash, it is easier to burn it than to make compost of it. For those types of biomass that are not completely recycled, give your suggestion (in column 3) for more complete recycling.

Table 26-1. Forms of biomass produced in our study village ecosystem and its fate

Name of primary biomass (1)	Relative amount (2)	What items obtained from biomass of column(1) and what happens to it (3)	Is complete recycling of this biomass happening in this ecosystem? (4)
Wheat	large	Grain – human food Straw – animal fodder	
Sugarcane	large	Juice – Bagasse – Green leaves – Trash –	

Instructions:

Column 2: Write here 'large', 'medium' or 'small'. For example, sugarcane trash is usually produced in large amounts, whereas, pulses are is produced in small amounts.

Column 4: Is the amount of original biomass taken from the soil returned to the soil in the form of mulch or compost? Yes or no.

Table 26-2. Reasons for incomplete biomass recycling and ways in which more complete recycling could be achieved

Name of primary biomass (1)	Reasons for incomplete recycling (2)	Suggestions for more complete recycling (3)

QUESTIONS

First discuss these questions in your class and then write the answer.

1. The biomass from village support area (such as fodder, fuelwood, bedding, etc.) is recycled to the land of individual families. In other words there is a continuous flow of biomass (and the plant nutrients it contains) from support area to private land. Is there any recycling of biomass within the support area ? If so, in what form?

2. When we grow trees for fuelwood and stemwood on our field boundaries or inside our fields, they drop old leaves every year and these feed the soil and in turn, the trees themselves and the other crops growing with them. In the case of fodder trees most of the leaves are taken away. In this case, how can the trees/soil be properly fed?

Teacher's signature:....................

Date:....................

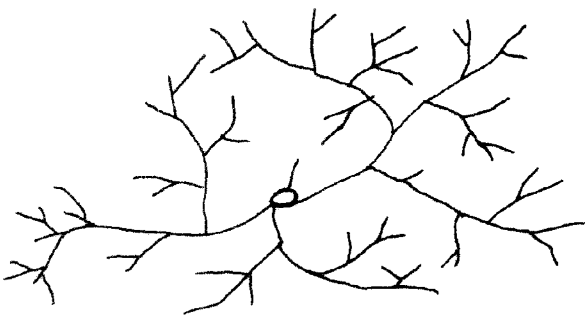
BOX 26-1

FEEDING OUR SOIL

In Boxes 9-1 and 16-3 we learned that living organisms are a very important part of the soil. To manage our soil well we must now learn more about the activities of these organisms.

There are many types of soil organisms.

1. Fungi There are many types of fungi, ranging from single cells to complex organisms like mushrooms and tree-bracket fungi. All are decomposers (Box 16-3), that is, they eat dead plant and animal tissues and animal excreta. The single cell types are the most common. They can be seen only under a microscope. Each cell grows many long branches called 'hyphae'.



   These hyphae grow over the surface of dead matter and secrete enzymes which dissolve it. They then absorb the dissolved substances. (Enzymes are like the juices in the stomachs of animals which digest the food they eat.) Mushrooms are bundles of fungal hyphae.

2. Bacteria These are single-celled organisms, but they do not have branches like fungi. They are also decomposers. (Like fungi, they are plants, but do not possess chlorophyll.)

3. Insects Examples of insects that eat dead matter are termites millipedes, ants and dung beetles.

4. Animals Examples of animals that eat dead matter are slugs, snails and earthworms.

There are many types of insects and animals in the soil that eat living plants and animals. In this box, however, we will consider only decomposers, i.e., those that eat dead matter. Incidentally, the common term for dead plant and animal matter is 'organic matter', and we will use this term from now on.

The soil organisms that feed on organic matter are very numerous; we do not realize this because we do not see them. If we could collect all these organisms from the soil of one 'are' of good forest we would have as much as 100 kg of living organisms. That is equal to three or four goats. Now you can imagine how much food (organic matter) these organisms need in one day. Their primary supply of organic matter is dead tree leaves, tree roots and dead trees themselves. In cultivated land, the soil organisms must be fed with compost and mulch.

Let us consider how the activities of these organisms affect the health and yield of crops.

Role in soil formation

Box 23-2 explained how soil is formed from solid rock by the action of rain water, the freezing and thawing of water, the force of growing plant roots, and the action of carbonic acid. Plants, and also soil organisms, produce carbon dioxide which combines with water to form this carbonic acid. Thus soil organisms help in the continuous process of soil formation.

Solubilisation of minerals and nitrogen

When organic matter is decomposed, the minerals and nitrogen it contains are released in a soluble form in which they can be absorbed by the roots of living plants. In theory all the minerals, and the nitrogen, could be added to the soil as pure minerals (like the ones in bottles in your school chemistry laboratory) and plants would live and grow. In practice this does not happen for reasons that will become clear in a moment.

Humus production

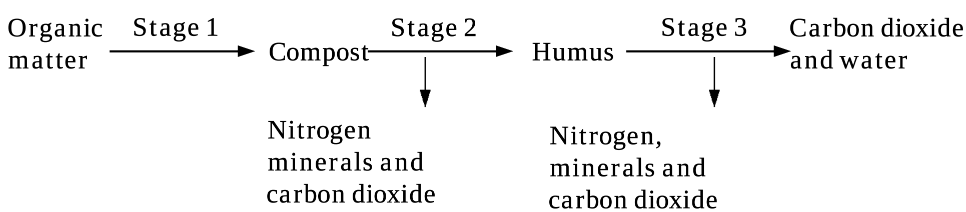
Humus is produced from organic matter when it is decomposed. It contributes to soil fertility is several ways. First of all it can soak up a lot of water because it is a soft, absorbent material. If we were to determine the water-holding capacity of a sample of 100 ml of soil mineral particles, we would get a figure of about 30 ml. (In Exercise 9 we learned the technique for determining the water-holding capacity of a soil). On the other hand, a sample of 100 ml of humus would hold about 500 ml of water. We can readily see that a soil with a high humus content will hold more water than one with a low humus content. Where fields are totally dependent upon rain water, humus keeps the soil moist for a longer time. In irrigated land, the less humus the soil contains the more often it must be irrigated.

Humus produces a substance called 'humic acid', which stimulates the roots of plants to grow. When plant roots grow longer and deeper into the soil, they can absorb more water and minerals.

Humus also reduces the rate of soil erosion when there is heavy rain. This is because it is somewhat sticky. It binds the smaller soil particles together so that they are less likely to get washed away.

In all these ways humus makes soil more fertile, and plants more healthy and productive. It is no wonder that people always judge the fertility of a soil by its colour; the darker it is, the more humus it contains and the more fertile it is.

Humus in the soil, once it is formed from organic matter (compost and mulch), does not last forever. Humus is continually being formed and used up in the soil. This process can conveniently be thought of as occurring in three stages.

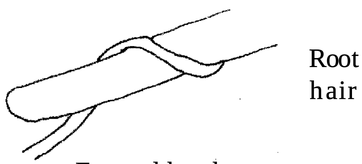


At stage 1 we put organic matter (dead plants, animals and excreta) into the compost pile. Here decomposition occurs as described in Box 26-2. When we put compost into the soil the second stage of decomposition is continued by the micro-organisms living in the soil and as a result of it, humus is formed. In the third stage humus is gradually converted into carbon di-oxide and water. As a result of stages two and three, minerals and nitrogen are released which feed our soil. Decomposition of mulch occurs directly in the soil from stage one to three.

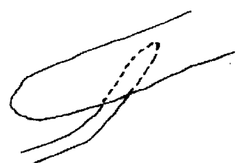
The first stage occurs very rapidly, in a few days or weeks in warm weather and when moisture is adequate. The third stage of decomposition occurs very slowly, requiring many years. Thus, if we have a cultivated field with good dark soil (a lot of humus in it) and we stop adding organic matter but continue to grow crops, the humus will slowly disappear. We can well imagine that the health and yield of our crops will go down. To maintain the health and yield of our crops, we must add fresh organic matter (i.e., compost and mulch) every year. We can maintain a high humus content in our soils only if we return all the primary biomass produced as such or in the form of human and animal wastes.

The formation of mycorrhizae

Some types of soil fungi are able to form a partnership with living plants. The name given to this partnership is a mycorrhizae. Both the fungi and the plant benefit from the mycorrhizae. The hyphe of the fungus grow around the root hair of a plant, and in some cases actually penetrate the root hair.



Fungal hypha
growing
around root hair



Fungal hypha
growing
into the root hair

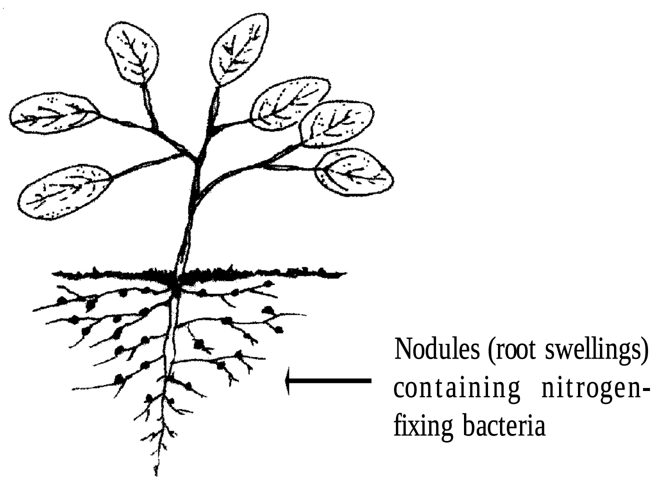
In both cases the fungus obtain glucose from the root which it needs to live and grow, and the fungus gives the root soluble minerals which it has absorbed from the soil. Since each fungus has a large network of hyphae spreading throughout the soil, the plant, with its help, can absorb two or three times more minerals than it could by itself. Moreover, the fungus gives the plant substances which stimulate its growth, and antibiotics. The antibiotics help the plant to fight diseases.

It has, however, been found that mycorrhizae do not form if there is not a good amount of compost/mulch in the soil. In soils to which compost/mulch have not been added, mycorrhizae are not found, but they are abundant in soils to which compost/mulch have been added. Also, in weak, diseased plants, or in those attacked heavily by insect pests, mycorrhizae are few or absent. In healthy, disease-free and pest-free crops, mycorrhizae are abundant. Experiments on crop plants and trees that are weak, diseased or pest-ridden have shown that they become healthy in two or three years only by adding good amounts of compost to the soil. Such recovery cannot be achieved simply by adding soluble minerals to the soil.

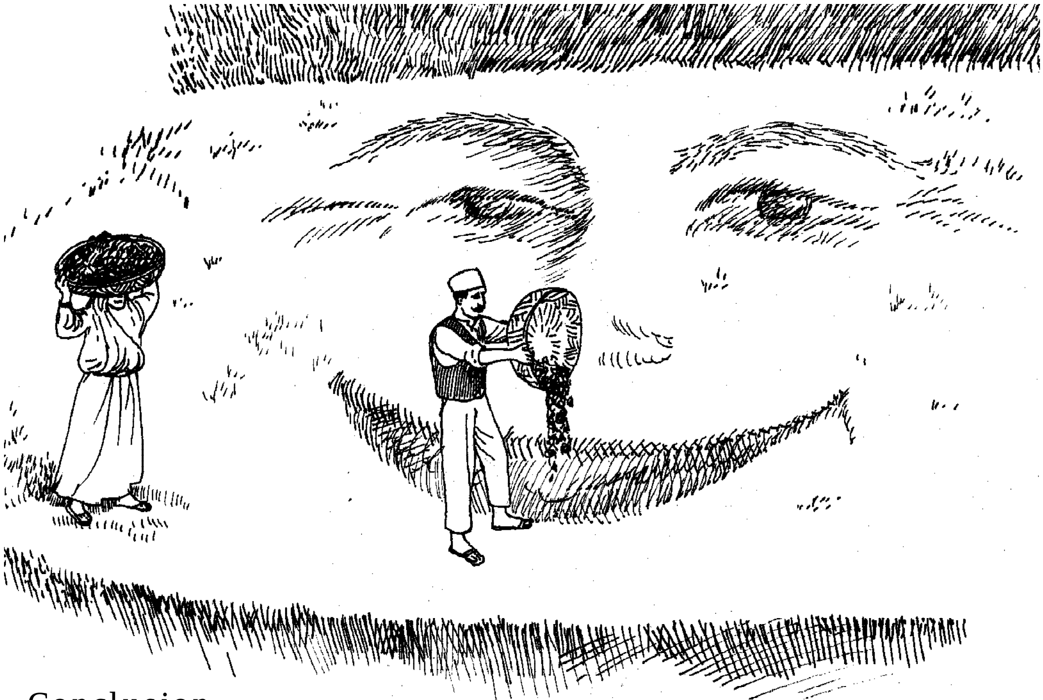
Nitrogen fixation

Some of the nitrogen needed by plants comes from the decomposition of organic matter. A lot of nitrogen is also produced in the soil by bacteria and fungi. They take nitrogen from the air and convert it into nitrates, a form that plants can absorb and use. Some of these bacteria and fungi live in the soil only, while others burrow into the roots of living plants. For food the free-living organisms require organic matter. The ones living inside the roots of plants get their food from the plant, though when there are no plants growing during a particular season or year, they can live freely in the soil, consuming organic matter.

The bacteria which live in the roots of plants cause small swellings, which can easily be seen. The roots of a bean plant look like this:



Plants which form these nodules (root swellings) are: peas, beans, fenugreek, soyabean, green gram, horse bean, lentil, *siris*, *acacia*, *Robinia*..



Conclusion

We have learned in the foregoing sections that the activities of soil organisms are essential to plant life. Where there is plenty of organic matter for these organisms to eat, they are found in large numbers, and the plants growing in that soil are healthy and productive. If plants are not vigorous, or if they are diseased or eaten by insects, it usually means that the soil organisms are few in number and are not healthy because they are not receiving enough organic matter to eat. In an undisturbed forest, trees themselves provide enough organic matter in the form of fallen leaves. In cultivated land, we remove all the plants (except for their roots) at harvest, and to feed the soil organisms properly we must add compost/mulch to the fields. To conclude then, we add compost/mulch to our fields to feed the soil organisms. In short we can say we are feeding our soil. The soil then feeds our crops, which in turn feed us. This is a useful way of thinking, and we will adopt it in this course. We will say: If we feed our soil well, it will feed our crops and we will get good yields.

When we use chemical fertilisers and pesticide to grow crops soil organisms are poisoned. As a result, the process of organic matter decomposition slows down. Gradually humus and nutrients vanish and the water-holding capacity of soil declines. Nitrogen-fixation by soil/root bacteria also slows down causing a deficiency of nitrogen in the soil. The health and yield of crops go down. Chemical fertilisers feed crop plants directly but they are not food for micro-organisms which remain hungry and become weak. Attacks of pests and diseases in such crops are more common. Pesticides, which make soil organisms still more sick. In these ways crop yields decrease year by year.

BOX 26-2

HOW TO MAKE GOOD COMPOST

What is compost?

Compost is made from animal dung and urine, bedding, and uneaten fodder, kitchen waste and ash. These materials are put into a pile daily . Just before ploughing, we transfer the piled-up material, or compost, to our fields. What happens to the dung and other materials during the period they remain in the pile?

The organisms in soil that decompose dead plant and animal tissues are also found in the compost pile. In the compost pile they start decomposing the dung, etc. in the same way they would do if we put these things directly into the soil. However, there is not enough time for them to complete the whole process. How much they do depends upon two factors: moisture and temperature. If these factors are favourable, we will see that the compost pile decreases in size before we remove it to the field. Also, the original materials do not at that time have the some appearance as they did when put in the pile; they are broken up into small pieces and are darker in colour. The compost will contain many soil organisms like earthworms, though most of them, like fungi and bacteria, are too small to be seen. By these signs we know that stage 1 (Box 26-1) is complete.

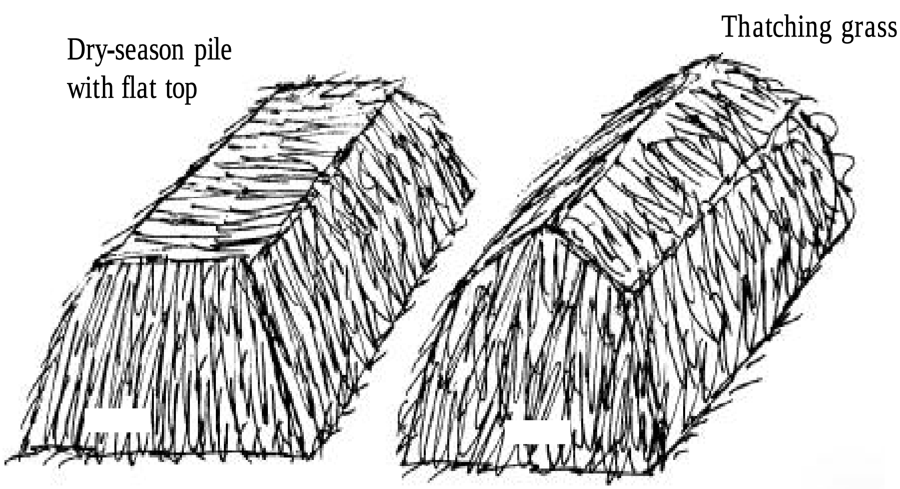
Soil organisms are more active in warm weather. Thus from April to November decomposition is rapid, while in a compost pile made in the winter decomposition will be slow.

The other essential requirement for the activity of soil organisms is adequate moisture. In the absence of moisture, they will not decompose the materials in the compost pile. Normally soil organisms are not active in the compost pile during the warm months before the monsoon rains begin because the material in the pile are too dry. When the rains begin, they become active.

The method of making compost

Compost is made in a pile by adding fresh material every day. On the first day spread the material about 10 cm deep on the ground in a rectangular area 1 m wide and as long as necessary. Over this sprinkle a handful of soil and several handfuls of ash. Also sprinkle whatever animal urine is collected that day. (The method of collecting urine was given in Box 24-1.) Repeat this procedure every day until the pile is about 1.5 m high. By the time the compost is removed to the field, the height will not be more than 1 m because the volume of the original material decreases as decomposition proceeds. In the dry season it may be necessary to add water to the pile so that the soil organisms remain active. Waste household water may be used, if it is free from detergent. How much water is to be added can be judged by removing a handful of material near the bottom of the pile; it should feel damp, like a wrung-out cloth. Too much water is as harmful as too little; with too much water, the rate of decomposition also decreases. When removing the compost to the field, transfer the material on the surface of the pile which has not decomposed, to a pile that is currently being made.

Compost piles made during the wet season may become too wet due to heavy rain. To reduce the infiltration of rain water, slope the top of the pile so that some of the rain water runs off the pile. Thus:



Wet-season pile. The pile is finished off with a sloping top. Thatching grass may be laid on the top to increase rain water runoff.

Compost is ready to use when the original materials are well broken down; entire leaves and grass stems should not be visible. Such compost begins to feed the growing crop as soon as it is applied to the field. Otherwise the growing crop will remain hungry for some time while the composting process (stage 1) is being completed. (Or we can say that the soil organisms must first eat before they can begin feeding the growing crop.)

In the proper method of making compost described above we add three things to the organic matter in the pile – soil, ash and animal urine. All these have an important role to play in making good compost. The handful of soil we add contains all the types of soil organisms that decompose organic matter. They multiply rapidly in the compost pile, if there is enough moisture and it is not too cold, and begin the work of decomposing the organic matter.

By adding ash to the compost pile we neutralise the acid produced by soil organisms as they decompose organic matter. If this acid is not neutralized, the work of the soil organisms becomes very slow, and it will take a very long time for the compost to be ready. Ash also supplies all the mineral elements that soil organisms (and living plants) require for life and growth. (These minerals were present in the wood that was burned; they are not destroyed by burning.) The soil organisms in the compost pile obtain minerals from the organic matter they eat, but also absorb the soluble minerals from ash.

Earthworms are very helpful in rapidly decomposing organic matter in the compost pile. However, they do not like acid surroundings. If we do not neutralise acidity by adding ash we will not find many earthworms in our compost. Earthworms also do not live in compost piles that are water-logged. Remember: the presence of earthworms is a sign of good compost.

Urine also adds soluble minerals to the compost pile as well as a lot of soluble nitrogen. These stimulate the soil organisms to grow and multiply and thus rapidly to decompose the organic matter we put into the compost pile. The prepared compost will also be richer in these minerals and in nitrogen than it would be if we did not add the urine. Such compost will feed our crops better.

If your compost is not moist enough after adding animal urine, be sure to add water.

Box 26-3

THE PUSA EXPERIMENTS

In this box two experiments are described. The results of these experiments clearly show the effect of compost on yield of the crops.

Pusa is located in the plains of Northern Bihar. The soils and climate are similar to plains and the low-altitude river valleys of Uttarakhand.

In the first experiment crops were sown in three plots adjacent to each other. Each plot was 0.5 nalis in area. Each was treated differently as follows.

Treatment 1 — No compost applied

Treatment 2 — 45 kg compost per *nali*

Treatment 3 — 90 kg compost per *nali*

The compost was applied to the plots before the kharif crop was sown each year. These three treatments were repeated 10 times in blocks of 3 plots in other parts of the same field. Thus there were 30 plots in all, 10 of each treatment. At the end of each season the crop in each plot was harvested, threshed separately and the grain weighed. The yield figures for each plot of same treatment were averaged. Thus the yield is the average of 10 plots.

The crops grown were maize in the kharif season and peas, barley, arhar and wheat in the rabi. The following four-year rotation of crop was followed.

Year 1 Maize — peas

Year 2 Maize — barley

Year 3 Maize — *arhar*

Year 4 maize — wheat

This crop rotation was followed in all plots. The crops were not irrigated and no chemicals were applied. The experiment was continued for 37 years, beginning in 1930. Yearly yield figures for grain were averaged for each treatment.

Experiment 2 was similar to experiment 1, and was conducted in an adjacent field. However, the treatments were only two.

Treatment 1 – No compost applied

Treatment 2 – 90 kg compost per year

The crops sown were maize in the kharif and oats, peas, wheat and gram in the rabi. These crops were sown in a four-year rotation. The experiment began in 1932 and continued for 35 years.

Note that the rate of applying compost was 45 and 90 kg per 0.5 *nali* plot. This is equivalent to 90 kg (about 3 *dalas*) and 180 kg (about 6 dalas) per *nali*. Grain yield figures were also calculated on a per-nali basis.

The results of these experiments are given in table 26-3-1. In both experiments the application of compost at the rate of 180 kg per *nali* per year greatly increased grain yield over the no-compost treatment. The increase in experiment 1 was greater than in experiment 2, probably because of differences in the soils and positions of the two fields, and also to the differing types of crop grown. The results of experiment 1 also show that the more compost applied, the greater is the yield of the grain (compare the yields of the 'no compost' plots with 90 kg and 180 kg compost).

Table 26-3-1. Yields of grain with different levels of compost application

Experiment number	Average annual yield of grain, kg/*nali*		
	With no compost	With 90 kg compost/*nali*/year	With 180 kg compost/*nali*/year
1	12	34	43
2	17	-	37

Date: ....

Code : Crops 7
Month : June

EXERCISE 27

THE CROPPING PATTERNS OF OUR STUDY VILLAGE

INTRODUCTION

In the past 40-50 years or so cropping patterns in India, including Uttarakhand, have changed. There can be many reasons for this. These changes may have brought benefits to farmers, but in some cases problems also. Where there has been change, we will try to discover its cause.

In this exercise we will determine the present cropping pattern of our study village, and, as far as possible, the patterns that existed two generations earlier (about 40 years ago).

PROCEDURE

1. Each team will visit its assigned family and request them to name the crops they grew the previous year, and the area of each crop. Write this information in Table 27-1 in the appropriate column and row. Be sure to ask if any land has been left fallow, and if, so in which season and how much area. Record the data in whatever units is convenient to the family members (e.g. hectare, are, acre or *bigha*, *nali*).

FOR THE TEACHER

Take up Boxes 27-1 and 27-2 before and Boxes 27-3 after this exercise.

Tell students to discuss the questions given at the end of the exercise with the members of their assigned families on the day of their visit along with the collection of data on the areas of various crops.

These questions must be discussed in depth by the students within their teams. You may request them to present their team answers to the class, and then conduct a general class discussion. Try to reach a general consensus of all the students on each question.

Table 27-1. Areas of different crops sown during the previous year

Year...............

Crop (hectare/are/acre/*bigha/nali*) (2) (3)	Name	Area of crop (1)
Rabi (November-March)		
	Fallow	
	Total	
Zaid (April-June)		
	Fallow	
	Total	
Kharif (July-October)		
	Fallow	
	Total	

2. Note that the totals for each season should be the same. If they are not, check your calculations and, if necessary, discuss the problem with the members of your assigned family until you discover the reason for the discrepancy. (Take guidance from the example in Box 27-1.)

3. Now calculate the total sown plus fallow area for the whole year as follows:

$$\text{Total sown + fallow area in one year} = \text{Total sown + fallow area in one season} \times 3 = \ldots\ldots\ldots\ldots\ldots$$

4. Now calculate the overall cropping pattern for the whole year using Table 27-2. To calculate the area and crop as a percentage of the total cropped area divide the acual area by the total of column 2. The total of column 3 should be 100.

Table 27-2. Overall cropping pattern for the whole year

Crop (1)	Area, hectare/are/ acre/bigha/nali (2)	Area, % of total cropped area (3)

Summarise the data in Table 27-2 in words.

QUESTIONS

Discuss the following questions with the members of your assigned family (especially the older members).

1. How does the present cropping pattern differ from that of 40 years ago?

2. Why have these differences come about?

3. Are some crops grown now that were not grown previously? Which crops? What is the reason for this change?

4. Were some crops that were grown earlier not grown now? Which ones? What is the reason for this change?

5. Has the percentage of fallow land increased or decreased from the past? Why?

6. Do you see any problems with the present cropping pattern? What are they? How could they be solved?

Teacher's signature:....................

Date:....................

BOX 27-1

HOW CROPPING PATTERN AFFECTS OUR VILLAGE ECOSYSTEM

In Box 4-1, 'The Stone Axe', we learned from professor sahib how our village ecosystem has become degraded. When all the trees disappeared we began using dried dung for fuel. This left too little compost for our fields and slowly their productivity decreased. Then, in recent years, we began adding chemical fertilisers to boost productivity. Productivity has increased, but the health of our crops has suffered and we now use chemical pesticides to treat them. But all these chemicals have made our fields still more sick.

Also in the past 40 years or so the area and intensity of irrigation have increased. As a result, crop yields have increased and cropping patterns have changed toward water-demanding crops like paddy and sugarcane, and away from traditional crops like maize, sorghum, wheat, pulses and oilseeds, which require less water. Crop yield have increased and there is more surplus to sell. This has increased our cash incomes, making possible many improvements in our lives.

At the same time several serious problems have been created. First, more extensive, and intensive, irrigation has caused falling water tables and water logging (Box 22-1, 'Water cycle in village ecosystem'). More recently, thick and prolonged fog during the winter is also ascribed to irrigation.

Second, there is a loss of biomass from our village ecosystem. We are producing more, and also selling more of what we produce. When we sell paddy, sugarcane, wheat and vegetables etc. large amount of biomass leave our ecosystem and never return. This adversely affects ecosystem health and productivity. The loss of biomass is also in the form of crop residues. When we grow fast-growing trees like popular and eucalyptus and sell the stemwood to paper mills and match factories there is also a loss of biomass.

Third, when we use tractors we do not need bullocks as in the past. The number of animals we keep goes down. We have less compost on the one hand, and on the other hand, we do not need all our crop residues for fodder (like paddy straw) and bedding (like sugarcane trash). The unused biomass is burned, and not properly recycled. (Minerals, but not nitrogen and organic matter are recycled.)

Fourth, attention to cash crops reduces crop diversity. Fewer mixed crops are grown and traditional crop rotations are forgotten. As a result attacks of pests and diseases increase.

Fifth, the change in cropping pattern affects our diet. Ever since the start of the 'Green Revolution', the amount of pulses we eat has gone down – because the area of pulse crops has gone down. This adversely affects the health of people who do not have a cow or buffalo or who cannot afford to buy milk.

The sixth adverse effect of cash cropping is on our purse. We no longer produce enough oilseeds to meet our needs. Even village people now buy much of the cooking oil they need from the market. (Much of the cooking oil in the market is now imported.) So, while we earn money from selling wheat, paddy, sugarcane and vegetables, we have to spend more to buy oil.

We also have to spend more money in growing cash crops than in growing traditional crops. Cash crops need large amounts of chemical fertilisers. As soil quality deteriorates from these, attacks of pests and diseases are more intense. To control these, every crop requires three, four, or more sprays of pesticides. These pesticides are becoming very expensive.

What can we do to solve these problems?

In villages where increased irrigation has disturbed the water balance (falling water table or water-logging), there appear to be two possible ways to correct it. One is to apply water more efficiently. At present we generally apply more water than is really necessary through carelessness. We can also reduce wastage of water by lining irrigation channels thus eliminating seepage losses. The other way to reduce water use is to reduce the areas of water-loving crops, and increase the area of traditional crops like pulses and oilseeds. How would such a change in cropping pattern affect us (our income, our health) and our ecosystem? This would be a good question for a class discussion.

Some guidance for doing Exercise 27

The following simplified example will help understand the procedure for doing Exercise 27.

For this example we will divide the year into three seasons: *rabi* (November to March); *zaid* (April to June) and *kharif* (July to October). With sufficient irrigation, it is possible to grow three crops per year in one field.

Suppose the family has 150 'ares' cultivated land. In the previous year the following crops were grown:

Crop	Name of crop	Area, 'ares'
Rabi	Wheat	50
	Sugarcane	80
	Barseem(for fodder)	20
	Total	150
Zaid	Maize+ Cowpea (for fodder)	10
	Sugarcane (continuing)	80
	Fallow	60
	Total	150
Kharif	Paddy	50
	Sorghum (for fodder)	20
	Sugarcane (continuing)	80
	Total	150

Total sown plus fallow area in one year =150 x 3 = 450 'ares'

Combining all three seasons we get the overall cropping pattern for the year:

Crop	Area ('ares')
Wheat	50
Sugarcane	240 (3Î80)
Paddy	50
Fodder	50
Fallow	60
Total	450

The approximate percentages, of each crop in the total sown area in one year are:

Crop	Area (percentage)
Wheat	11.1
Sugarcane	53.3
Paddy	11.1
Fodder	11.1
Fallow	13.3
Total	99.9 (say 100)

BOX 27-2

WHERE DO THE PESTICIDES GO?

When we spray pesticides on our crops we are intent on killing insects which feed on crop plants or fungi which cause plant diseases. We do not stop to think where these pesticides go later on. Since they are poisonous to human beings and animals as well as to pests, this question is very important. Now that you have learned about the water cycle in the village ecosystem, it is possible to answer this question.

Pesticides kill pests by contact with their bodies and by poisoning their food. In the former case the pesticides is absorbed into the body. In the latter, the pesticide on the leaves of plants is eaten along with the leaves, or the pesticide is absorbed by the plant through its leaves, circulating to all parts of the plant making them poisonous. From this you can understand why almost all our food contains pesticides. Foods from those crops sprayed most, have the most pesticides in them. An example is *gur* (unrefined sugar). (Recall here the discussion that occurred in Box 5-1 ‘Pest: our problem’).

Insects that have been poisoned are eaten by frogs, birds and spiders and these too, die after some time. They also die as a result of the spray directly. These organisms have definite role in making an ecosystem healthy. They control the number of pests. When these organisms are killed pests become still more of a problem because they rapidly become resistant to pesticides. We spray still more pesticides, poisoning our food and water still more. Most of the pesticides we spray on our crops, falls on the ground, either directly while spraying or by being washed off plants by rain. They dissolve in water (rain or irrigation water) and enter the soil along with the water. There they kill many soil organisms like earthworms, termites and bacteria. Finally, the pesticides reach the ground water. It is this water that we pump to meet our household needs and to irrigate our crops. Thus all the water we drink in our home and use to prepare our food contains pesticides. The water our cows and buffaloes drink contains pesticides which are passed on to us in milk.

Most of the pesticides we use eventually reach our rivers through slow underground water flow and in surface runoff of water. There they kill water plants and fish. You can understand why fish are poisonous when eaten by people.

How do we know that pesticides end up in ground water? The Centre for Science and Environment in Delhi recently took samples of water from tube wells in and around Delhi and tested them for pesticides. In all cases several pesticides such as DDT and malathion were found.

The conclusion is that it is probably not possible to get pure water anywhere in the plains. Artesian well water probably has less pesticides in it because pesticides are not much used in the hill region of Uttarakhand. This may also be true for river water entering the plains from the hills.

What happens to people who drink water with pesticides in it? The amount of pesticides is of course very little compared to the dose we spray on insects. We do not feel sick, and we do not die. However, the small amounts of pesticides we drink and eat every day accumulate and after some years they cause various serious diseases.

How do you think you can solve this problem of pesticides poisoning? Discuss this question with your parents and in your class at school. Summarise your discussions in the space provided below.

Date: ....

Code : Trees 7
Month : July

EXERCISE 28

TREE CARE - 1

INTRODUCTION

Last year in Exercise 16 you learned how to transplant tree seedlings. You also observed the progress of the seedling you transplanted. Now it is time to summarise those observations and draw some important conclusions about proper tree seedling care.

PROCEDURE

1. Observe all the seedlings you transplanted last year (Exercise 16), review your notes on their progress over the past one year and then answer the following questions.

   a. How many seedlings did your team transplant?

   b. How many plants have survived?

   c. What is the survival percentage?

   d. For those seedlings that died, what do you think was the cause of death?

   Write your answers in Table 28-1 in the appropriate line.

2. Now exchange survival percentage data with other teams and fill up Table 28-2.

FOR THE TEACHER

Take your students to their plantation site (Exercise 16) where they can observe their seedlings after one year. In the previous class period tell them to bring their 7th class workbook with them to the class so that they can refer to their notes on the progress of their seedlings over the past year. Take up Boxes 28-1, 28-2 and 28-3 before doing this exercise.

Table 281. Teamwise observations on the progress of tree seedlings over one year (Team no ....)

Type of plant	No of seedlings	transplanted No of	seedlings surviving	Survival percentage Cause(s) of death

3. Looking at the information in Table 28-2 answer the following questions.

a. Which type of tree survived best?

____

b. Which type of tree had the lowest survival percentage?

____

c. What do you think are the reasons?

____
____
____
____
____
____
____
____
____
____
____

Table 28. Survival percentage of different seedling types

Team No	Name of type of tree					
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
Total						
Average						

4. Looking at all the observations together, can you suggest how seedlings care can be improved in the future? Do the observations suggest any other conclusions? Write your answer in the space below.

5. If there are extra tree seedlings in your school nursery, you should plant new seedlings in the pits where last year's seedlings died. Take care of them during rest of this school year.

Teacher's signature:....................

Date:....................

BOX 28-1

HOW TO MANAGE TREES FOR FUELWOOD PRODUCTION

There are three main ways of producing fuelwood. After planting seedlings, or encouraging them to establish naturally, we allow them to grow to maturity, and then cut them. In this way we begin obtaining fuelwood only after many years. Another way to produce fuelwood is by the method of pollarding. In this way we begin obtaining fuelwood much sooner. This box describes the method of fuelwood production by pollarding.

We also obtain fuelwood as a by-product from trees grown for timber. Fifty percent or more of the wood produced by timber trees is fuelwood (i.e., thinnings, tops, branches and sawing waste).

Which types of trees do we plant?

For ready reference here is a list of some trees in which pollarding is possible

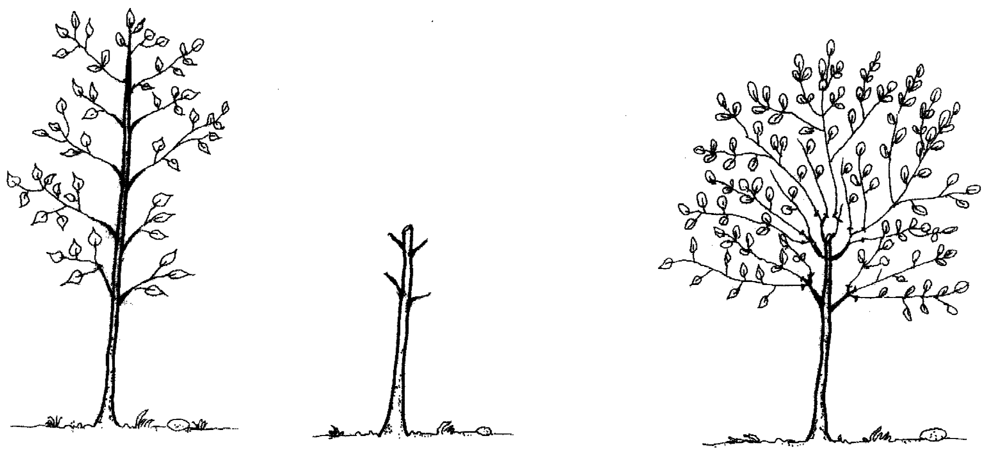
Acacia	*Gliricidia*	*Bakain*	*Grevillea*	*Shahtut*
Babool	*Akrot*	*Faliyant*	*Robenia*	*Mehal*
Bakain	*Banj*	*Kharik*	*Tilonj*	*Beru*
Kimu	*Timul*	*Bhimal*	*Kweral*	*Padam*
Panger	*Poplar*			

Method of harvesting fuelwood

When the saplings reach a height of 4 to 5 metres, they are topped at a height of 2 m. Also, the main branches are cut back to stumps about 20 cm long (pollarding).

New shoots will grow out of the stumps. These should be thinned to two or three near the top of the stump. These are allowed to grow until they are 5-10 cm in diameter. They are then cut off just above the place where they emerge from the stump.

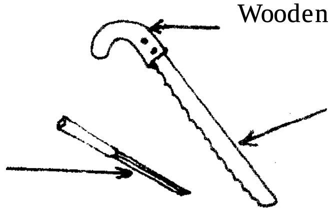
The stems when cut are an ideal size for the *chulha* (cooking stove) when cut into suitable lengths. They do not need splitting.



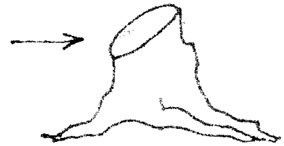
Tree sapling 4 m high	Stump of sapling after topping at a height of 2 m.	After some years shoots are ready for cutting

In this method of managing trees, we encourage them to convert most of their food into wood rather than leaves. Of course, every time we cut the trees we get some green leaves too, if the tree is a fodder type. These leaves can be fed to animals. We can also collect some dry, fallen leaves from, under the trees for animal bedding.

The cutting of tree trunks and pollarding of shoots must be done neatly. If the cut ends of the stumps are split, or if the bark is peeled back, fungi can easily attack the tree. The tree may then die. For neat cutting, a small handsaw made from a piece of bandsaw is suggested. It looks like this:



Also, all cuts should be made at an angle, like this:



Managing existing trees in new stand

There may be some trees in the project area when we begin rehabilitation. If these are fuelwood-producing types, they may either be pollarded or removed. If they are not too old, they will survive pollarding and then can be managed like the new trees. If they die the stump may then also be cut at ground level. Very large, old trees, should be completely removed. Old trees, even if they seem healthy, and even if they do produce pollarded shoots when cut, will grow slowly. If they are removed, the new trees will take their place and produce much more wood per square metre than the old trees would. If any existing tree which has been topped does not grow vigorous pollard shoots, it should be completely removed. All these operations should be completed within two-three years of starting rehabilitation so that the old trees do not shade and suppress the new ones.

Replacement of old trees

Trees, like people and all other living organisms, have a definite life span. To sustain yield, we will have to watch the trees in the fuelwood stand year to year. When it appears that the growth rate of new shoots is decreasing, then is the time to replace the trees.

New trees may establish themselves naturally from seed if there are seed trees near by. Or they may come from root suckers with some types of tree like, *acacia*, *shisham* and *shahtut*. Otherwise seedlings will have to be produced in the nursery and planted out. In planting seedlings, do not plant a seedling of a given type at a place where an old tree of the same type has been removed. The principle underlying this suggestion is that of 'crop rotation' which we follow in growing crops on cultivated land. Rotated crops are generally healthier and more productive than when the same crops are grown continuously on the same land.

Seed production

Pollarded trees do not produce seeds. But in future we shall need a constant supply of seeds of every type of tree that is growing in our fuelwood stands. From time to time trees must be replaced to keep our stands productive. We must therefore be sure that a few trees of every type are growing naturally in our village. These can be grown on field boundaries, along roads and canals or around our houses.

BOX 28-2

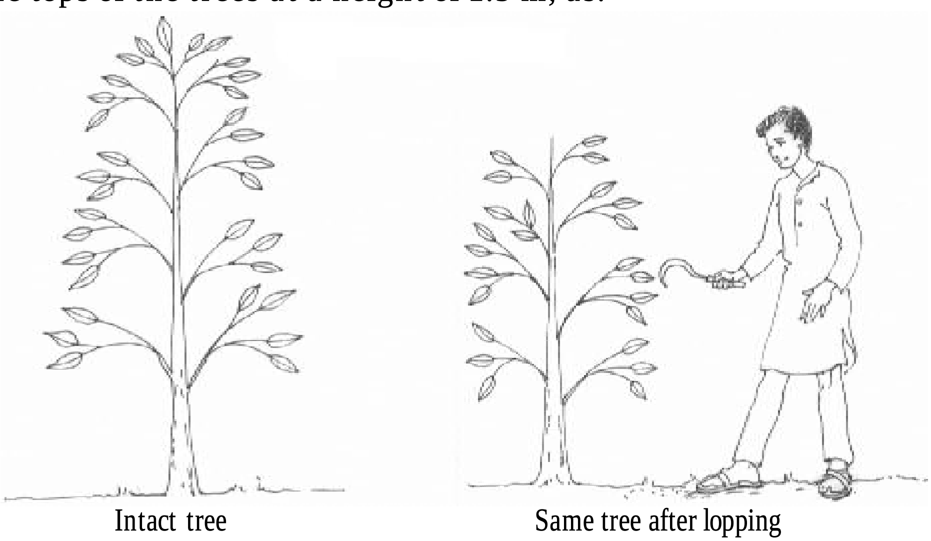
HOW TO MANAGE TREES FOR FODDER PRODUCTION

To produce large amounts of fodder, a tree must be encouraged to convert most of its food to leaves, and not wood. We do this by preventing the growth of the stem or trunk. We keep the tree small like a bush. Harvesting is also then easier. This box explains how this is done.

For your particular village select these fodder types which grow in your area (Exercise 3 ‘Our Village Tree’s) or which could grow there (Box 8-1 ‘Information About Collecting Tree Seeds’). Be sure to select both deciduous and evergreen types so that you will get green fodder year around.

The method of establishing a fodder tree stand is the same as for establishing a stand of trees for fuelwood production (Box 25-1 ‘Restoring Trees In Village Common Land’) Transplant 50 tree seedlings per nali at a distance of 2 m x 2 m.

The method of managing the trees once they are established is as follows. Allow the seedlings to attain a height of about 2 m. Cut of the tops of the trees at a height of 1.5 m, as:



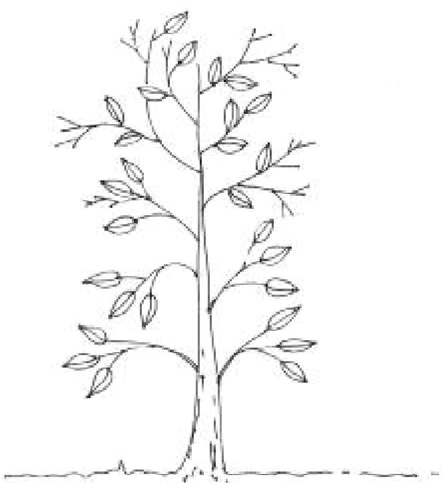
Intact tree
2 m high

Same tree after lopping
to a height of 1.5 m

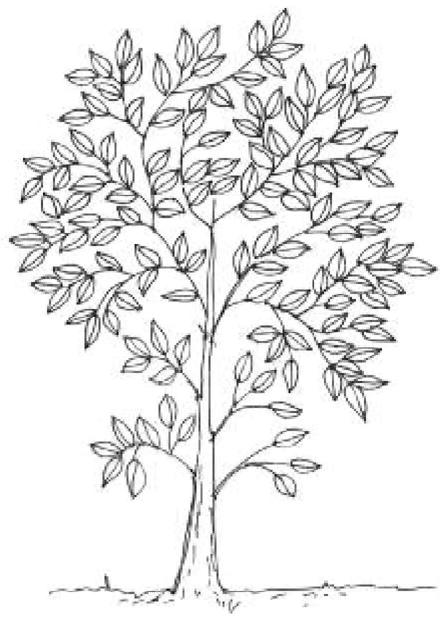
The tree will quickly send out new branches. In two or three years it will assume the shape of a round bush, as:

Here is the same tree after same time. It has grown many new branches, and is more leafy than before. It is about 2 m in diameter, thus filling all the space between itself and its neighbouring trees. It is about 2 m high.

Now the tree is ready to be lopped. The man is harvesting the leaves, taking care to cut only new twigs.



After harvesting, the tree looks like this.



After some time, it has grown new leaves and is ready to be cut again.

The rule for cutting the leaves is: only cut the length of new twig that has come out after the previous harvesting. We can recognise new growth of twigs by their lighter colour. We can also say: the tree should gain its previous size, about 2 m in diameter and 2 m high, before being cut again. If we observe this rule the tree will give a constant yield and will not become weak. This is sustainable harvesting.

Leaves should be cut holding the twigs with one hand and cutting them off cleanly with a very sharp sickle. Chopping or slashing the tree injures the ends of the branches left on the tree. It is from these ends that new shoots will grow – if the ends have not been damaged.

If we make fodder trees like, *shatut*, *kachnar*, *siris*, *subabool*, *babool*, etc. into bushes and do regular lopping, then they may give 6-15 kg green fodder per year per tree or 300-750 kg green fodder per 'are' per year. The yield will depend upon the fertility of the soil, proper spacing and on whether or not the trees are irrigated.

In fodder stands leaf fall is reduced since we harvest a lot of green leaves. Some dry leaves are needed to form humus and to protect the soil surface from erosion. Therefore dry leaves should not be collected from fodder stands. Remember, dry leaves catch fire quickly, therefore protect the stand from fire.

The replacement of old trees can be done as explained in Box 28-1 'How to Manage Trees for Fuelwood'.

Fodder bushes do not produce seeds. Seeds must therefore be produced as described in Box 28-1. Seeds can also be obtained from trees in our village.

BOX 28-3

HOW TO MANAGE TREES FOR STEMWOOD PRODUCTION

Aside from fuelwood we also need wood for many other purposes. These are:

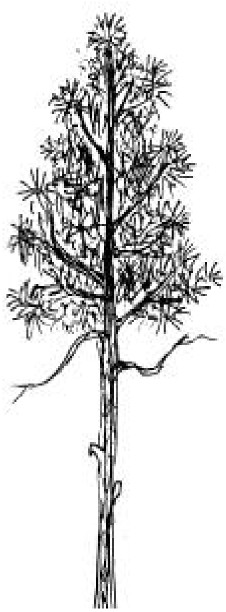
Bamboo is not a tree, but we use its stem for construction and making furniture, baskets and mats.

1. Timber: This is sawn wood (planks and beams) used in house construction and furniture making.
2. Round wood (*ballis*) for house roofs and floors, fence posts.
3. Wood for agricultural implements.
4. Wood for basket and mat making.
5. Wood for kitchen utensils (*tekis, moosals, bellans, chaklas,* etc.)

Wood for these various purposes comes primarily from the stems of trees. If we grow trees at a close spacing (2m x 2m) and allow them to grow undisturbed, they will develop long, straight stems which are ideal for all these purposes.

The stemwood stand is established in the same way as a fuelwood stand (Box 29-1). The types of trees to be planted, and to be allowed to establish naturally, are those that will supply all our needs for stemwood. Bamboo should also be planted with trees.

Existing trees of suitable types may be kept in the stand if they are not too old or too deformed to produce good stemwood.



Chir : Produces stemwood for house construction.

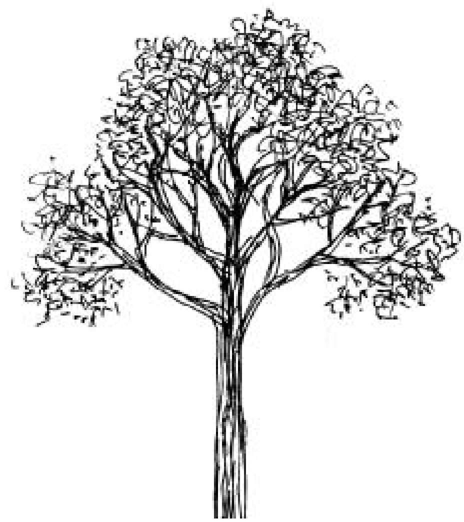
As the trees grow they will begin to crowd each other. When this occurs, they should be thinned. The weakest trees, or those that are diseased or deformed should be removed. They may be used for poles or fuelwood. After thinning, the canopy of the stand should close again in one or two years.

As the canopy of the stand closes, and as the trees grow taller, the lower branches begin to die. They may be cut off for fuelwood.

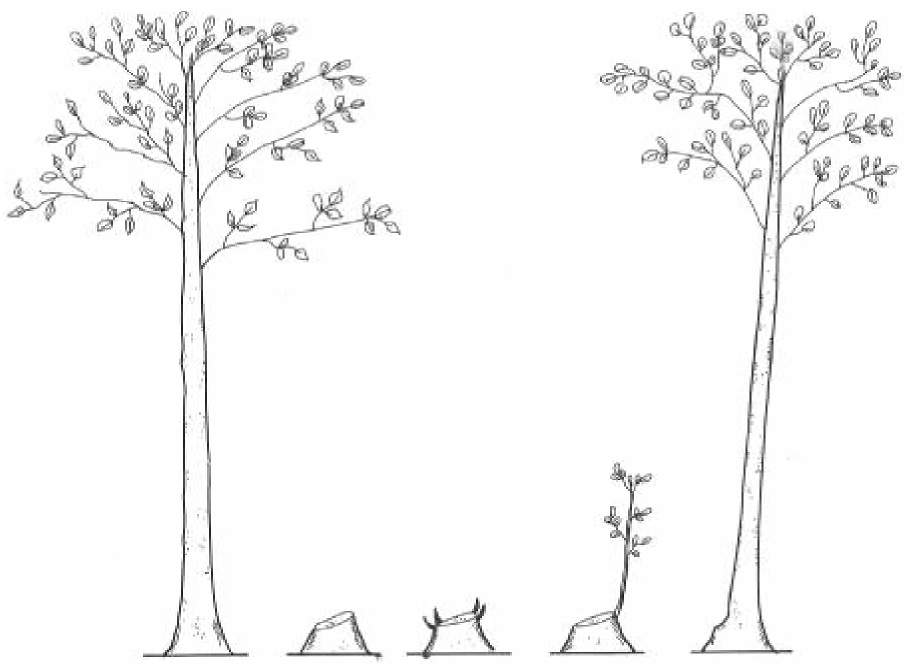
Individual trees may be cut as needed, or when they are mature. If trees are not cut when they are mature they will grow more, but only slowly. It is better to cut them or plant new seedlings in their places. They may also be coppiced. In coppicing, the main stem of the tree should be cut at a height of 25 cm. After some time new shoots will come out from the stump. If we allow all of them to grow we get many thin stems, whereas we want one or two thick stems. Therefore, cut all except one or two of the new shoots. These will grow rapidly and can later be harvested for stemwood.

When stemwood trees are harvested it is best to climb up the tree and cut off the top and branches before felling the stem. This way less damage is done to the surrounding trees.

The open spaces in the stand after trees are felled should be filled by coppice stems from the stumps of the felled trees themselves or by planted seedlings.



Shisham : Produces good quality timber wood. Its wood is used for making furniture.



It seedlings are planted; they should be of a different type of tree than the trees felled.

Trees grown for stemwood will generally produce seed. You will have an opportunity to select the best trees of each type from which to collect seeds.

Stemwood, like fuelwood, must be dried before it can be used.

Bamboo is managed somewhat differently from trees. It grows in clumps which spread from year to year by sending up new stems around the edges. The new stems remain green in colour for the first year. They should never be harvested. Only older, yellow-coloured stems in the interior of the clumps should be harvested. The spaces left after harvesting these mature stems will be filled by new green stems. These also should not be cut until they mature, i.e., until they become yellow in colour.

Date ; ....

Code : Trees 8
Month : July

EXERCISE 29

SUPPORT AREA REHABILITATION PROJECT 3. PRODUCING TREE SEEDLINGS

INTRODUCTION

This exercise will be started in February of this year. It will continue for about two and half years, until July of the year you are in the 10th class.

REQUIREMENT

1. *Kutlis* – one for each team
2. Watering cans – one for each team
3. Canisters (for carrying and measuring water) – 3 or 4
4. Plastic seedling bags – according to requirement
5. Soil (from a cultivated field) – "
6. Compost (well-decomposed) – "

PROCEDURE

1. With the help of Table 29-1, make a calendar for producing seedlings and transplanting them. For information on when seeds should be planted and when the seedlings are ready for transplanting, see Box 29-2.

FOR THE TEACHER

Take up Boxe 29-1 before the beginning of this exercise. Arrange periods from time to time for class to do the field work of this exercise.

Table 29-1. Calendar for producing and transplanting tree seedlings

Species	Seedlings for initial planting		Seedlings for gap-filling	
	Month and year of planting seeds	Month and year of transplanting seedlings	Month and year of planting seeds	Month and year of transplanting seedlings
(1)	**(2)**	**(3)**	**(4)**	**(5)**

2. Next, with the help of Table 29-2, calculate the number of seedlings of each specie that you will produce.

3. Calculate the area of nursery space you will need for your seedling bags. (Refer to Box 29-1 for suggested spacings.) Normally, the area required for the first year will be more than enough for the second year also. In case all your seedlings will take more than 9 months to be ready for transplanting, add the space required for the second year to that required in the first year. Write your answer here:

   Nursery area required for bags: _______________ m^2

   Total nursery area needed
   (for bags, paths and work space): _______________ m^2

4. Make a neat sketch of the nursery area on the opposite page. The bags are to be kept in blocks 1 m wide. Write in the lengths of the blocks of bags for each type of tree.

7. Your teacher will divide the total number of plants of each type by the number of teams. Your team will thus raise some seedlings of each type, both for initial planting and for gap-filling. Write down here the number of seedlings your team must produce.

Type of tree	No of seedlings	
	initial planting	gap_filling
1.		
2.		
3.		

6. Calculate the amount of soil and compost needed for your team's seedlings. Write the amounts here:

   Amount of soil: _______________ kg

   Amount of compost: _______________ kg

   Discuss with your teacher from where to bring this soil and compost.

7. Build shades for protecting your seedlings from sun and hail.

8. Read about the species of tree to be raised in Box 25-1. Take the required seed from your teacher at the appropriate time and proceed to raise your seedlings. Members of each team will have to take turns looking after the team's seedlings during holidays.

9. Using Table 11, keep a diary of your work. Note your observations on germination, growth rate, or on any unusual problems.

Table 29-1. Calculation of number of seedlings to be produced

Species (1)	Area to be planted, nalis (2)	Number of seedlings to be planted per nali (3)	Total number of seedlings for initial planting (4)	Extra seedlings (20% more) (5)	Grand total number of seedlings for initial planting (6)	Number of seedlings for gap filling (30% of column6) (7)	Grand total of all seedlings to be produced (8)

Instructions for completing Table

Column 1. Write the names of types you have chosen.
Column 2. Take the areas from Exercise 25.
Cloumn 3. Take number of seedlings per nali figures from Table 29-1.
Column 4. Column 4 = column 3 figure multiplied by column 2 figure.
Column 5. Column 5 = column 4 figure x 20/100
Column 6. Column 6 = column 4 figure + column 5 figure
Column 7. Column 7 = column 6 figures x 20/100
Column 8. Column 8 = column 6 figure + column 7figure

Table 29-2. Diary for seedling production

Species (1)	Date of planting (2)	Approximate time taken for germination, days (3)	Date of transplanting into bags (4)	Approximate height of seedlings at time of transplanting to field (5)	Percent survival of seedlings in nursery (6)	Comments (7)

Instructions for filling up Table

Column 1. Make separate entries for the initial planting and gap filling seedlings of each type.
Column 4. This column is for use with types that are raised in nursery boxes and later transplanted into bags. Like *beru* and *timul*.
Column 6. Calculate this as follows:

$$\% \text{ survival} = \left(\frac{\text{No. of seedling bags sown/planted} - \text{No. of empty bags at transplanting time}}{\text{No. of seedling bags sown/planted}} \right) \times 100$$

Teacher's signature:....................

Date:....................

BOX 29-1

HOW TO MAKE A PLAN FOR SEEDLING PRODUCTION

1. Area and class of land to be afforested

To make a plan for seedling production we must know how many seedlings of what species are to be produced. We begin by making a map of the area to be afforested, and then estimate its area. Suppose, for example, the piece of land depicted on page 89 is to be afforested. The land is 5 nalis in area. 2.5 nalis of this are class I land and 2.5 nalis are class III.

2. Species of trees to be planted

The land in our imaginary example is part of the support area of a village. The residents of the village would like to produce as much fodder as possible. Fodder species can grow well on class I land, but may not even survive on class III land. Therefore it was decided to plant oak on class I land, and acacia (for fuelwood) on class III land.

3. Numbers of seedlings to be produced

Let us continue with our imaginary example to show all the steps in planning a nursery.

We plan to plant our seedlings of a spacings of 2 x 2 metres. We will thus need 50 seedlings per nali. Our total requirement of seedlings will be:

Oak: 50 x 2.5 nalis = 125

Acacia: 50 x 2.5 nalis = 125

In addition to these numbers, let us plan to produce 20 percent more seedlings. Thus total requirement increases to:

Oak: 125 + (125 x 20/100) = 150

Acacia: 125 + (125 x 20/100) = 150

This way we will not run short of seedlings. The extra seedlings will compensate for the seedlings which die in the bags. There will also be an opportunity to discard some of the weaker seedlings at the time of transplanting.

After transplanting our seedlings in the field, some will die, even with the best of care. Say we expect 20 percent to die. We must therefore produce the following numbers of seedlings for gap-filling.

Oak: 150 x 20/100 = 30 seedlings

Acacia: 150 x 20/100 = 30 seedlings

These additional 30 + 30 = 60 seedlings will be raised one year later then the main crop. This is because gap-filling is done one year after the main crop of seedlings is transplanted.

4. Nursery area needed

Each seedling bag is 8 cm in diameter. Initially no space need be left between rows of bags in the nursery. Later the rows should be 8 cm apart to prevent crowding of the seedlings. Thus, seedlings are 8 cm apart in lines and the lines are 8 + 8 = 16 cm apart. Each seedling in its bag therefore needs 8 x 16 = 128 cm^2 area in the nursery. Using this figure we calculate the nursery area required for all the seedlings to be produced

$$\text{Oak: } \frac{150 \text{ bags} \times 128 \text{ cm}^2}{10{,}000 \text{ cm}^{2}*} = 1.82 \text{ m}^2$$

*One square metre = 10,000 cm^2

$$\text{Acacia: } \frac{150 \text{ bags} \times 128 \text{ cm}^2}{10{,}000 \text{ cm}^2} = 1.82 \text{ m}^2$$

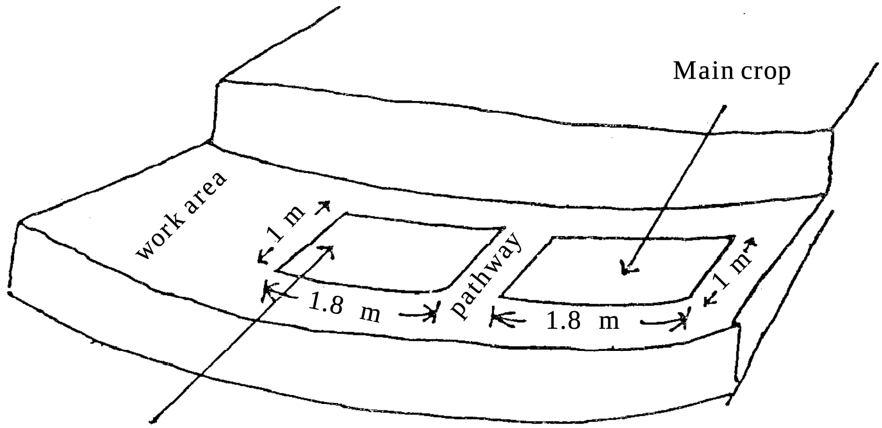
Total = 3.64 m^2

This is the space required in the first year. We must also raise 30 oak and 30 acacia seedlings for gap-filling in the second year.

$$\text{Seedlings for gap-filling} = \frac{60 \times 128 \text{ cm}^2}{10{,}000 \text{ cm}^2} = 0.77 \text{ m}^2$$

5. Arrangement of bags

Let us assume that we have a terrace 2 m wide. We can arrange the bags in blocks 1 metre wide. This width is convenient for watering and weeding the seedlings. The arrangement of block would look like this:



All paths in the nursery are 0.5 m wide. The total space needed for the bags, for paths and for work (filling bags etc.) is equal to about 3 times the space needed only for the bags. In this case the total area needed is about 3.64 x 3 = 10.92 m^2, or say, 11 m^2

6. Shades

Two shades will be needed (see Box 10-1), one for each block of bags shown in the above diagram. Each one should be 1 x 1.8 m in size.

7. Water requirement

Every 150 bags requires about one canister of water at each watering. In hot weather, when there are no rains, watering must be done every 4-5 days, while in winter every 8-10 days is enough. After planting, while the seeds are germinating, watering needs to be done more often, every one or two days, but less water is needed each time.

In hot weather, before the rains begin, all the seedlings in the first year would need about

$$\frac{300 \text{ bags}}{150 \text{ bags/canister}} = 2 \text{ canisters}$$

of water every 4-5 days. Less water would be needed in the winter, and during the second year.

8. Requirements of soil and compost

Altogether, 360 seedlings are to be produced. Each bag requires about 700 g of soil-compost mixture. The total requirement is thus

$$\frac{360 \text{ bags} \times 700 \text{ g/bag}}{1{,}000 \text{ g}} = 252 \text{ kg}$$

Of this two-thirds is soil, or

$$\frac{252 \times 2}{3} = 168 \text{ kg}$$

One third is compost, or

$$\frac{252 \times 1}{3} = 84 \text{ kg}$$

Reference box

BOX 29-2

INFORMATION ABOUT RAISING TREE SEEDLINGS

LOW-ATTITUDE TREES AND SHRUBS

Acacia

Acacia seedlings can be produced in the nursery or by direct sowing. With direct sowing, continuous weeding is necessary since the seedlings cannot tolerate shading.

For direct sowing, sow seeds at the onset of the monsoon. For nursery plants, sowing is done in April. Seeds must be soaked for 24 hours in cooled, boiled water before planting. Plant several seeds in one bag and later thin to one seedling. Germination percentage is about 50. Germination takes about one month. The seedlings will be ready for transplanting in July when the seedlings are three months old.

Babul

Babul is propagated by direct sowing. Nursery-raised seedlings usually do not survive after transplanting. Sow the seeds at the onset of the monsoon. With direct-sown seed great care must be taken to water (if necessary) and weed the seedlings and to protect them from grazing animals. Seeds begin germinating in one to two weeks and continue for two weeks. Germination percentage is 60-70.

The seeds of *babul* must be soaked in cooled, boiled water for 24 hours before sowing. After soaking, sow the seeds immediately.

Bakain

Before sowing, the stones of *bakain* should be soaked in cold water for two days. Sowing is done in February/March. Stones are sown 2 cm deep, one in each bag. 60 grams of stones are enough for 100 bags. Each stone contains four or five seeds. The germination percentage of the seeds is about 60. Therefore, each bag will have up to four seedlings. These should be thinned to one per bag when they are about 5 cm high. Germination takes about 10 days.

Water and weed the seedlings regularly. The seedlings do not need to be shaded from the sun, but protection from hail is essential.

Seedlings may be ready to transplant in July when they are four or five months old. Since *bakain* is a deciduous tree, the seedlings can also be transplanted in the winter after they have shed their leaves. Finally, they can also be transplanted in the following July (when they are 16 months old) in case they were too small for transplanting in the first July.

Ber

Ber is propagated by direct sowing or by nursery-raised seedlings. Direct-sowing of seeds is done in dug-up lines or patches (in which some compost is mixed). Soak the seeds for eight hours in cold water before sowing. Sow 2 cm deep at the onset of the monsoon. Germination begins in 15 days and may take two months to be completed. Germination percentage is about 50. Weed the seedlings regularly. After one year thin to give a one-metre spacing between plants.

Sowing for nursery-produced seedlings is done in April-May. Place the seed in a 20-percent salt solution and skim off the seeds which do not sink. These are discarded as they are not viable. Soak viable seeds in plain, cold water for eight hours before sowing. Weed and water the seedling bags regularly. Seedlings are ready for planting out in July when they are two-three months old.

Cassia

Cassia can easily be propagated by the direct sowing of seeds with the onset of the monsoon. Fresh seeds need no treatment, but old seeds should be treated before sowing. They are put in boiling water and the water allowed to cool. Remove seeds after eight or ten hours. Regular weeding is needed to ensure the survival of the seedlings. Watering should be done if there is a break in the monsoon. Germination is complete in one month. Germination percentage is near 100.

Gliricidia

Gliricidia is propagated by large stem cuttings (up to 2 m in length) at the beginning of the monsoon. They are planted directly in the field.

Grevillea

Grevillea may be propagated by the direct sowing of seeds with the onset of the monsoon, or by nursery-grown seedlings. For nursery grown seedlings plant the seeds in November-December. Germination takes three weeks. Germination percentage is about 70. Seedlings are ready for transplanting the following July.

Imli

Imli is propagated by direct sowing or by nursery-raised seedlings. The seeds are direct-sown with the onset of the monsoon. Sowing depth is about 1.5 cm in small beds dug to a depth of 30 cm, Mix some compost in the dug soil. Germination begins in one week and is completed in about one month. Regular weeding is needed until the seedlings are well established.

For nursery-grown seedlings sowing is done in bags in March-April. Weed and water the bags regularly. The seedlings are ready to plant in July when they are three or four months old.

Jamun

The best way to propagate *jamun* is by direct sowing at the onset of the monsoon. Germination is complete within one month. Germination percentage is nearly 100. Weed the seedlings regularly, and water if there is a break in the monsoon. Seedlings are very sensitive to hot sun if there is no rain.

Kachnar

Kachnar seeds are sown in bags in September. Sow three or four seeds per bag, and later thin to one healthy seedling. Weed and water the seedlings regularly. They are ready for transplanting in July of the following year when they are seven or eight months old.

Neem

Direct sowing may be done with the onset of the monsoon, taking care to protect and weed the seedlings, and, when necessary, to water them. Sow seeds immediately after collection. No seed treatment is necessary. Seeds begin germinating in about eight days and continue for about three weeks. Germination percentage is 60-70.

Nursery-raised seedlings may be transplanted at the beginning of the following monsoon.

Sal

New *sal* trees are produced by direct sowing and by nursery raised seedlings. Direct sowing is done in prepared soil (that is, after digging and mixing compost) with the onset of the monsoon. Use only fresh seeds. Germination begins in about ten days and is completed in about one month. Germination percentage is about 80. Regular weeding is necessary. Watering is also necessary if there is a break in the monsoon.

For nursery-raised seedlings, seeds are planted in plastic bags or in *donas*. *Donas* are containers made by stitching *sal* leaves together. The entire *dona* with seedling is placed in the soil at the time of transplanting. The *dona* rots away. (*Donas* can be used for sowing of other trees in place of plastic bags.) Nursery sowing is done in June. Water and weed the bags/*donas* regularly. The seedlings are ready for planting out in the following July when they are one year old.

Sesbania, basna

New plants are produced by direct seeding with the onset of the monsoon. No seed treatment is necessary. Remove weeds around new seedlings until they are well established.

Shatut

The best method of propagating *shatut* is by nursery-raised seedlings. Seeds are sown in May and the seedlings are ready for transplanting in July.

The seeds are very small. Mix the seeds with ash for easy and uniform sowing. Also mix a few drops of kerosene with the seeds; this prevents ants from carrying away the seeds. Cover the seeds lightly with fine soil and gently water. Keep the soil surface moist. Germination begins in about a week and continues for ten days or so.

Germination percentage is about ten. Thin the seedlings to give one per bag. Water and weed the bags regularly.

Shisham

Shisham regenerates itself by coppice and self seeding.

Artificial propagation is by direct sowing, and by nursery-raised seedlings, by stem cuttings and by root cutting (root suckers). Sowing of seeds is done in March in the nursery. The seeds germinate in about two weeks. Germinating percentage is 90. Water and weed the bags regularly. The seedlings are ready for transplanting in the following July. Direct sowing of seeds is done in July. The seedlings should be watered if there is a break in the monsoon and weeded regularly.

Root suckers can be dug up in July and planted in the field immediately. At least a 15 cm length of root should be taken out with the sucker. Water the root suckers if there is a break in the monsoon.

Stem cuttings 20-25 cm long and finger-thick containing four nodes can be planted. Cuttings should be taken from the previous year's growth of stem. Plant one cutting in each bag, with two nodes below the soil surface and two above. Weed and water the bags regularly.

Siris

Siris seeds are sown in April/May and the seedlings are ready for transplanting in July of the following year when they are 14 months old.

Siris plants can also be raised from stem cuttings. They are planted in February and are ready for transplanting the following July. The method of producing plants from stem cuttings is the same as for *sisham*.

Subabool

Subabool is propagated by direct sowing or nursery-raised seedlings. The seed must be treated by pouring the seeds into boiling water, immediately removing the container from the fire, allowing to cool and then decanting off the water.

Direct sowing is done at the onset of the monsoon. Plant the seeds 1.5 cm deep, mixing the seed with soil dug from unser healthy *subabool* trees before sowing. Germination begins in four to six days and germination percentage is 60-70. Regular weeding is essential as seedlings are very delicate.

For nursery-raised seedlings sow two seeds per bag in March-April. Weed and water the bags regularly. If both seeds germinate, cut off one. (Do not pull it out, as this will damage the root of the seedling to be retained.) Seedlings are ready for transplanting in July. In the nursery, shift the seedling bags every month, otherwise the taproot of the seedling will grow through the bottom of the bag and into the soil underneath.

Teak, *Sagaun*

Teak is propagated by direct sowing of seed and by nursery-raised seedlings. Direct sowing is done with the onset of the monsoon in prepared soil (digging and compost), followed by weeding as necessary. Germination begins in about 15 days. The seed must be treated before sowing by soaking in water and then drying in the shade. Nursery sowing in bags is done in April. Water and weed the bags regularly. The seedlings are ready for transplanting in July when they are three months old.

HIGH-ALTITUDE TREES AND SHRUBS

Acacia

Acacia seeds require treatment before sowing in order to germinate. They are put into boiling water which is then allowed to cool. The seeds are left in the cooled water for 12 hours. They are then removed and sown immediately.

Three seeds are sown in each bag. Depth of sowing is about 1 cm. Sowing is done in March. About 4 g seed is needed for 100 bags.

Germination occurs in 7-14 days. Germination percentage is about 80.

The bags are watered frequently, but lightly, until the seedlings are about 5 cm high. Subsequently, water at longer intervals, as recommended in Box 10-1. Weed regularly. Thin the seedlings to one per bag when they are about 5 cm high. Put thinned-out seedlings in bags where no seed has germinated.

The seedlings are ready for transplanting in July of the year in which the seed are sown. That is, they will be ready for transplanting when they are 4-5 months old.

Akrot

Akrot seeds are sown in November. Two seeds are sown in each bag. Depth of sowing is about 3 cm. About 3 kg seeds are enough for 100 bags.

Germination occurs in 30-35 days. Germination percentage is 70-80.

Water and weed the bags as recommended in Box 10-1. Thin the seedlings to one per bag when they are about 5 cm high. Put healthy thinned-out seedlings in bags where no seed has germinated. The seedlings are ready for planting out in July when they are 20 months old.

Bakain

Before sowing, the stones of *bakain* should be soaked in cold water for two days. Sowing is done in February/March. Stones are sown 2 cm deep, one in each bag. 60 g of stones are enough for 100 bags.

Each stone contains 4-5 seeds. Germination percentage of the seeds is about 60. Therefore, each bag will have up to 4 seedlings. These should be thinned to one per bag when they are about 5 cm high. Germination takes about 10 days.

Water and weed the seedlings regularly. The seedlings do not need to be shaded from sun, but protection from hail is essential.

Seedlings may be ready to transplant in July when they are 4-5 months old. Since *bakain* is a deciduous tree, the seedlings can also be transplanted during the following winter. Or they can be transplanted in the following July (when 16 months old), in case they were too small for transplanting in the first July.

Bane

The seeds of *bane* are very small, and the method of raising seedlings is the same as described for *beru*. Sow the seeds in February-March. The seedlings will be ready for transplanting into the support area in July of the following year.

The preferred way of propagating bane is by stem cuttings. These are obtained from existing trees in the month of January when the trees are leafless. Cuttings should be 1-2 cm in diametre and 20-25 cm long. Plant one cutting in each bag, leaving one bud above the soil surface. Weed the bags regularly and water the cuttings so that the soil is kept moist. Shoots will appear in March-April. The plants can be transplanted in July of the following year.

Banj (banj, rianj, tilonj)

Oak seeds must be sown in bags as soon as they are picked -- that is between October and February (see Box 6-1). Plant two seeds in one bag about 1 cm deep with the cap downwards. Germination will begin in 10-12 days and will be complete in 4-5 weeks. If they fail to germinate in about one month plant two more seeds in the bag. If two seeds germinate carefully remove one seedling and plant it in a bag where no seed had germinated. Weed and water the bags regularly. If the seedlings are too small for transplanting in the following July, leave them for one more year and transplant them in the following July.

Beru or Pheru

The seed of *beru* is tiny. It is mixed with wood ash to ensure uniform sowing. The sowing is done in wooden boxes, tins or shallow *gumlas* filled with a mixture of ½ fine soil and ½ fine compost. The seeds are covered by sprinkling a little of the same mixture over them to a depth of 2-3 mm. Watering is done very gently. The boxes should be protected from heavy rain which can wash out the seed. The germination percentage is low. Sowing is done in June.

When the seedlings are about 5 cm high they are transplanted into seedling bags, one in each bag. Care must be taken when transplanting that the roots of the seedlings are not injured or curled up. After transplanting into bags, the seedlings should not be shaded. Weed and water the seedlings regularly.

The seedlings are ready for transplanting in the support area in July of the following year, i.e., when the seedlings are 13 months old.

Beru can also be propagated by stem cuttings. These are planted in February. Cuttings with 4 nodes are used. They should be made from the previous year's growth of branch, not the current year's. Plant one cutting upright in each seedling bag with two nodes below the soil surface. Weed and water the bags regularly. The cuttings will be ready for transplanting in July, i.e., when they are 4-5 months old.

Bhimal

Bhimal seeds need to be treated before they are sown. This is done by placing them in boiling water. The water is then allowed to cool. The seeds are removed from the cooled water after 12 hours. Sowing is then done immediately.

Sowing is done in March. Two seeds are sown per bag, about 2 cm deep. About 15 g of seed will be needed for sowing 100 bags. Germination percentage is about 80.

The bags must be watered and weeded regularly. The seedlings cannot tolerate shade, and they are therefore not to be place under a tree or a shade. However, protection is needed against hail.

Thin the seedlings to one per bag when they are about 5 cm high.

Seedlings are usually ready for transplanting to the support area only in July of the year following the sowing of seed, i.e., when they are about 16 months old.

Bhimal plants can also be made from stem cuttings in the same way as is described for *beru*.

Brunj

Brunj seeds are tiny. A mixture of ½ fine soil and ½ fine compost is filled in wooden boxes, tins or in shallow *gumlas*. The seeds is sprinkled on the surface and then covered by sprinkling more of the same mixture 2-3 mm deep. Sowing is done in March.

Germination occurs in 2-3 weeks. Germination percentage is about 35.

Water the boxes gently and weed regularly. The boxes are kept under shade until two leaves appear. (That is, two true leaves in addition to the cotyledons.) After this they are removed from the shade. The seedlings are transplanted to seedling bags when they have 4 true leaves. One seedling is put in each bag. Place the bag in the shade.

Water and weed the bags regularly. The seedlings are ready for transplanting in July.

If animals do not graze around brunj trees, many naturally-germinated seedlings will be found under big trees. These may be transplanted readily in July. If they are big enough (15-20 cm high), they may be transplanted directly into the support area. Otherwise they may be transplanted into seedling bags, grown for one year, and then planted out in the support area next July.

Chamlai

Chamlai seeds should be shown soon after collection in November-December. Plant 2-3 seeds per bag, and later thin to one plant. Surplus, healthy thinned plants can be transplanted into bags where no seed has germinated. Weed the bags regularly and water to keep the soil moist.

The seedlings are ready for transplanting in July when they are about 6 months old.

Chir

A special mixture is needed to produce healthy chir seedlings. Mix 1/3 fine soil from cultivated field, 1/3 fine soil taken from beneath a healthy *chir* tree in the support area, and 1/3 fine compost. The support area soil contains micro-organisms which make the roots of *chir* seedlings strong and healthy.

Below 1,000 m altitude *chir* seeds are sown in January. The seedlings are ready for transplanting into the support area the following July, when they are 6 months old. At higher altitudes seeds are sown in September/October. The seedlings are ready for transplanting the following July.

Two seeds are panted per bag. 20 g seed is needed for 100 bags. Germination is usually complete in 4-8 weeks. Germination percentage is 80.

Watering and weeding is done regularly. Thinning to one seedling per bag is done when the seedlings are about 5 cm high.

Deodar

The seeds of *deodar* should be sown soon after collection, that is in November-December. Plant 2-3 seeds per bag and thin to one. Surplus, healthy seedlings may be transplanted to bags in which no seed has germinated. Weed the bags regularly and water to keep the soil moist.

The seedlings are ready for transplanting when about 2 ½ years old, in July.

Jujube

The seeds of *jujube* should be soaked in water overnight before planting. The planting time is April-May. Plant two seeds per bag and later thin to one seedling. Weed and water the seedling bags regularly. The seedlings can be transplanted to the support area in July when they are 2-3 months old.

Kachnar

Kachnar seeds are sown in September. Sow 3-4 seeds per bag, and later thin to one healthy seedling. Weed and water the seedlings regularly. They are ready for transplanting to the support area in July of the following year when they are 9-10 months old.

Kail

A special soil mixture is needed to produce healthy *kail* seedlings. Mix 1/3 fine soil from a cultivated field, 1/3 fine soil from beneath a healthy kail tree in the support area and 1/3 fine compost. The support area soil contains micro-organisms which make the roots of *kail* seedlings strong and healthy.

Seeds should be sown in November soon after collection. Since the germination percentage is poor, plant 4-5 seeds in one bag. Thinning to one plant can be done later, if necessary. Germination takes about 2 months. Weed and water the seedlings regularly.

Kail seedlings grow slowly and will be ready for transplanting to the support area in July when they are 2½ years old.

Kanchula, pangoi

The seeds of *kanchula* may be sown as they are collected in March-April. Sow three seeds per bag, and thin the seedlings to one if necessary. Weed and water the seedling bags regularly. The seedlings will be ready for transplanting to the support area in July when they are two months old.

Kharik

Just before sowing, the dried fruits of *kharik* are soaked in water to soften their flesh. They are then rubbed to separate out the seed. The seed is put into boiling water which is then immediately allowed to cool. The seed is removed from cooled water after 48 hours. It is then sown immediately.

Sowing is done in March-April. If seed is plentiful sow 3 seeds per bag. If not, sow two seeds. Germination begins in 2 weeks and is completed in about 4 weeks. Germination percentage is about 60. 40 g of fruits are needed to sow 100 bags if two seeds are sown per bag. If 3 seeds are sown per bag, 60 g seed will be needed for 100 bags.

When the seedlings are 5 cm high, thin them to one per bag. Weeding and watering are to be done regularly.

The seedlings are transplanted into the support area in January when they are about 9 months old.

Kimu

The seeds of *kimu* are planted in June. Plant 2-3 seeds per bag covering lightly with soil-compost mixture. Water very gently until the seeds germinate. Protect bags from direct rain which can dislodge the seed.

Weed and water seedling bags regularly. Thin the plants to one per bag when they are 5 cm high. The seedlings are ready for transplanting the next July when they are 13 months old.

Kimu plants may also be prepared by means of stem cuttings. These are placed in bags in February, and are ready to transplant the following July when they are 5 months old. The method of raising plants from cuttings is as described for *beru*.

Kweral

The seeds of *kweral* are sown in March-April. Before sowing they are soaked in cold water for 24 hours.

One seed is sown per bag, 1.5 cm deep. 25 g seed is needed for 100 bags. Germination percentage is nearly 100.

Mehal

Mehal seeds are sown in seedling bags in the period January to April. Two or three seeds are sown per bag if necessary. Weed and water the bags regularly. The seedlings will be ready for transplanting to the support area in July of the following year when they are 16-18 months old.

Mehal trees can also be propagated by stem cuttings and root suckers. Stem cuttings are planted in February-March. The method is same as described for *beru*. The plants will be ready for transplanting into the support area in July of the same year. For propagating by root suckers, dig up suckers (small shoots growing near the parent tree) in July and transplant them to pits prepared in the usual way (Box 16-1) in the support area. In digging up the sucker, expose the root from which it is growing to a distance of about 6 cm on each side of the stem, and cut the root at these points with a sharp *bariyat* (a heavy sickle).

Padam

The seeds of *padam* are sown in May-June, as soon as they are collected. Sow two seeds per bag, and thin to one seedling if both germinate. Thinned, healthy seedlings may be transplanted in empty bags. Seedlings can be transplanted in July of the next year when they are one year old.

Padam may also be propagated by root suckers. The method is as described for *mehal*.

Pangar

The seeds of *pangar* must be sown immediately after collection, that is, in the period October-November. Sow one seed per bag. Germination percentage is high, 80-90 percent. To produce the required number of seedlings, plant two seeds in a few bags. If both germinate, transplant one into any bag where the seed has failed to germinate. Weed and water the seedling bags regularly. The seedlings will be ready to transplant into the support area the following July.

Poplar

The best method of making new plants of *poplar* is by planting branch cuttings. The method is the same as given for *bane*.

Robinia

Robinia seeds require treatment before sowing in order to germinate. This is done by putting them in boiling water for 5 minutes or in cold water for 24 hours. They should be sown immediately after treatment.

Sowing is done in March. Plant 2 seeds in each bag, 1.5 cm deep. 4 g seed is enough for 100 bags. Germination begins in 7 days and takes 10 days to be completed. Germination percentage is about 75.

After sowing, water the bags frequently, but lightly until the seedlings are about 5 cm high. Excess watering causes the seedlings to become sick.

Weed the bags regularly. Thin the seedlings to one per bag when they become 5 cm high.

The seedlings are ready for transplanting in January, i.e., when they are 10 months old.

New plants may also be produced from root suckers. The method of doing this is described for *mehal*.

Sakina

Sakina seeds are sown in November-December. Plant 2-3 seeds in each bag, and later thin to one plant per bag if necessary. The seeds are very small. It is therefore best to sprinkle the seeds on the soil surface and then sprinkle a little fine soil over them. Weed and water the bags regularly. The seedlings will be ready to transplant in July two years later when they are about 18 months old.

New *sakina* plants may also be produced by branch cuttings. The method is as described for *bane*. The cuttings are planted in August-September.

Sandan

Sandan seeds should be planted as soon as they are collected, that is, in May-June. Before sowing, soak them in water overnight.

The seedlings are ready for transplanting into the support area in July of the same year when they are 2-3 months old.

New plants may be made from branch cuttings as in described for *bane*.

Since *sandan* produces many root suckers, these can also be dug up and planted. The procedure is as described for *mehal*.

Shahtut

Seedlings of *shahtut* are produced in the same way as for *kimu*. The seeds are sown in March and the seedlings are ready for transplanting the following January when they are 10 months old.

Plants can also be made from stem cuttings as in the case of *kimu*. Cuttings are planted in bags in July and the plants transplanted into the support area in the following January.

Siris

Siris seeds are sown in April-May and the seedlings are ready for transplanting in July of the following year when they are 14 months old.

Siris plants can also be raised from stem cuttings. They are planted in February and ready for transplanting the following July. The method of producing plants from stem cuttings is the same as for *beru*.

Timil

Seedlings of *timil* are produced in the same way as those of *beru*.

Timil may also be propagated by stem cuttings. Two-metre long stem cuttings should be planted directly into pits in the support area in July.

Toon

Toon seeds are planted as soon as they are picked in April-May. Sprinkle them on the soil surface and cover with a thin layer of fine soil. Germination takes about 2 weeks. Thin the seedlings to one per bag. Water and weed regularly. The seedlings will be ready to transplant into the support area in July of the following year when they are one year old.

Utis

Utis seedlings are produced in the same way and at the same time as those of *brunj*.

Bans (Bamboo) and *ringal*

The most certain way to propagate bamboo and *ringal* is to plant pieces of rhizome. Bamboo and *ringal* grow in clumps of many culms (stems). These clumps grow in size as the clump gets older by the spreading of rhizomes around the edges. These rhizomes send up new shoots at the beginning of the rainy season. These rhizomes with their new shoots may be dug up at that time and separated from the main clump. If the rhizome pieces have old culms growing from them, these culms should be cut off at about 1 m height from the ground. The pieces are planted in the support area at the beginning of the rainy season in July in prepared pits as are tree seedlings.

Date: ....

Code : Water 4
Month : August

EXERCISE 30

ANALYSIS OF RAINFALL DATA

INTRODUCTION

Rainfall data is regularly collected at your school. You all have learned how to record rainfall. Now let us tabulate the data for one complete year and draw some conclusion from them. You will need to consult the rainfall copy maintained by your teacher.

PROCEDURE

1. In Table 30-1 write down the total rainfall for each month for one year, beginning with the month in which you have started to measure it.
2. Total the monthly rainfall figures to obtain the year's rainfall in Table 30-1.

QUESTIONS

1. Is your area one of relatively high rainfall, or low? Why?

____

____

____

2. Calculate the amount of rainfall in the monsoon season (June, July, August and September.) What percentage is this of the total annual rainfall?

   Answer: ....cm

   ....%

3. Do you think that the total rainfall during this year was average, more than average, or less? (Your teacher may be able to supply data for previous years for comparison; otherwise answer from memory.)

____

FOR THE TEACHER

Take up Boxes 30-1 before and 30-2 to Box 30-5 after this exercise.

Table 30-1. Monthwise rainfall for one year at our school/college

Month	Monthly rainfall, cm	No. of rainy days
June		
July		
August		
September		
October		
November		
December		
January		
February		
March		
April		
May		
Total		

4. What was the rainfall during the *rabi* season (October to March)? Was it enough? Why?

5. Look at the daily rainfall data in your school rainfall copy for the period 1st June to 31st May. On which day did the maximum amount of rain fall? Give the date and amount. What do you think will be the effect of such heavy rainfall in one day?

6. At which time of the year is soil erosion from our cultivated land maximum? What is the reason for this? What can be done to reduce it? (See Boxes 18-1, 18-4, 18-6, 21-3 and 25-3.)

Teacher's signature:....................

Date:....................

BOX 30-1

THE RAINFALL PATTERN OF UTTARAKHAND

Rainfall is measured and recorded at many places in Uttarakhand. Here are the average rainfall figures, month by month, for 18 places measured between 1965 to 1988.

Month	**Rainfall, cm**
June	17
July	42
August	43
September	20
October	6
November	1
December	3
January	5
February	5
March	5
April	2
May	5
Total	154

From these data we see that rainfall is high in the months of June, July, August and September compared to that in other months. Why is this?

To answer this question let us look at a map of India and the Indian Ocean (Figure 30-1-1). Every year between June and September strong winds blow clouds from the ocean across India. The direction of these winds is shown by the arrows. Clouds move in land from the

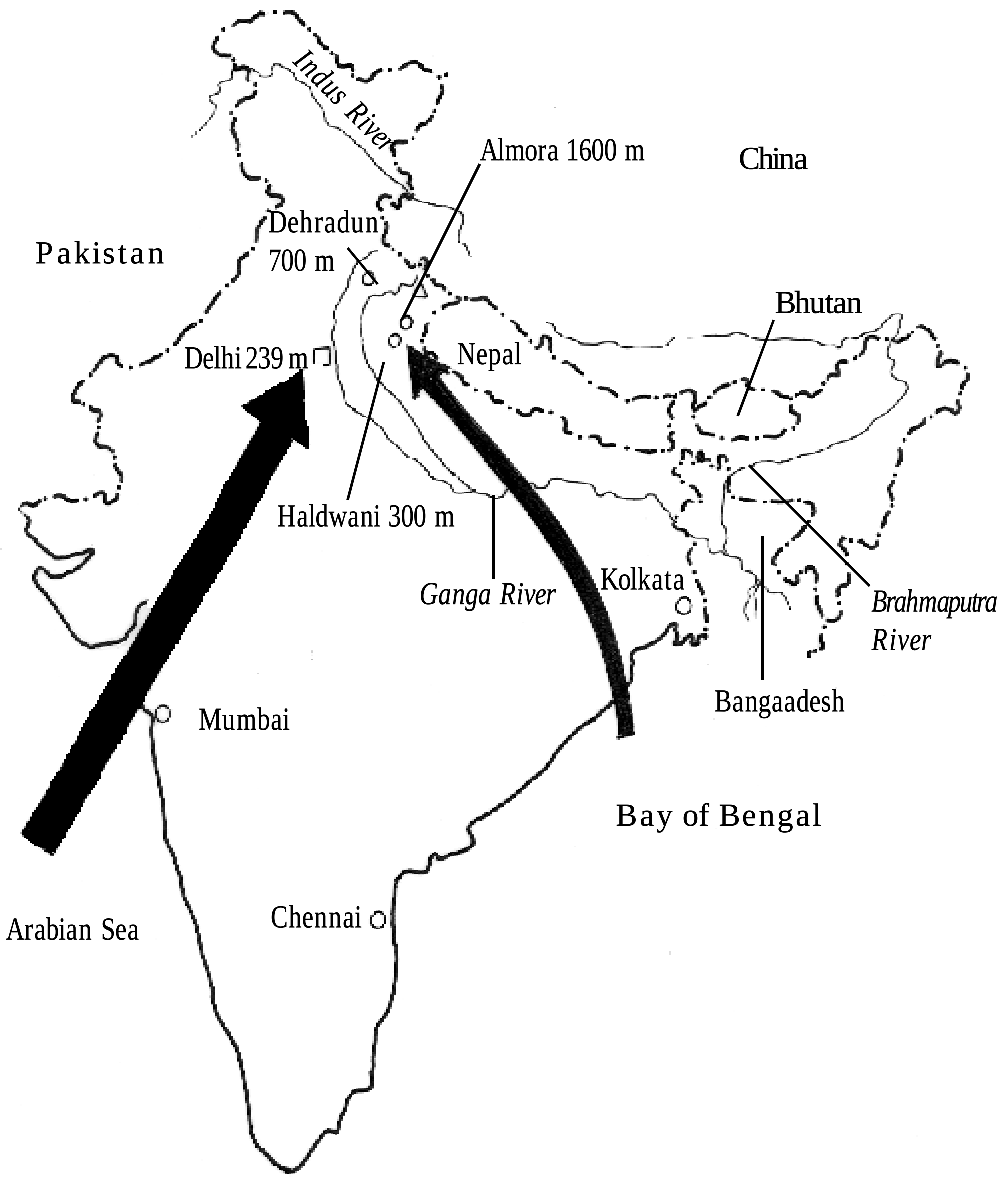


Figure 30-1-1. Map of India showing the direction of approach of the monsoon (thick arrows)

Bay of Bengal and the Arabian Sea. As they move across the country they gradually drop their water in the form of rain. The coming of these clouds, and the rain they bring, as called the 'monsoon'. Clouds from the Bay of Bengal reach Uttarakhand in June to give 'pre-monsoon' rain, or the '*chhoti barsat*'. The main monsoon comes to Uttarakhand from the Arabian Sea and is responsible for the rain in July, August and September.

Of course some clouds also come to Uttarakhand from the ocean between October and May, but they are small ones and come only now and then.

As the monsoon clouds strike the Himalayas, they drop their water rapidly. Thus the outer slopes of the Himalayas receive more rainfall than the plains below. As they move across the mountains they become smaller and smaller as you can see in Figure 30-1-2. The outward (i.e. South-Western) facing slopes receive more rain than the inward-facing slopes.

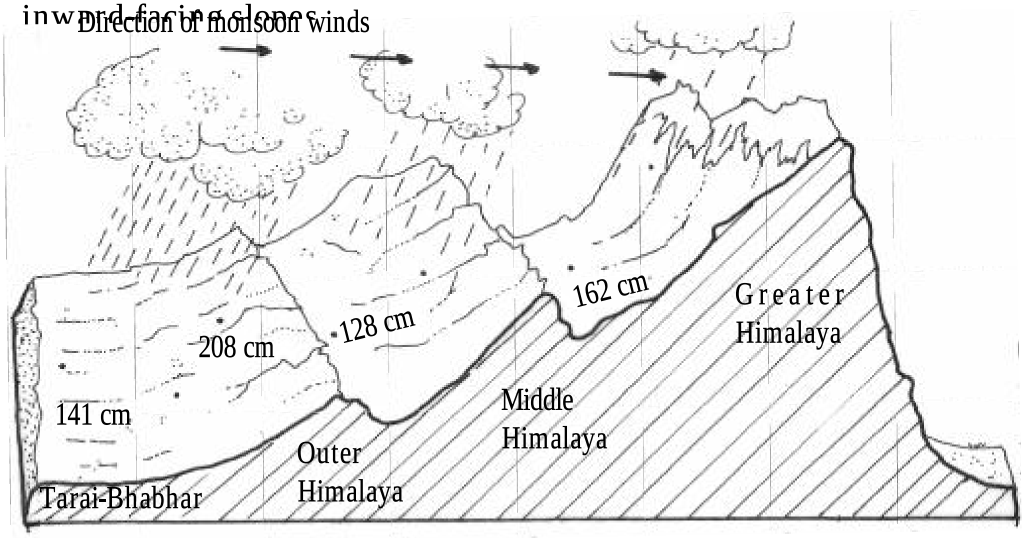


Figure 30-1-2. Diagram showing the movement of the main monsoon winds from the Arabian Sea across the Himalayas.

Thus in Garhwal the average annual rainfall for Mussoorie, Narendra Nagar and Rajpur on the outward-facing slopes of the mountains is 285 cm, while the average of seven locations in the Middle Himalayas is only 109 cm.

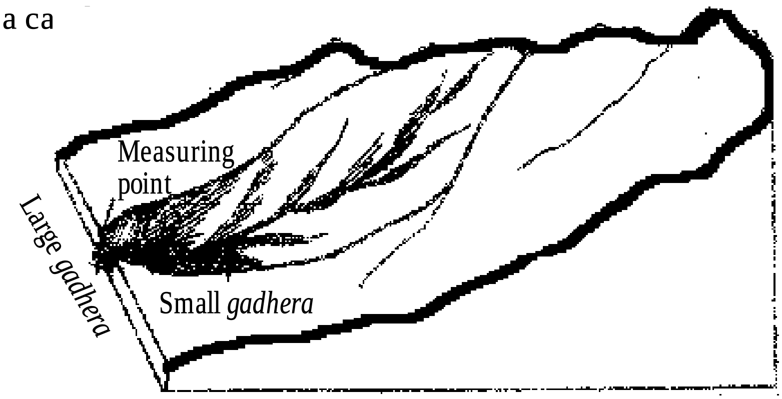
Rainfall at any one place varies from year to year. Here for example are the annual rainfall totals for Nainital for ten years.

Year	Annual rainfall, cm
1968	216
1969	304
1970	236
1971	300
1972	260
1973	284
1974	159
1975	249
1976	190
1977	172

Box 30-2

WATER CATCHMENTS

A catchment is an area of land from which all surplus rain-water drains through a single *gadhera* (ravine). The following diagram shows a ca



All the rain-water falling inside the boundary marked by the black line, and which is not absorbed by the soil, must flow through the small *gadhera* at point x. Rain falling outside this boundary flows into some other *gadhera*.

Taking a catchment as a unit for study, we can determine how much of the annual rainfall soaks into the soil, and how much runs off the surface of the land. We can also determine how much soil is eroded away. Here is a simple example to show how this is done.

Suppose the above-pictured catchment is 100 nalis in area, and rainfall is 1,000 mm per year. Total rain water received by the catchment is:

$$\text{Total water received} = \frac{1000 \text{ mm}}{1000} \times 200 \text{ square metres} \times 100 \text{ nalis}$$

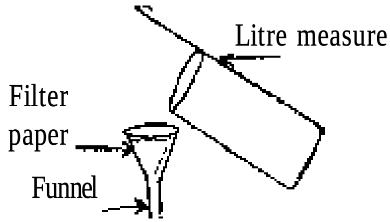
$$\text{,, \quad ,, \quad ,,} = 20{,}000 \text{ cubic metres}$$

During the year we measure the water flowing in the *gadhera* at point x when it rains. We do this by making a small barrier of soil or wooden planks, and an outlet or spout, and measuring the rate of water flow. From this we can calculate the amount of water flowing out of the gadhera after each rain. (With light rains no water may flow, with heavy rains much water will flow.)

Let us assume that we have determined in the above way that during the year 2,000 cubic metres of water have flowed down the *gadhera* of our catchment. The persent rain-water running off the land (and not soaking in the soil) is:

$$\text{Total water received} = \frac{2{,}000 \text{ cubic metres}}{20{,}000 \text{ cubic metres}} \times 100 = 10 \text{ percent}$$

We can also take samples of the water flowing down to the gadhera during a storm in our one litre measure. We can filter this water with a filter paper as:



The soil in the water remains in the filter paper. The filter paper is then dried in the sun, and weighed. We also weigh the filter paper before filtration. Here are our results:

Weight of the filter paper	=	10 g
Weight of the filter paper plus dry soil	=	12 g
Weight of the dry soil	=	2 g

One litre of run-off water contains 2 g of soil. One cubic metre of run-off water therefore contains 2 g x 1,000 litre = 2,000 g or 2 kg soil.

Suppose that 200 cubic metre runoff occurred in this particular rain storm. Therefore the soil eroded from the catchment will be:

Soil eroded from catchment = 2kg/cubic metre x 200 cubic metre

,, ,, ,, ,, = 400 kg

The amounts of soil for every rain storm for the whole year are totalled. Suppose the total is 2,000 kg. Then the soil eroded in one year from one nali is calculated as follows:

$$\text{Soil eroded per nali in the catchment/year} = \frac{2{,}000 \text{ kg}}{100 \text{ nalis}} = 20 \text{ kg}$$

Judging by the soil erosion figures from actual catchments (see Box 30-3), we conclude that in this example, erosion rate is small. The support area here must be well managed. That is, it must be protected from grazing and fire. Remember, both grazing and fire increase the rate of erosion. As we said in Box 18-1, they cause “accelerated erosion”.

BOX 30-3

AN EXAMPLE OF SUPPORT AREA REHABILITATION

The outer Himalayas, or Siwaliks, of Haryana (near Chandigarh) are composed of soft sedimentary rock. When the trees disappear from these mountain slopes due to grazing and fire and the soil surface becomes exposed , the soil erodes rapidly. Measurements of water flow and soil erosion rates were made on the degraded uncultivated land of a village in this region before and after rehabilitation.

Year	Percentage of rainfall running off the land	Soil erosion, kg/'are'/year
1964 (no trees, much bare soil surface and many large gullies)	25	800
1965 (one year after boundary wall and check dams made and trees planted)	20	250
1974 (thick grass cut by hand, trees ten years old)	10	20

In the first year (1965) much of the soil eroding from the land was trapped by the gulley plugs and retained in the catchment. The further reduction of soil loss in latter years was due to the spread of grass to cover the surface of the soil completely. The young trees also helped to hold the soil and protect the soil surface.

The yields of grass from this catchment were not measured. But we know from other places (see box 28-3) that the yi eld increases with protection.

All these figures show how protection of degraded uncultivated land and sustainable harvesting of fodder, can increase yield. Because of protection the grass spreads to cover the soil, thus protecting it from erosion. Fertile top soil can build up, giving healthier grass plants (or trees), also contributing to more yield. The yield of water from springs is also increased because more rain water soaks into the earth.

BOX 30-4

SUKHOMAJRI

The scene of this story is Sukhomajri, a small village located in the Sivalik hills of Harayana not far from Chandigarh. The Sivalik are the foothhills at the outer edge of the Himalayas, a continuation of the foothills of Nainital and Dehradun Districts of Uttarakhand. Sukhomajri had 71 families in 1977, 5000 'ares' of cultivated land and 5000 'ares' of village uncultivated land. In addition, the people of the village had rights to collect fodder and fuelwood from the Forest Department land surrounding the village. As there were no trees left and very little grass in the village uncultivated land or in the Forest Department land, the productivity of the cultivated land was very low and the people consequently very poor. And every year the surrounding slopes eroded more and more; huge gullies (called 'choes') as much as 20 metres deep sometimes formed during a single monsoon season. While the village men tried to find employment outside the village, the women spent most of their time and energy searching the surrounding slopes for fodder and fuelwood.

The people of Sukhomajri were unable by themselves to analyse their problem, or to think of a solution. In fact no one could. It was quite by accident that a solution was found at all. Here is how it happened.

At the centre of Chandigarh city lies beautiful lake Sukhna. It was built along with the city in 1958, covers an area of 180 hactares and had an average depth of 8.4 m No sooner was it built, however, than it began to get filled up with soil carried from the nearby eroding Sivalik hills. By 1977, 60 percent of its original volume was filled with soil, in spite of massive annual operations to remove the deposited soil.

Attempts were made by the Forest Department to fence the slopes above the lake, to prevent the grazing of animals from Sukhomajri and thus allow regeneration of vegetation and reduce erosion. However, the people broke the fences and continued to send their animals to graze. They saw that their rights were being denied for the benefit of people living in Chandigarh. When one villager was told not to graze his animals in the fenced area he retorted: "Who are you to tell me not to graze my cattle here. My forefathers did it and so will I."

In addition to fencing, check dams were also constructed across some of the choes to reduce the flow of water (and hence soil during the monsoon). These dams were built by the Central Soil and Water Conservation Research and Training Institute, Chandigarh. It was these check dams that suddenly suggested a solution to the problems of both Sukhomajri and Chandigarh.

A large check dam was completed above Sukhomajri just before the monsoon season 1977. In that very year the monsoon failed and very little rain fell. The *Kharif* crop of maize withered and died. At the same time it was discovered that the soil of that area would hold water so that the little rain that did fall collected behind the check dam. It was obvious to the people of the village that their crops could have been saved if that stored water could have been used for irrigation.

With help from the Central Soil and Water Conservation Research and Training Institute and the Ford Foundation, the people of Sukhomajri built two more check dams above the village to collect rain water for irrigation. Each of three reservoirs, which vary in diameter from70 to 100 metres, is connected by a pipe to a system of irrigation channels that distributes water to the fields below the dams. In all some 36,000 cubic metres water is available from these reservoirs every year for irrigation. To prevent siltation of the reservoirs the people of Sukhomajri agreed among themselves not to graze their animals on the slopes above the reservoirs; no fence is even required now to stop grazing. Consequently grass has sprung up and the slopes have turned green again. The people have also planted tree seedlings in this area.

As a result of irrigation and the protection of the slopes above the reservoirs the production of crops and milk in Sukhormajri increased. Another benefit from this irrigation project is that the women are able to get fodder more easily and closer to home, thus saving time and energy for other work such as growing vegetables (also made possible by irrigation). As the trees grow up in the years to come, even more fodder will become available, and more fuelwood too. The people of Chandigarh are happy because no more soil flows into their beautiful Sukhna Lake.

One of the problems the people of Sukhomajri had to solve once their reservoirs were made was how to share the water. Like fodder and fuelwood produced on the village uncultivated land, water too belongs equally to all families of the village. Moreover, the construction of the dams had been a community effort. The problem was that the amount of water in the reservoirs was less than required to irrigate all the cultivated land in the village. Also, the water could not even reach all the cultivated fields – some of them were at a higher level than the reservoir. So everyone could not use the water for irrigation.

To begin with, the people of Sukhomajri set up a Water Users Association in which every family was represented. After much debate the association decided that every family would receive an equal share of the available water. This share was about 36,000/71 = 507 cubic metres per year. If any family could not make use of their share of water, they could sell it to another family at a price fixed every year by the Water Users Association.

Only 3120 'ares' of land could be reached by the water out of a total of 5000 'ares'. The average amount of water per 'are' was thus 36,000/3120 = 11.53 cubic metres. Since this amount is not enough for the full irrigation of a wheat crop, it was decided that only two supplemental irrigations of 5.8 cubic metres each would be given to the wheat crop. Therefore a strict rotation of water allocation was adopted. That is, the amount of water alloted to each family (who actually used the water – their own share plus purchased shares) was calculated, as well as the dates on which it was to be delivered. The actual rationing was done by allowing the water to flow from the reservoir into the main channel for a calculated period of time.

As we said already, every family agreed not to graze their animals on the slopes above the reservoirs. One or two families did try to do so, but the village panchayat (council), on the advice of the Water Users Association, stopped their share of the water. They soon stopped breaking the rule of 'no grazing'.

The important lessons that the people of Sukhomajri have taught us is that our villages can only be made green and prosperous again if everyone shares the work and shows the necessary restraint. And, of course, everyone must share the benefits equally.

BOX 30-5

IRRIGATING OUR CROPS

During the long dry period from October to May each year our crops give low yields because they do not receive enough water. In years when rainfall is unusually low, winter crops may dry up and die. The same is true of upland paddy during the summer. In the plains summer crops cannot be grown at all in the summer without irrigation, and vegetables cannot be grown at all anywhere in Uttarakhand during the dry season without irrigation. Sugarcane is not grown at all without irrigation. Fruit trees produce more fruit if they are irrigated.

In thinking about irrigation there are five questions we must ask ourselves. These are: 1) How much irrigation water should be given? 2) When should it be given? 3) Where will the water come from? 4) How will the water get from its source to our fields? 5) How will it be applied in the field?

How much water?

The amount of water to be given to a crop depends upon the amount of water received as rain during the growing season in a particular village. Let us take a specific village to see how the calculation is done. In village 'A' the average rainfall between October and March, as determined by rainfall measurements over several years, is 20 cm. From experience and experiments we know that a good crop of wheat needs about 40 cm. This means that in an average year we should give our crop about 20 cm of irrigation water. This is equivalent to

20 cm/100 x 200 square meters/*nali* = 40 cubic metres/*nali*

Of course, in extra dry years we would need to give more water than this, and in wet years less. Other crops will need more or less water than wheat; for example, gram needs less and potatoes need more than wheat.

When to give water?

In general, experience and experiment show that irrigation water should be given about four times to the wheat crop during the growing season. The approximate times for these are: 1) sowing time; 2) one month after sowing; 3) in January; and 4) in February. The exact times for 3 and 4 depend upon the duration of the crop, which varies with temperature – that is, with altitude. For a wheat crop in village 'A' in an average year we can give about 5 cm, or 10 cubic metres of water at each irrigation. If there is good rainfall at any of these times, irrigation at that time can be reduced or skipped altogether. The first irrigation can be given either immediately before or immediately after sowing. After the seed heads are fully formed, that is when the grains are filled, no more irrigation should be done.

Sources of water

As you have come to know from Exercise 22 and Box 18-2, there are four types of water source: 1) springs and seepages; 2) wells (open, tube, and artesian); 3) streams and rivers; and 4) canals. These water sources must be situated at places wherefrom water may be delivered to our fields by gravity (after it is lifted to the surface of the land in the case of wells), otherwise they are useless for irrigation. Thus in the hills river water may be abundant in a village, but it cannot be used to irrigate fields above it. The same is true for springs and seepages. In Exercise 22 you have already learned how to measure the water production by springs, seepages and small streams. From these data you can calculate how much area of crop can be irrigated. Here is how the calculation is done. Suppose spring 'B" has a measured flow rate of 7 litres/minute in the month of February. In 24 hours it will produce

7 litres x 60 minutes/hour x 24 hours = 10,080 litres

or about 10 cubic metres. If one *nali* of wheat requires 10 cubic metres for one irrigation, then about one nali could be irrigated with the water produced in 24 hours. To use this water, however, it has first to be collected in a tank before being taken to the fields to be irrigated; we will discuss this in the next section.

If the source of irrigation water is a tube well, and artesian well or a canal, the water is carried to the field in a channel. The amount of water flowing in the channel per minute is measured by a 'V' notch device. Ask your teacher (or your maths teacher) to explain how this works. Say the 'V' notch device in a channel tells you that one cubic metre of water flows past that point in one minute. The channel will thus deliver enough water to irrigate one *nali* of land (growing wheat) in 10 minutes – or, enough to irrigate one 'are' in 5 minutes.

Of course, soil type varies considerably from village to village and from field to field within each village. Some soils require more water than others to become full (Exercise 9), and also dry out more slowly. Thus some fields need to be irrigated more lightly and more frequently than others. The calculations given above are meant to give a general idea.

In practice, you must learn to judge when your crop needs water and how much it needs. When your crop begins to suffer from water shortage the plants will show symptoms of water stress like curling and drying of the leaves. You must irrigate before your crop reaches this point. The only guide is to dig a small hole in the field and carefully look at the soil. In general, if the top 3-4 cm layer of soil is completely dry it is time to irrigate. When the entire soil profile becomes fully wet, enough water has been given.

Water conveyance

Water is conveyed from source to field in channels (for wells, rivers and canals) and in plastic pipes In general, for springs, seepages and small streams in upland villages in the hills, plastic pipes will be an easier and cheaper way of delivering water to fields than channels because the gradient from source to field is usually very high. Otherwise, to control the flow of water a series of short channels joined by drop boxes must be constructed. These are expensive to build and maintain and they occupy a lot of land.

Wherever channels are made they should be lined with cemented brick work to prevent seepage (see Box 22-1).

In most cases, springs, seepages and small streams do not have a high enough flow rate for effective irrigation. We must deliver water to our fields at a rate of at least 200 litres/minute. Therefore, we must collect water from a spring that produces 5 litres of water per minute in the month of February for

$$\frac{200 \text{ l/minute}}{5 \text{ l/minute}} = 40 \text{ minutes}$$

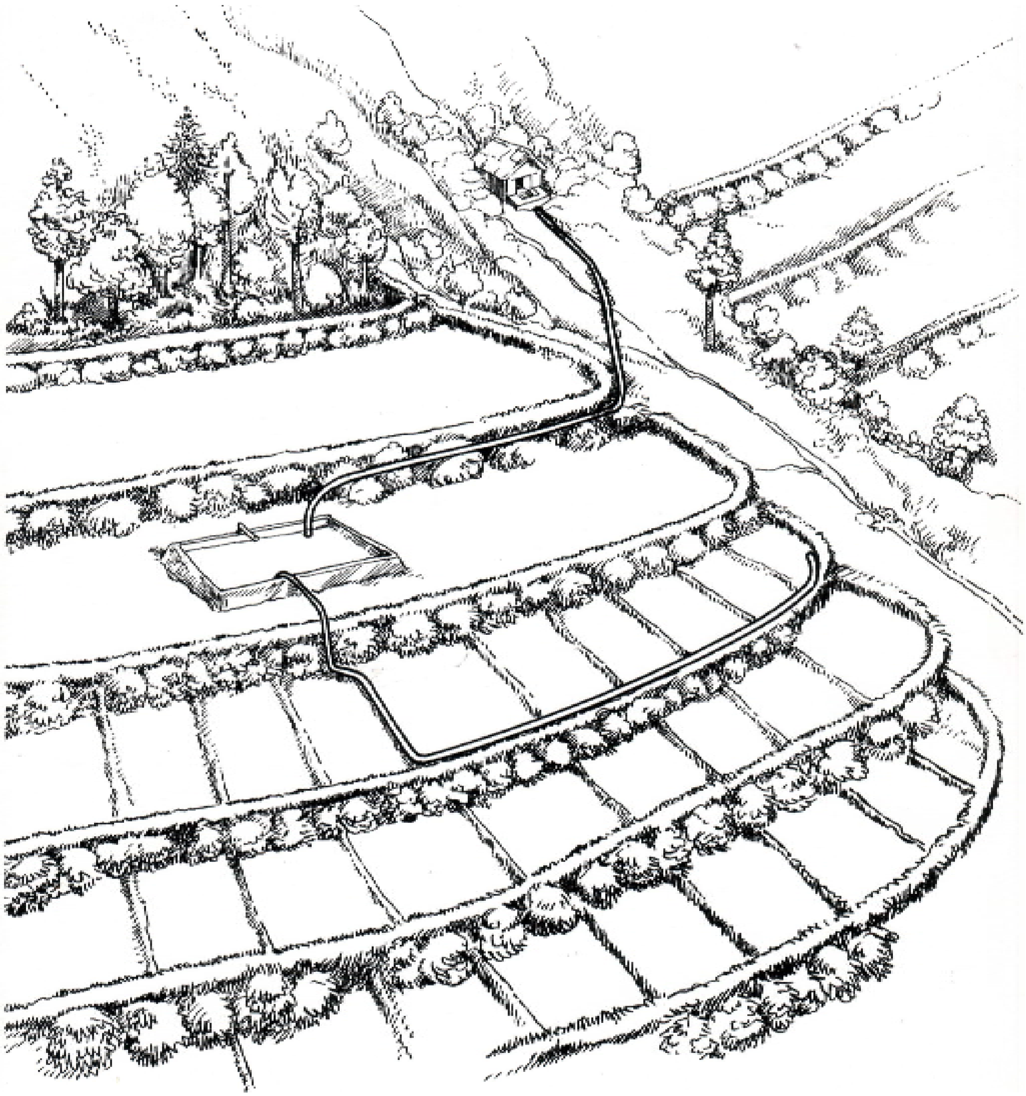


Figure 30.5.1. An arrangement to use spring water for irrigation using a plastic-lined tank in an upland village.

in order to irrigate a field for one minute. If we want to irrigate one nali (10 cubic metres of water) we will need to collect water for

$$\frac{10000 \text{ litres}}{5 \text{ litres/minute}} \times \frac{1}{60 \text{ minutes}} = 33 \text{ hours}$$

If we want to irrigate our wheat fields once every 30 days, we can irrigate

(30 days x 24 hours/day) x 1/33 hours = 23 *nalis*

An arrangement for collecting spring water for irrigation using a plastic-lined tank is shown in Figure 30-5-1.

Systems of application

With channel irrigation a kuchha, temporary irrigation channel is made from the main (*pucca*) distribution channel along the edge of a field, or in its centre. Beds are prepared on one or both sides of this *kuchha* channel and the required amount of water is let into one bed after another. Each bed is made in such a way that water flows evenly over the entire bed from the inlet within a few minutes. When the water has reached the other end of the bed and begins to accumulate there, the flow from the *kuchha* channel is switched to the next bed.

For upland hill villages, the technique for irrigating with a plastic pipe is shown in Figure 30-5-1. As with channel irrigation, the flow is shifted from bed to bed as each bed fills up. For the delivery of the water from the tank to the fields, a pipe of about 5 cm diameter is needed.

In orchards a small bund can be made in a circle around each tree with a diameter of approximately that of the crown of the tree. These are connected by a kuchha channel to deliver water from the source.

For newly-planted fruit trees, a *mutka* (earthen pot) may be buried next to the transplanting pit, leaving its mouth showing above the soil surface. This *mutka* is filled with water and the mouth closed with a lid or a stone. Water slowly seeps out of the *mutka* into the surrounding soil where the tree roots can take it up. The *mutka* is topped up with water from time to time.

Vegetables in our kitchen garden can be irrigated by hand with waste water from the house (Box 21-1).

Date: ....

Code : Crop 8
Month : August

EXERCISE 31

MIXED CROPPING

INTRODUCTION

This exercise is the third in the series of exercises on the natural way of farming, which we are doing at home. In our vegetable gardens (Exercise 11) we are growing many varieties of vegetables mixed together. Mixed cropping is an essential feature of organic farming. In other words, it is the way nature 'farms'. In a natural forest ecosystem we find many types of trees, shrubs, ferns, grasses and herbs mixed together. The different types are more healthy in mixed crops and give more yield.

Now, however, many farmers are growing wheat, paddy, sugarcane, etc. as single crops and using chemical fertiliser and pesticides. As a result of this many problems have been created, such as more resistant pests and diseases and decreasing soil fertility. By following the principles of organic farming, including mixed cropping and crop rotation, we can overcome these problems.

In this exercise we will learn how to grow mixed crops in rotation for the main crops in our village.

Procedure

1. Request your parents to let you grow mixed crops in your garden, preferably in a plot next to your vegetable plot. About ten square metres will be sufficient. You can make compost for this plot in the same way that you are doing for your vegetable garden.
2. Use the same diary you are already maintaining for your vegetable garden. Make a copy of Table 31-1 in your diary and use it to plan your crops and record your results. Make a new table for each season.

FOR THE TEACHER

Take up Boxes 31-1, 31-2 and 31-3 before this exercise.

Check the students' vegetable garden diaries from time to time. Ask each student to describe his/her work and results to the class. This will be an evaluation as well as sharing of experiences. Once in a while visit the students' homes to see their gardens and give suggestions and encouragement.

3. Before beginning your work discuss your project with your parents and neighbours. They will guide you. Ask them what crop mixtures are grown in your village, and why crops are grown in mixtures. Write their answers in the space given below.

4. Ask a few old people of your village what crop mixtures were being grown when they were young. Write their answers in the space given below.

In the beginning, plan to follow the traditional mixtures of your village and also the traditional rotations. Later you can experiment with your own mixtures. Boxes 31-1 and 31-2 explain the principles of making crop mixtures. You may try more than one mixture in each season if you wish, but each mixture should be sown in an area of not less than five square metres.

5. In growing mixed crops strictly follow all the principles of organic farming (Box 11-1) that you are following in growing vegetables. Take seeds from your parents or neighbours, to begin with. Later you can make your own seeds.

6. In mixed crops, all the different types may not be ready to harvest at the same time. Harvest each when it is ready, dry it and thresh the grain. Then weigh it and record the results in Table 31-1. Make a note of weeds that you may harvest for food or fodder e.g. *bathua*, Amaranthus. These are not sown by you, but are a valuable part of your mixture.

7. Be certain to collect seeds and keep them carefully. Select seed plants from your crops and harvest them separately.

Table 31-1. Details of mixed crops

Season......................

Crop rotations of your village (1)	Crop mixture of this season (2)	Varieties of crop seeds used (3)	Source of the seed (4)	Sowing date (5)	Observ-ation on health of crops, weeds, weather, etc. (6)	Yield of grain (7)	Problems and possible improve-ments in the future (8)

Instructions:

Column1. Write down the full crop rotation of your village. Your mixture is one part of this (see Box 31-1). You will follow this rotation in subsequent years. Use one Table for each season (*rabi*/*kharif*)

Column 2. Crop mixture you used for your plots.

Column 7. Record the yield of each type of grain in kg/'are' or *nali*. Also record the total yield of all grain in kg/'are' or *nali*.

Teacher's signature:....................

Date:...................

BOX 31-1

HOW TO GROW MIXED CROPS

We have learned the principles of organic farming in Box 11-1 and are following these in growing vegetables. Now we will grow grain crops using these same principles. Review the four principles in Box 11-1 before reading this box.

Now we will discuss the general principles of forming crop mixtures. Shoor Vir Singh is a farmer in Mohanpur village in Bijnor District (see Box 31-4). He is an agricultural graduate. After finishing his studies he returned home to manage his family land. At first he adopted modern farming methods, put a lot of chemical fertilisers and pesticides on his crops. However, he observed how these chemicals affected the plants, animals and insects in his fields. He saw that good insects like spiders (which eat crop destroying insects), and helpful soil animals like earthworms (which turn mulch and compost into fertile soil) were killed by these chemicals. He stopped using them and began to practise organic farming, learning from other organic farmers and from traditional farming. For the guidance of other organic farmers he has given the following principles of mixed cropping (Box 31-4).

1. One principal type This will form the main plant population of the mixture. Since the food item required by us in the largest amount is cereals, wheat, barley, millets (*mandua*/ragi) and paddy will usually be the principal species. Other principal crops in some circumstances might be soyabean, pigeon pea, mustard, black gram and pea.

2. One or more companion types These form a subordinate population in the mixture; plants of this type complement the plants of the principal type in the utilisation of available sunlight and nutrients. In other words, they fill a space that would otherwise be occupied by weeds. If the principal type is a cereal, a legume will usually be a good companion crop. Examples are wheat + lentil + pea + gram+ mustard, upland paddy + maize + soyabean. If the principal crop is a legume, a cereal is a good companion crop. Examples are: soyabean + maize, pigeon pea + sorghum. If the

principal and companion types are both low-growing, a tall plant type can be added to the mixture as a second companion crop. Examples: paddy + hemp + sorghum + millet; cotton + groundnut + sorghum/millet. In principal every mixture should have at least one tall-growing type and one low-growing type.

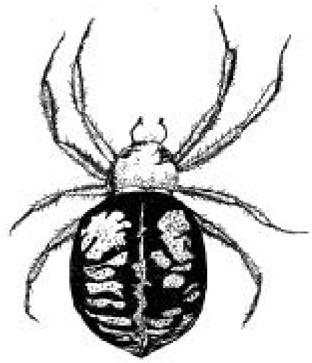
3. One or more ancillary types: Aside from the main cereals, pulses and oilseeds, many other foods are needed in small amounts simply to vary our diet or that of our animals. Mustard may be mixed with wheat, again in small amounts, for use as a condiment or for its medicinal value. Similarly, linseed (*alsi*) may be grown with paddy and millet.

4. One or more test types or varieties: You may want to introduce new types and varieties of crops in small amounts and to evaluate their performance.They should be done in the already established mixtures, that is, in the type of mixtures in which they would be grown in the future if they are successful. Thus a new variety of wheat should be evaluated by sowing a few seeds in our existing mixture of wheat + mustard + lentil, or wheat + gram. By observing its performance in this mixture, you will be able to decide, after several years, whether it is better than our current village variety.

Devising new mixtures, or modifying existing ones is a matter for experiment. Not all types are compatible, or perhaps not in the proportions in which we first try them. New/modified mixtures must be observed for several years; their performance in drought years, for example, may be better or worse than in normal years. How do they stand up to epidemics of specific diseases and pests? Then too, the matter of convenience of sowing and harvesting must be considered.

Aside from the species of plants we sow, there will come into existence a distinct array of other plants that appear in the field by themselves. These are usually called 'weeds' – that is, 'useless or harmful' species. They are, however, neither useless nor harmful if properly managed. Some of them produce food for us to eat, or fodder for our animals. They also help keep the soil surface covered, and they produce plant material for our compost pile. Finally they may help to make the main crops more healthy. They usually form the lowest level in the ground cover, and also fill gaps among the sown types. Weeds also protect the soil surface during the intervals between the harvesting of one crop and the sowing of the next. They are, indeed, to be considered parts, and essential parts too, of the crop mixture.

However, weeds must not be allowed to grow too tall, or they may crowd out the sown types. If this happens they can be cut back. The foreign grasses *tipatiya*, *gajar ghas* (parthenium) and *lahsunia* are appearing in many villages. They spread quickly and are difficult to control. It is best to uproot them when they first appear.



In the same way each crop mixture develops a unique array of microorganisms, insects and animals. In a healthy, well-managed mixed crop there are rarely serious outbreaks of disease or pests. Each organism has its place (niche) and its population is controlled by predators (like the spider at the right). There will always be some disease and some pest attacks on crops – it is unavoidable. But if we disturb the delicate balance of types by mismanagement the population of some organism or other may suddenly increase, causing more than usual damage. Poison sprays often appear to be effective in reducing the population of pests and disease-producing organism. But this is only so in the short run. In the long run, experience the world over has shown that poison sprays only increase disease and pest problems, and at the same time poison the food produced by the sprayed crops. As a general rule, when we have an outbreak of disease or a severe pest attack, we should search for the cause of it rather than thinking of destroying the disease organisms or the pest. The cause will usually be faulty management; only occasionally does unusually bad weather upset temporarily the normal balance in the crop leading to disease and pest outbreaks.

In addition to these principles of growing grain crops we will add one more. This is that we should not grow the same mixture in the same field in two consecutive years. For example if we grow maize or millet as main crop in *kharif* season then paddy can be the next year's main crop in that field. Each village has its own distinctive sequence of crops. Such a sequence is called a 'crop rotation'. When we decide on a crop mixture for Exercise 31, we should also decide on a suitable rotation.

BOX 31-2

WHEAT AND GRAM

Some years ago an experiment was done at Kota in Rajasthan. Rainfall is low and there is no irrigation. Wheat and gram are the common crops grown in the *rabi* season. In this experiment two plots, each of two 'ares', were marked out in the same field. Plot A was divided into two equal subplots, each of one 'are'. In one subplot wheat was sown in lines, and in the other gram was sown in lines. In plot B a mixture of wheat and gram was sown in alternate lines.

Plot A (two 'ares')	Wheat (one 'are')	Gram (one 'are')
Plot B (two 'ares')	Mixture of wheat and gram	

These plots were replicated several times in different parts of the same field. The results are averages of similar plots/subplots in all replications. The experiment was carried out for five years. The results are given in Table 31-2-1.

Table 31-2-1. Results of mixed cropping experiment at Kota, yield of grain, kg/plot/subplot

	1958-59	1959-60	1960-61	1961-62	1962-63	Average
Plot A						
Wheat	3.7	-	4.6	5.7	1.8	
Gram	5.7	3.6	5.0		2.0	
Total	9.4	3.6	9.6	7.7	1.8	6.4
Plot B						
Wheat + Gram	13.1	4.8	2.7	9.5	3.7	8.8

These results show that the mixture yielded more total grain than wheat and gram sown separately. (Compare the total yields for plot A with the yields for plot B.) This must have been due to a more complete use of sunlight, nutrients and particularly of water. Wheat has shallow, fibrous roots, while gram has deep tap roots. A lower incidence of disease may also have occurred in the mixed crop. In 1959-60 rainfall was very poor and the wheat died. In 1962-63 the gram died due to gram blight disease. In both years plants of the surviving type partly compensated for the yield lost by the death of plants of the other type. Over the five years, the average yield of the mixture in plot B was nearly 40 percent more than that the total of the species sown separately in plot A. Yield was more, and also more stable, with the mixture.

Observations were made at the Vivekananda Institute in Almora on the incidence of disease in finger millet (*mandua*) and soyabean when these were grown as pure crops and as a mixture. The incidence of blast disease in finger millet (brown/black spots on leaf and upper stem) was less in the mixture than in the pure crop. 'Incidence' here means the percentage of plants affected and/or the severity of infection. The incidence of hairy caterpillars on soyabean leaves (they eat the leaves) was less in the mixture than in the pure crop. The yield of grain was 30 percent greater for the mixture (alternate lines of finger millet and soyabean) than the combined yield of these same crops grown in separate plots.

BOX 31-3

MANAGING FRUIT TREES

In some areas of Uttarakhand, mono-cropping of fruit trees (about 3 trees per are) is practiced, usually with chemical fertilisers and pesticides and often with little or no mulch or compost. However, farmers are now realizing that this method of producing fruit is unsustainable. The soil in such orchards become depleted and diseases and pests become unmanageable. Organic farming, including mixed cropping, is a sustainable alternative method. The principles of mixed cropping have already described in Box 31-1.

Shoor Vir Singh is also growing fruit trees naturally. From his experience he suggests the following guidelines.

1. Grow fruit trees directly from seed rather than transplanting seedlings. This gives healthier, stronger trees.
2. Give sufficient place for each tree to grow.
3. Allow fruit trees to grow naturally without pruning. This also gives healthier tree and greater yield.
4. Grow fruit trees in mixtures. For example, along with mango trees some trees of peach, guava, silk cotton tree (*semel*), *ber*, *pipal* (*Ficus religiosa*) and banana should be grown. These act as companion crops.
5. Some other companion crops are *shisham*, *siris*, *jamun*, *neem*, *bakain*, *karonda (Carissa carandas)*. These trees are used for fodder, fuelwood and/or stemwood. The height of these trees should be kept lower than that of the fruit trees. Fallen leaves of these trees and fruit trees should be left as mulch.
6. Use no chemicals.
7. Grow turmeric and coriander in the shade of the fruit trees.

Further points to be kept in mind are:

(a) When an existing tree in an orchard gets old or dies and is removed, a tree of a different type should be planted in its place. This is the principle of 'crop rotation' applied to fruit trees.

(b) Compost should be spread in the orchard if fodder leaves are taken from it. Otherwise compost is not necessary. Fallen leaves and natural ground cover will provide enough compost.

(c) Young trees must be given space to grow by cutting back the ground cover around them. The cut material can be used as mulch.

(d) With this way of growing fruit trees, disease and pest problems will be negligible. If problems do occasionally arise then use the insect and disease control measures given in Box 11-2 'Sita-Dahi'.

(e) The natural method of tree management should never be applied to existing trees. Trees that are used to chemicals may become sick and die if the chemicals are stopped. Therefore, plan to start natural farming only with new plantations.

(f) If an old plantation in which the trees are sick and the soil depleted is to be converted into a new plantation, it will be best if the old trees are removed and the land left fallow for two years. Better still, grow green manure in it and mix it in the soil. This will regenerate the soil and the natural basic ground cover for the new orchard.

BOX 31-4

AN EXAMPLE OF ORGANIC FARMING

The uses of chemical fertilisers and pesticides, and changes in cropping pattern (Box 27-1) have increased food production in our country. However, our village ecosystems have become unbalanced, or we can say that they are sick. In sick ecosystems high yields cannot be maintained. Therefore we must find ways of farming that restore our ecosystems and keep them healthy in the future. The way suggested here is to follow the five principles of 'Organic Farming' (Boxes 11-1). This includes growing trees in our village ecosystem as well as crops, and, where necessary, reducing water use to restore water balance (Boxes 5-1,' Pests', and 22-1, 'Water cycle in the village ecosystem').

A few farmers in all parts of India, who earlier applied chemicals and excessive amounts of irrigation water, are now adopting organic farming practices. Of course, they apply the general principles of organic farming in way that suits their particular soils, climate and crops. We can learn much from them. Shri Shoor Vir Singh lives in Chanda Nangli village in Bijnor District. The conditions there are similar to those in the plains of Uttarakhand. Shoor Vir Singh has 4.4 hectares (440 'ares') of irrigated land, all in one compact block. Earlier he practiced chemical agriculture and got very good yields; in fact in 1980 he had been recognized as a progressive farmer of the District.

When he practiced chemical farming, he become aware of the harmful affects of the chemicals, particularly the dying of soil organisms. As a result he started reducing the use of chemicals and after 1983 stopped using them altogether. At the same time he begin practising organic farming (Boxes 11-1, 31-1 and 31-3). Initially, his yields went down. In the case of wheat the yields went down from about 50 kg/'are' to about 12 kg/'are' in the first two years. But over the neat six years, as he gained experience, yields increased again. In the case of wheat his yield is now about 37kg/'are', plus small quantities of lentil, linseed (*til*), mustard and green fodder which he grows as companion crops mixed with the wheat. He says that by taking advantage of what he has learned, other farmers can do in only two years what it took him eight years to do. He did not adopt organic farming in all his land at once but field by field over a period of several years.

His main crops are paddy (80 'ares'), wheat (80 'ares') and sugarcane (240 'ares') in rotation. In all cases he mixes six or more companion crops (see Box 31-1 'How to Grow Mixed Crops'). He applies about 100 kg compost per 'are' to wheat. Between wheat and paddy (May-June) he grows a mixture of *Cannabis sativa* (hemp) and *Sesbania bispinosa* (*dhaincha* for green manure), and sorghum, millet, maize and cowpeas for fodder. ('Green manure' is a crop that is cut when it is fully grown but still green. It is put directly on the soil as 'mulch', or mixed in the soil by ploughing.) Sugarcane is fertilised only by crop residues and weeds applied as mulch. His yields are: wheat 37 kg/'are', paddy 30 kg/'are' and sugarcane 625 kg/'are'. The yields of companion crops are extra. He also grows sorghum and *berseem* as main crops in kharif and rabi seasons, respectively, in about 60 'ares' of land with five-six other companion crops, all for fodder. He uses all crop residues and weeds as mulch.

He has an orchard of 30 'ares' in which he grows mixed trees. There are mango, guava, *Bombax ceiba* (silk cotton tree), *ber*, *pipal*, *shisham*, *siris*, *jamun*, *neem* and *bakain* (see Box 31-3). These trees produce fruit, fodder and wood.

To do his ploughing and carting work, he has a pair of Hariana bullocks. He also has two buffaloes. All the *gobar* (dung) goes into a *gobar* gas plant, and gives the family enough gas for all their cooking.

Shoor Vir Singh does not attempt to kill pests in his crops or chase them away; instead he feeds them. Take the case of termites. When he was practising chemical farming termites were a problem. He says that termites are decomposers, eating dead plant material. If there is not enough dead plant material in the field, they eat the live sugarcane plants. By putting mulch, the termites are fed, the sugarcane is saved and the mulch is turned into humus.

In olden times families used to make gur (brown sugar made by boiling down sugarcane juice) at home from their sugarcane. Shoor Vir Singh's family still do. They use the bagasse to boil the juice. The *gur* is sold to people who are happy to get *gur* made from sugarcane that is grown without chemicals. They also give chemical-free pulses and vegetables to their friends and relatives.

Shoor Vir Singh has found that over the years, as the humus content of his soil has increased, its water-holding capacity has also increased. Previously much water was wasted because the soil could not hold it, and it drained away deep into the soil. Now, he applies only half as much water as he did when he was using chemicals.

From this example we can see that, by imitating nature in farming, our fields not only feed us but also remain healthy and productive.

Date: ....

Code : Soil 3
Month : September

EXERCISE 32

SOIL PARTICLE ANALYSIS

INTRODUCTION

In the Box 9-1 we learned that the major part of a soil is rock particles. These particles are various sizes, from those you can easily see to those that are so small that they can only be seen under a microscope. In this exercise we will analyse the particles of soil. The term 'analyse' means to separate different entities comprising a mixture. Soil is a mixture of particles of different size groups. We will separate these groups and determine the proportion of each in a soil sample. Box 32-1 explains what these groups are, how they are separated and how to calculate their proportions. It also explains why soil particle composition is important for growing crops.

REQUIREMENT

1. *Kutlis* – one for each team
2. Piece of plastic sheet – one for each team
3. Plastic bag, 2 kg capacity – one for each team
4. Clear-glass bottle (preferably with a wide mouth), 1 l capacity – one for each team

PROCEDURE

1. Visit your assigned household and request permission to take a soil sample from one of their fields. Teams 1-5 will request the householder to show them their best fields, i.e., the one which gives the highest yields of crops. These team will then take soil samples from these fields. Team 6-10 will request to take samples from their assigned householders' poorest fields. You may explain to them that you are trying to learn why some fields give high yields and some low yields. <u>Take samples only from fields which do not have a standing crop</u>.

FOR THE TEACHER

Take up Box 32-1 before begining this exercise, and Boxex 32-2 and 32-3 afterwards.

2. Take soil samples in the way described in Box 32-1. Fill in the hole you have made after taking the sample. Be sure to thank the numbers of your assigned household for their help.

3. It is important to have one sample, at least, from a field located in a valley bottom, next to a stream or river. If no team has taken a sample from such a site, your teacher will request one team to take a sample from a nearby village where there is such a field. This team will have two samples to analyse.

   For the sake of comparison, it is desirable also to have one sample of pure river sand. If it is not locally available, take (with permission) a sample from any building site. One team will be assigned this task by your teacher.

   Finally, again for the sake of comparison, one team should take a sample of *chikni mitti* (clay). Every village has one or more sites from which everyone takes their requirements.

   In all, there will be 12 or 13 samples for the class to analyse. Three teams will each have two samples.

4. Determine the cmposition of your sample(s) in the way described in Box 32-1. Write your results here:

   % clay ....
   % silt ....
   % sand .... (includes 'sand' and 'course sand and gravel')
   What is the textural class of your sample? ....

   (Note: If your team has an extra sample, write your results on the blank space below. Also show all calculations in this blank space.)

Enter your results in table 32-1 column 3. Also fill in column 2. Exchange data with other teams to complete Table 32-1.

Table 32-1. Textural class of soil sample

Team number (1)	Description of sample (name, quality, site) (2)	Textural class of sample (3)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
Valley-bottom field soil		
Chikni mitti		
Sand		

5. Each team should make 10 small paper packets containing about 50 g of each of its samples. Write the name and textural classification of the sample and your team number on each packet. Give one packet to every other team. In this way each team will have 12 or 13 packets, one of each of the samples taken by the class. The members of each team should try to distinguish at least 'good' and 'poor' samples, *chikni mitti*, river sand and valley-land soil, by feeling beteween their forefingers and thumb, without being told which sample is being felt.

QUESTIONS

1. Looking at the results of the analysis of samples of the first 10 samples in Table 32-1, do you find any correlation between 'good' and 'poor' fields and textural classification? If so, what? What is the significance of this correlation?

2. Is there any difference between soil from river valley fields and from terrace fields on sloping land? What is the significance?

3. Why is *chikni mitti* called "*chikni*" (smooth, slippery)?

4. In years of poor rainfall, crops growing in fine-textured soils may survive, while those growing in coarse-textured soils may die. Why?

Teacher's signature:....................

Date:....................

Box 32-1

SOIL TEXTURE AND TYPES

How can you judge the quality of a soil? Are there methods by which we can determine rapidly whether a soil will produce a good crop (i.e., a high yield) or a poor one? The answer is: yes. Soil quality can rapidly be judged by determining the texture and its colour. Texture means how the soil feels when you rub a little of it between your fingers. This box explains why soils differ in texture and how texture is related to crop yield. The colour of any particular soil gives us an idea of its humus content; the darker a soil is, the higher its humus content. You already know why humus is important for good crop yields (Box 26-1). The ability to judge soil quality by these two methods is a skill that you can acquire by testing a wide range of soils, and comparing the results.

What is soil texture?

Aside from humus and soil organisms, soil is made up of small particles of rock. Some soils have a high proportion of very small particles, like the soil used in the house to build a chulha, or to plaster floors and walls (*chikni mitti*). Soil from most fields has a greater proportion of large particles. The *chikni mitti* feels smooth if you moisten a little of it and rub it between your fingers. Field soil, by comparison, feels coarse; you can feel the presence of of rock particles. Sand, which we obtain from river beds, has had all the small rock particles washed away, leaving only very large particles. It feels very coarse compared to field soil. You must test each of these yourself to understand the differences. We say that *chikni mitti* has a 'fine' texture. By comparison, we say that the field soil has a 'coarse' texture, and the sand a 'very coarse' texture.

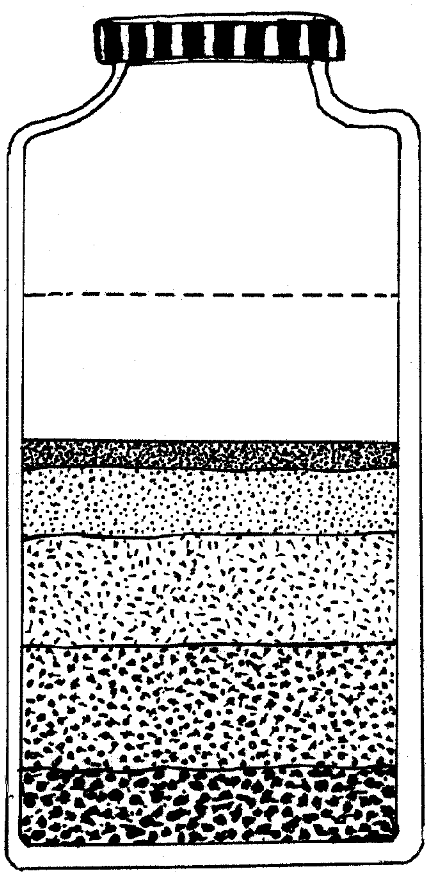
A method of determining soil particle composition in the laboratory

Fully to understand the subject of soil texture, we must examine a few samples in the laboratory. The method of examination is as follows.

1. From a field make small hole 15 cm deep, collecting on a plastic sheet all the soil removed.

2. Mix the soil thoroughly on the plastic sheet. Remove stones, roots, twigs, grass and weeds. Crush all lumps. Put 1.5 kg of the soil in a plastic bag to take the laboratory.

3. Fill a clean, 1 litre glass bottle (preferably with a wide mouth) half full with the prepare soil. Add water until the water fills the bottle to the 2/3 rds level. Screw on the cap and shake the bottle vigorously for one minute. Place the bottle on a shelf and do not disturb it for one week.



4. After one week, you will see that the soil has settled to the bottom of the bottle, leaving more or less clear water at the top. Do not touch it, when examining. You will also see bands of soil of different colours. If you examine these different bands carefully you will see each is made up of different-sized particles. (A magnifying glass can help you see these differences more clearly.)

The largest, coarse sand and gravel, settle most quickly and form the bottom layer. These particles are more than 2 mm in diametre. Next are sand particles (particle size 0.05 - 2 mm). Individual clay particles are so small that they can only be seen under a microscope. At the very top will be a layer of undecomposed organic mater and humus.

5. Measure the total depth of mineral particles (i.e., clay + sand + coarse sand and gravel), and the thickness of each layer separately. In the diagram above, total depth is 5 cm and the depth of the separate layers is: Clay, 1 cm; silt, 1.5 cm; sand + coarse sand and gravel, 2.5 cm. The percentage composition (by volume) of this soil is thus:

$$\% \text{ clay} = \frac{1.0 \times 100}{5.0} = 20$$

$$\% \text{ silt} = \frac{1.5 \times 100}{5.0} = 30$$

$$\% \text{ sand + coarse sand and gravel} = \frac{2.5 \times 100}{5.0} = 50$$

The relation of soil particle composition to texture

Soil with a higher percentage of 'sand' (i.e., sand + coarse sand and gravel) will feel more coarse to the touch than those with less percentage of sand. *Chikni mitti* has a high percentage of clay, and a low percentage of sand; it feels smooth and is said to have a 'fine' texture. Table 32-1-1 shows the approximate correspondence between soil composition and texture.

Table 32-1-1. Correspondence between soil composition and texture

Soil textural class	Approximate composition
Very fine	40% clay 30% silt 30 % sand
Fine	30% clay 30% silt 40 % sand
Medium	20% clay 20% silt 60 % sand
Coarse	10% clay 15% silt 75 % sand
Very coarse	5 % clay 10% silt 85 % sand

Relation of soil texture to crop yield

The inherent productive potential of a soil is determined by the proportions of mineral particles of different size groups of which it is composed. (This is apart from the effect of humus.) Small particles have a large particle surface area for a given volume than larger ones. Thus one cc of clay particles, for example, has about 1000 times more particle surface area than one cc of sand particles. It is the film of water held on the surfaces of soil particles that is critical for crop production; this water does not drain away by gravity, and yet can be extracted by plant roots. (Recall that you measured the amount of this water in Exercise 9.) Thus soils with a fine texture hold more water which plants can use than those with coarse texture. This is very important during the dry season when rain is infrequent.

Minerals and nitrogen in the soil are attached to the surface of soil particles. Thus for the most part they do not drain away with surplus water. Plant roots extract these minerals and nitrogen directly from the surfaces of soil particles. (When you study chemistry you will become to understand this process better.) Since finer textured soils have a larger particle surface area than coarse-textured ones, they also contain more available minerals and nitrogen to growing plants.

An experiment was done at the Vivekanand Institute, Almora clearly shows the effect of soil texture on crop yield. Wheat was grown in two fields in the same year having different soil texture. One field had a 'fine' texture and the other one had a 'coarse' texture'. In both fields compost was applied at the rate of 200 kg/nali before sowing the wheat. When ripe, the wheat was harvested and weighed. Here are the results.

Soil texture	Yield, kg/*nali*/year	
	Grain	Straw
Fine	31	87
Coarse	12	38

The higher yield on the field with the fine textured soil is the result of more available water and nutrients.

BOX 32-2

PLANT NUTRIENT CYCLING

Plants are known to require the following 16 chemical elements to live and develop.

Those obtained from air and water	Those obtained from both soil and air	Those obtained from the soil		
Carbon Hydrogen Oxygen	Nitrogen	Iron Manganese Copper Phosphorus	Potassium Zinc Boron Molybdenum	Calcium Magnesium Sulphur Chlorine

Carbon is obtained from the carbon dioxide of the air, oxygen from air, and hydrogen from water (Box 16-3 'Trees and their food'.)

Another term for these chemical elements is 'nutrients'. Nutrients are those elements that are essential for the nutrition of plants.

The nutrients listed in the second and third columns are absorbed by plants from the soil. Dead plant tissues decompose in the soil, releasing these nutrients (see Box 26-1 'Feeding our soil'). There is thus a cyclical flow of nutrients from soil to plants and back to the soil. Let us study this cycling of nutrients in a little more detail.

The diagram in Figure 32-2-1 gives a complete picture of plant nutrient cycling.

On the right side of the diagram is the familiar process in the soil by which dead plant and animal tissues are decomposed. Animal excreta are also decomposed. Some of these nutrients are absorbed by the roots of living plants. And some are leached out of the soil by water. 'Leaching' means that nutrients are dissolved by water and carried out of the soil in the water.

Another source of nutrients for living plants is the rock. As rock disintegrates to form soil, some of the nutrients it contains get dissolved. These nutrients too may be leached to some extent.

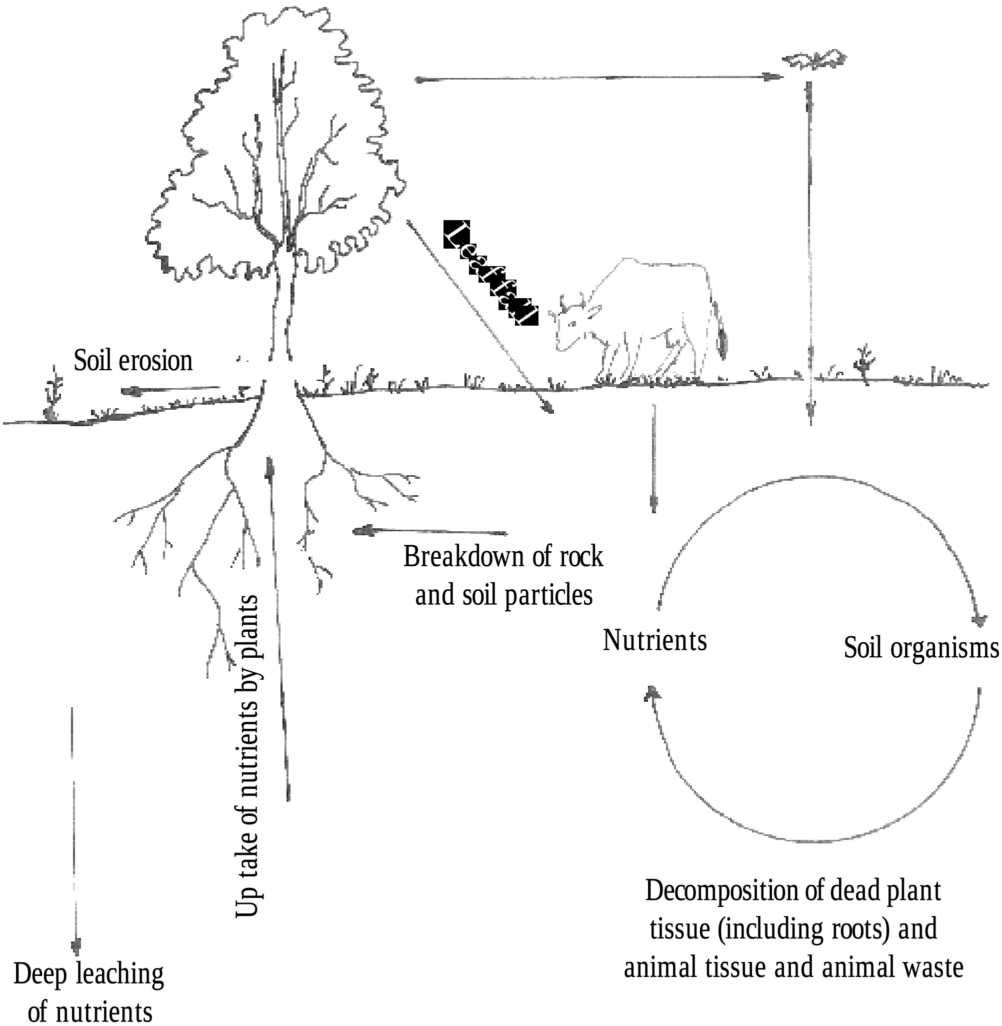


Figure 32-2-1. Diagram depicting plant nutrient cycling in nature

When rain water runs off, the surface of the land it carries soil particles and also humus. These both contain nutrients.

In a climax forest community the losses of nutrients by leaching and soil erosion are very little. These losses are approximately balanced by the addition of minerals by the disintegration of rock in the process of soil formation. Most of the nutrients are cycled between living plants and the soil. When such a community degrades, or regresses, the proportion of nutrients lost through leaching and soil erosion increases. One reason is that as the community degrades more and more bare ground is exposed to the action of rainwater run off and soil erosion increases (Box 18-1 'When it Rains'). Also, degraded communities do not have trees. The deep roots of trees intercept nutrients leaching downward through the earth. Other plants like grasses have only shallow roots which cannot recover nutrients from deep layers of the earth.

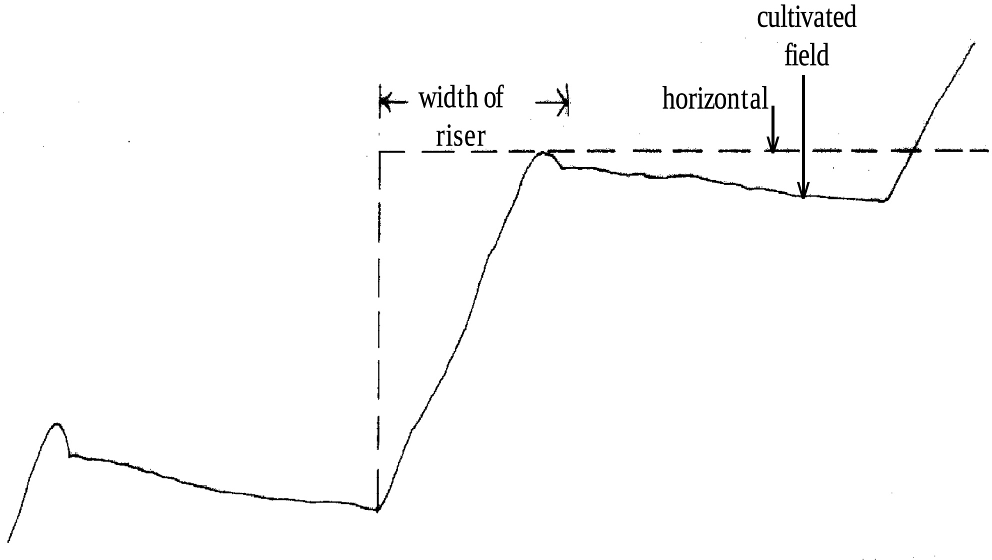
Nitrogen in soil does not come from the decomposition of rock and soil particles. Some of it comes from decomposing plant and animal tissues. Some also comes from the atmosphere through the activities of soil organisms as you have learned in Box 26-2 'How to make good compost'.

Trees are especially important for nutrient recycling. Because of their deep roots they can catch the nutrients that leach below the level of the roots of crop plants. This is one reason why it is important to plant trees around the edges of our fields, and in strips across the field (Box 24-1 'Where can we grow trees'). The nutrients absorbed by the tree roots are recycled to the soil in fodder, mulch and the ash from fuelwood. These recycled nutrients feed the subsequent crops and the trees themselves. We might thus think of trees as 'nutrient pumps'.

Box 32-3

THE MANAGEMENT OF TERRACE RISERS

A terrace riser is a vertical wall or steep bank between adjacent terraces on a hillside.



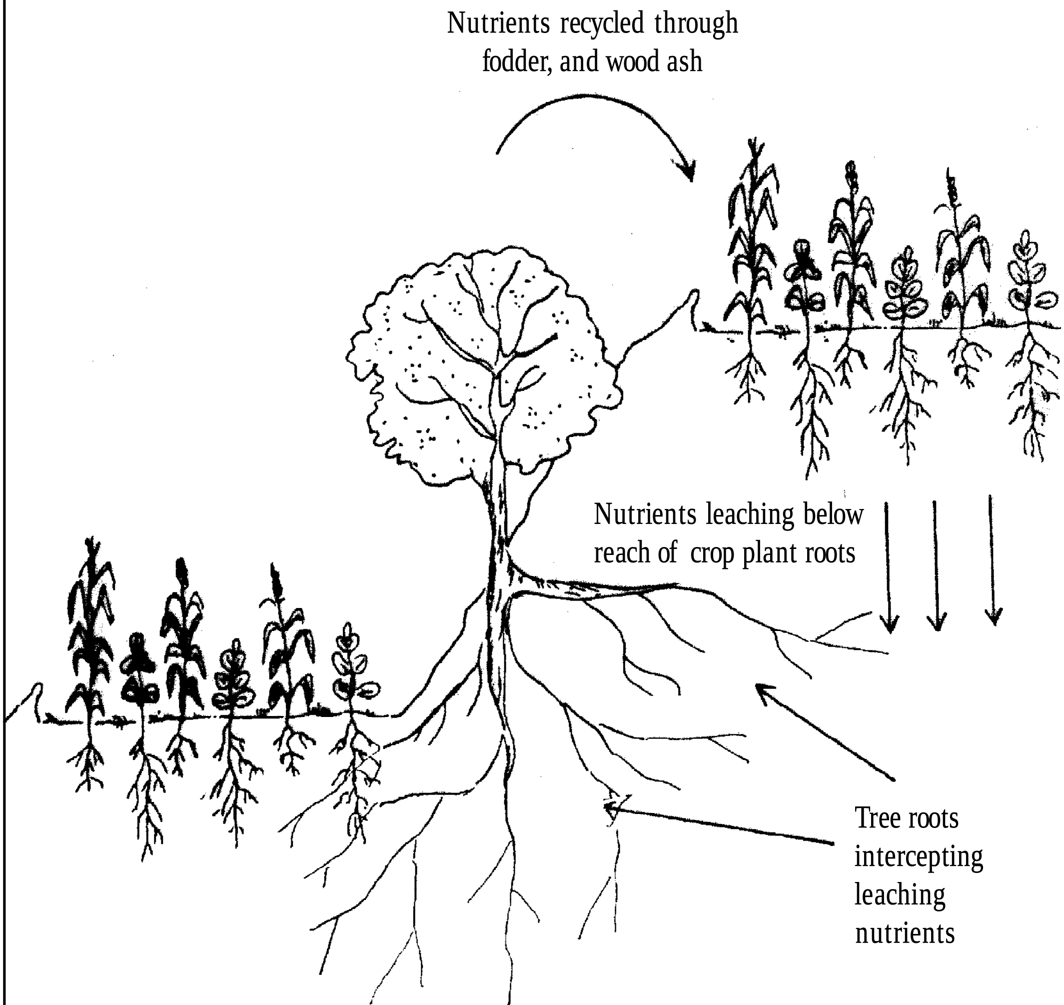
Terrace risers are uncultivated and therefore constitute part of the support area. It should be managed as support area. Specifically:

1. No grazing should be permitted. Grazing of the terrace risers prevents the establishment of trees, and breaks down the bunds at the front edges of fields. When the bunds are broken, soil erosion from fields increases.

2. No fires to be set. Fires also kills tree seedlings.

3. Trees should be planted and then harvested in a regulated way.

Trees have an especially important role to play in maintaining the productivity of our land. Nutrients leached from cultivated fields are captured by tree roots and brought back into circulation through leaves and wood. Trees act like nutrient ”pumps”.



Trees on terrace risers should preferably be kept small so that they do not shade the fields too much. Fodder trees can be maintained as bushes and fuelwood-producing species can be pollared. Under the trees, a good ground cover of grasses and shrubs should be maintained. On low risers small shrubs like *chamlai* and *sakina* may be preferable.

To facilitate the planting and correct management of trees on terrace risers, each riser should be considered to belong to the owner of the field above it.

Be sure to muzzle your bullocks when ploughing (see Figure 32-3-1)!

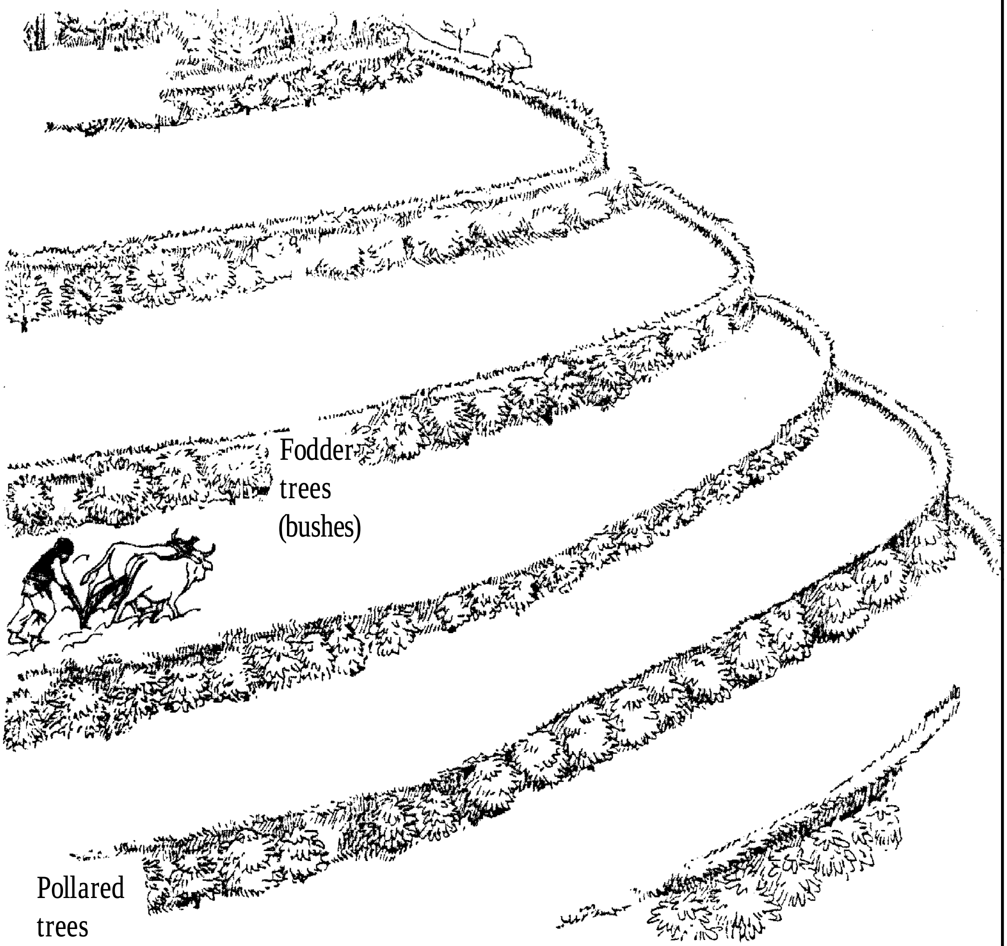


Figure 32-3-1. Trees planted on terrace risers to act as nutrient "pumps". They are kept small as fodder bushes and pollared trees.

Date: ....

Code : Soil 4
Month : October

EXERCISE 33

CLASSIFICATION OF CULTIVATED LAND

INTRODUCTION

It is common experience that not all fields are equally productive. In Box 32-1 you learned that, aside from the amount of compost applied to it, soil productivity is determined by its texture. Box 33-1 explains why soil texture varies from field to field even within the same village. It also describes a rapid method of classifying cultivated land on the basis of slope angle. In this exercise you will classify the cultivated land of your study village.

REQUIREMENT

1. Slope-angle measuring device (?) — one for each team

PROCEDURE

1. Assemble at your village map. Divide the cultivated land of the village into distinct blocks, each with an approximately uniform slope angle. Number or name each block and demarcate it on your village map (Exercise ?). Your teacher will then assign teams to these blocks. Note these team assignments in Table 33-1, column 2.

2. Go to your assigned block and measure slope angle at several places. Write the slope angle measurements on the opposite blank page and average them. Record this average figure in Table 53-1, column 3.

3. At each site at which you determine slope angle, examine the soil. Decide on its texture. Write your decisions on the opposite page, and decide which is the predominant soil texture in your block. Enter your decision in Table 33-1, column 4.

FOR THE TEACHER

Take up Box 33-1 before begining this exercise.

4. In column 5 of the Table 33-1 write in the class of land based upon slope angle (see Box 33-1 for guidance).
5. Exchange data with other teams and complete Table 33-1.
6. From the results in Table 33-1 estimate the approximate proportion of each class of land in the total cultivated land of the village. Write your estimates here.

Bottom land ______________

Good-quality upland ______________

Poor-quality upland ______________

Table 33-1. Slope angle, soil texture and classification of cultivated fields of study village

Team number (1)	Block Assignment (2)	Average slope angle (3)	Predominant soil texture (4)	Classification (5)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

QUESTIONS

1. Discuss your results with the members of your assigned household. What are their comments?

2. Possibly one or more classes of cultivated land are not found in your study village. If so, why?

3. Are different crop rotations followed on different classes of land? Why?

4. Is compost applied uniformly to all classes of land? If not, why not?

5. Does the classification of cultivated land done in this exercise help you to interpret the yield data you obtained in Exercise ?? How?

Teacher's signature:....................

Date:....................

BOX 33-1

A METHOD OF CLASSIFYING CULTIVATED LAND

In Box 18-1 we learned that soil erosion is more intense on steeper slopes than on gentler ones. This is because water flows faster on steeper slopes and thus dislodges and carries more soil. The result is generally shallower soils on steeper slopes than on gentle slopes (Box 23-5). Naturally-occurring class III sites are generally on steeper slopes. (Some class III sites occur on gentle slopes due to accelerated erosion -- that caused by improper support-area management.)

At the same time, soil eroded from steep slopes tends to accumulate in valley bottoms where slope is gentler or the land is flat. The rate of flow decreases as water reaches level land and the soil particles it carries settle down. The diagram in Figure 33-1-1 shows how the combined process of natural soil erosion and deposition occurs.

When soil erodes from higher slopes to valley bottoms it is mostly the smaller particles of clay and silt that erode. The soils of valley bottoms thus contain higher proportions of silt and clay particles than soils on slopes. In Box 32-1 we learned that these are the most important particles in the soil; soils with higher proportions of these particles are more fertile. Thus soils on steep slopes are less productive (e.g. of tree growth) than these lower down for two reasons: they are less deep and less fertile.

When terraces are made, the depth and fertility of the soil in the terrace fields is determined by the depth and fertility of the soil at the site where the terraces are made. Thus terrace fields on steeper slopes are less productive than those on less steep slopes or those in valley bottoms. Further, where terraces are not properly made (see Box 18-4) accelerated erosion occurs from the fields, and this is usually greater from terrace fields on steeper slopes. This further reduces the depth and fertility of the soil in terrace fields on steep slopes in comparison to those of fields on less steep slopes and flat land.

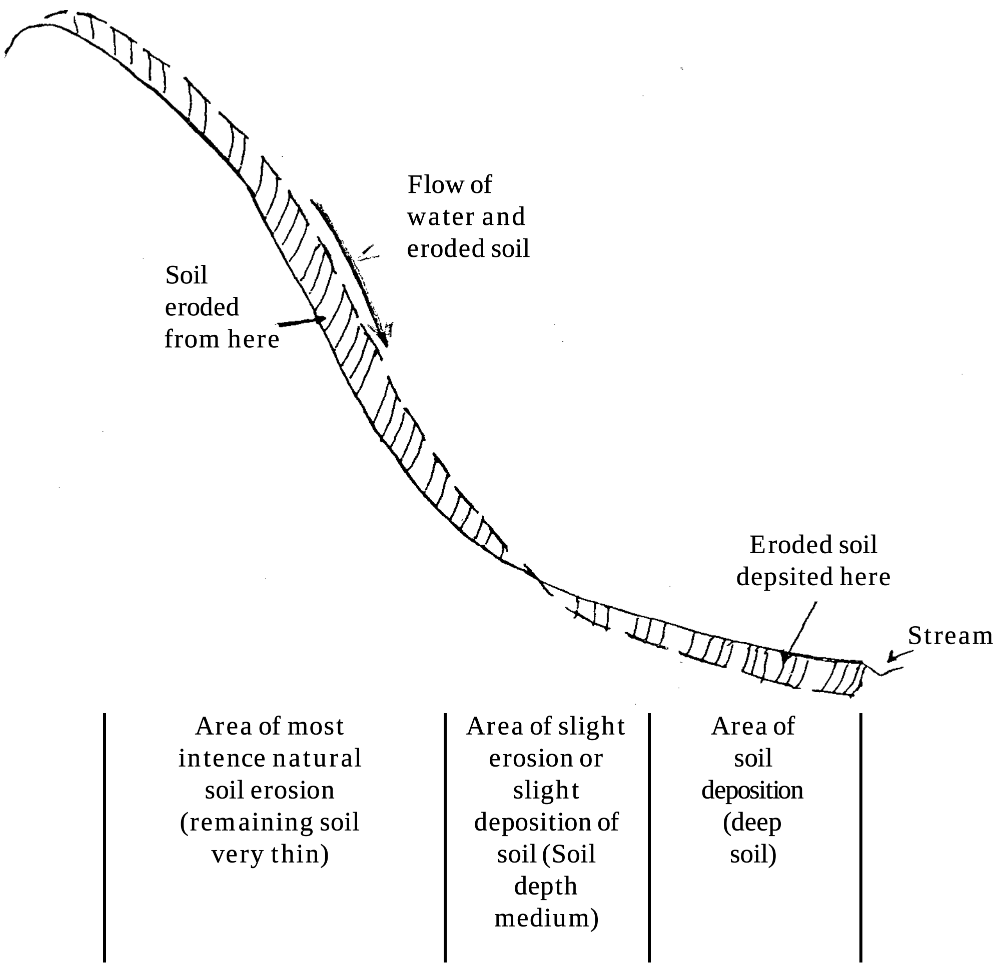


Figure 33-1-1. A cross-sectional view of a mountain slope showing areas of soil erosion and soil deposition

Table 33-1.Relationsip between site slope and soil texture at three sites in the Khafra-Bhaura catchment in Dwarahat Block, District Almora

Site of field	Slope angle at site of field, degrees	Soil depth, cm	Angle of outward terrace slope, degrees	Clay content %	Silt content %	Sand content %	Textural class
Bottom of slope, next to Kafara naula	12	104	2	14	20	67	Medium
Half-way up the slope	21	98	3	11	12	77	Coarse
Near the top of the slope	26	23	12	5	13	82	Very coarse

* The term “sand’ includes ‘sand’ + coarse sand + gravel

The data in Table 33-1 shows the relationship between site slope angle and soil texture; the steeper the slope the coarser the texture of the soil. You will also notice that the outward slope of the terrace field near the top of the slope is much greater than those of the fields lower down. This is because the original depth of the soil at this site was very shallow, thus making it impossible to construct a level terrace unless it is very narrow. Of course accelerated soil erosion will be very high from this field, reducing its depth and fertility even more.

On the basis of the data given in Table 33-1, and data from other similar investigations, we may broadly classify cultivated land on the basis of site slope angle as shown in Table 33-2.

Table 33-2. Classification of cultivated land in Uttarakhand

Class	Average site slope, degrees	Soil depth	Texture	Relative productivity
Bottom land	0-5	Deep (100 cm or more)	Fine to medium	3
Good quality upland	5-20	Medium (up to 100 cm)	Medium to coarse, with gravel	2
Poor quality upland	More than 20	Shallow (as little as 25 cm)	Coarse to very coarse much gravel and stones	1

In order to classify any particular field according to this scheme all that is necessary is to measure slope angle at the site of the field. To do this use the device.

Stand on the outer edge of one field while another person stands on the outer edge of a field 2 or 3 terraces higher up.

The first category of land, 'bottom land', is rare in Uttarakhand, occurring only in broad, flat valleys beside big streams or rivers (e.g., the field of fine textured soil at the Vivekananda Institute mentioned in Box 32-1).

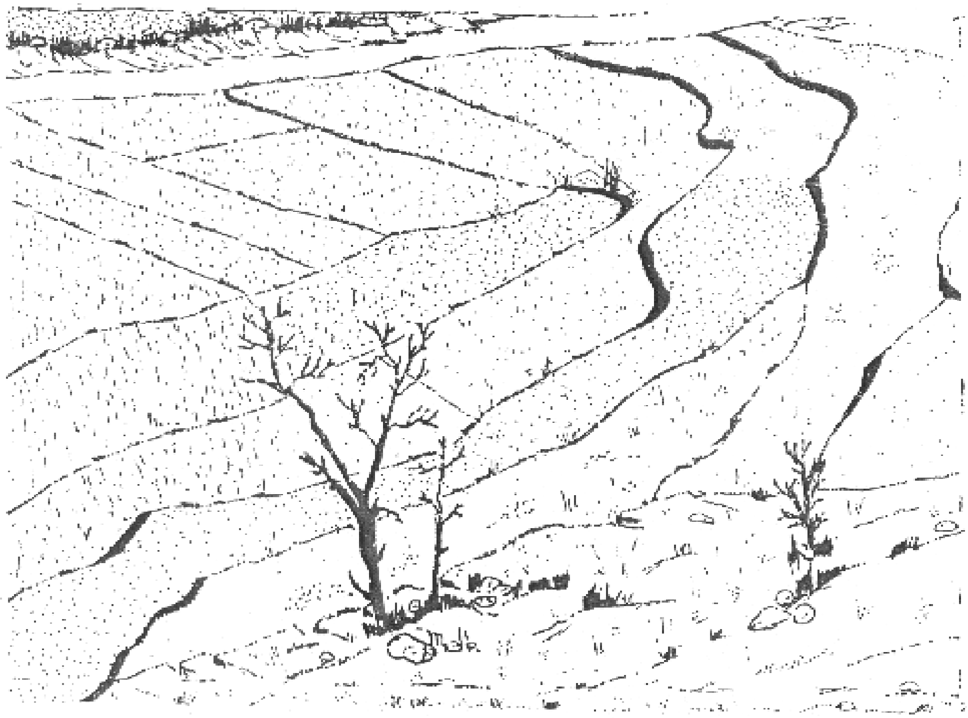


Figure 33-1-1. The Land along the stream at the top of this drawing is bottem land. At right, this grades into good-quality upland as the original site slope increases.

In general, it has ben found that the relative productivity of these three classes of cultivated land are 3, 2, 1. These figures mean that if a field of the first category (bottom land) produces 30 kg of grain per nali per year, fields in the second category (good-quality upland) and of the third category (poor-quality upland) in the same locality and in the same year will produce about 20 kg and 10 kg, respectively. These figures are for unirrigated conditions; much bottom land is irrigated, increasing its relative productivity to 4 or 5.

Date: ....

Code : Fodder-1
Month : November

EXERCISE 34

SUPPORT AREA REHABILITATION PROJECT. MEASURING GRASS YIELD 1.

INTRODUCTION

Last year in Exercise 24 you began a support area rehabilitation project in your study village. You decided the area, helped enclose it with a wall, and perhaps made some check dams. Since there has been no grazing in this area since last year, the grass is now mature and ready to harvest. In this exercise we will harvest the grass, weigh it and calculate its yield.

With continued protection, grass yield is expected to increase year by year and the types of grass will probably change. We want to determine by how much grass yield increases year by year. Thus we will repeat the measurement of yield next year (when you are in 9th class) and the year after that (when you are in 10th class).

More grass yield results from more grass plants and bigger, healthier plants. Before doing this exercise, read Box 34-2. There you will learn that in the process of natural regeneration, *Themeda* and *Arundinella* grass plants appear and gradually become more numerous. To follow this process we will count the numbers of these plants in sample area each year, beginning this year in the present exercise.

REQUIREMENT

1. Sickles - one for each student
2. Ropes to the bundles of grass - approximately one for each student
3. Tape measures, 1.5 m - one for each team
4. Spring balance - one

FOR THE TEACHER

Take up Boxes 34-1 and 34-2 before the beginning of this exercise.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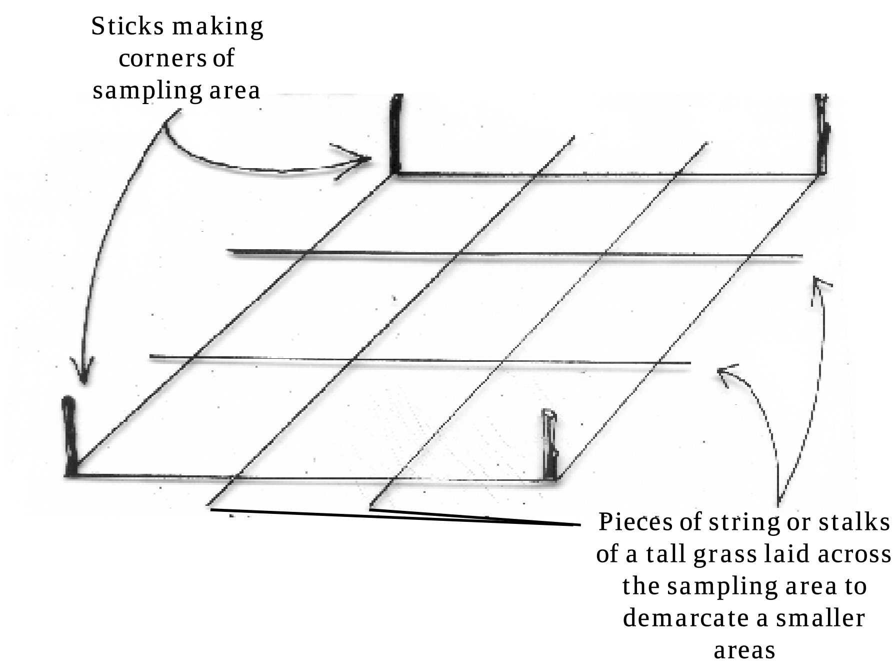
PROCEDURE

1. Your teacher will assign each team one part of the project area for the purpose of grass cutting. All the grass in the project area is to be harvested by the class.

2. Each team should go to its assigned area. Before starting to cut the grass, select a one square metre area that is typical of the part of the area assigned to you. Measure the sample area carefully with a tape measure, and demarcate the four corners with sticks or stones. Do not include any transplanted tree seedlings in your sample area.

3. Within the 1 m^2 sample area, pick up all dead leaves covering the ground so that each plant is clearly visible. Standing at one edge of the sample area, estimate by eye approximately what percent of the area is bare ground. One team member should stand at each side of the square and make his/her own estimate. Then write down the four estimates on the opposite page. Calculate the average. Subtract this figure from 100 to get "percent plant cover". Write this figure in column 2 in Table 34-1.

4. Next count the total number of plants growing within the 1 m^2 sample area. In order to make the counting easier divide the area into nine compartments, as shown below, using pieces of white string, or stalks of a tall grass.



Make use of the following three diagrams as tables to record the numbers of plants in each of the nine sections of your sample area.

Number of
total plants

Total of
nine sections =

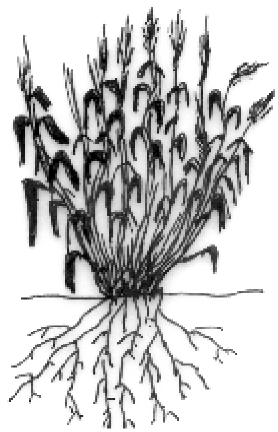
Numbers of
non-grass plants

Total of
nine sections =

Numbers of *Themeda*
plus *Arundinella*
grass plants

Total of
nine sections =

In counting grass plants, remember that one plant may have many stems. For example, the following is one plant, though having five stems.



Record the three totals obtained above in Table 34-1.

5. Cut all the grass in your team's assaigned portion of the project area. Be careful not to damage any of the tree seedlings you may have transplanted earlier. Make pullas and finally headloads. Weigh all the headloads cut by your team. Write these weights in a column on the blank space in this page. Total the column and write the total in Table 34-2.

6. Handover the cut grass to the residents of your study village.

7. Complete Tables 34-1 and 34-2 by exchanging data with all the other teams in your class.

Table 34-1. Data on plant cover of sample

Team no. (1)	Percent plant cover (2)	No. of *Themeda* and *Arundinella* plants (3)	No. of other grass plants (4)	No. of total grass plants (5)	No. of non-grass plants (6)	Total no. of plants (7)	Percent grasses in plant cover (8)	*T & A* grasses as % of all grasses (9)
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
Total								
Average								

Notes for completing Table 34-1.

1. The figure for column 5 is obtained by subtracting the figure in column 6 from the figure in column 7 (i.e., Column 5 = Column 7 – Column 6)
2. Column 4 = Column 5 – Column 3
3. Column 8 = $\frac{\text{Column 5}}{\text{Column 6}} \times 100$
4. Column 9 = $\frac{\text{Column 3}}{\text{Column 5}} \times 100$

Table 34-2. Weights of fodder cut from project area.

Team number	Weight of fodder cut by team
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
Total	

PROBLEMS/QUESTIONS

1. Calculate the yield of fodder per nali from your rehabilitation project area. Divide the total fodder produced (Table 34-2) by the area of the project area (from Exercise 22). Write your answer here :

   Yield of fodder: ____________ kg/nali

2. How does the yield of fodder from your project area compare with its potential yield? Review Box 34-1 before answering this question.

   ____
   ____
   ____

3. Judging by the findings of the grassland survey done in Garhwal (Box 34-2), what is the condition today of your project area compared to what you might expect after several years of protection? In giving your answer, be sure to consider each of the following:

   a. Percent plant cover

   b. Percent grasses in the plant cover

   c. Percent *Themeda* plus *Arundinella* plants in the grass cover

   ____
   ____
   ____
   ____
   ____
   ____

4. In case you did not find any *Themeda* or *Arundinella* plants in your project area, look for them elsewhere. Mention here where exactly you have found some plants. Describe the place. Why do you think you found them there, and not in your project area.

   ____
   ____
   ____

5. Name any other species of grass plants you recognise in your project area (refer to diagrams in Box 32-1).

6. Do you think that there is anything you might do to hasten the improvement in the grass cover of your project area? If so, what?

Teacher's signature:....................

Date:....................

BOX 34-1

COMMUNITIES

A population is defined as a group of all the organisms of a single type (or species) living in a particular area. Now we study the behaviour of groups of species, that is, populations. These are called communities. No individual population can exist in isolation. All depend on other populations for their survival and well-being.

A community may thus be defined as a group of interdependent populations living in a particular area.

The example of a community given above is highly theoritical and simplified. Let us take now a real-life example that of an oak forest undisturbed by man or his domestic animal. There are very few such forests left in Uttarakhand. Perhaps you will have a chance one day to see such a forest. For the present imagine you are walking in an undisturbed, thick oak forest. You will see many species (populations) of organisms. Most prominent are the oak trees themselves. But there are other species of tree also, like *brunj* and *angyar* and may be *utis*. In addition there are shrubs and ferns covering the ground. Many species of insects, birds and animals live here on the ground and in the trees. Examples are: *kakkar*, *langur*, grass snakes, toads, birds, butterflies. In the soil there are many species of decomposers — bacteria, insects, worms. Altogether, there are hundreds of population living in the forest. And each is dependent upon all the others.

The forest community we are considering consists of hundreds of populations, but it is named after only one of them, the oak trees. We call this an oak community, or an “oak forest”, because oak is the most conspicuous population. Trees are large compared to other organisms. Among the tree populations, the oak population is the largest — most of the trees in the forest are oak trees.

Oak forest is the most common natural community in Uttarkhand, though the species of oak tree in the community varies with altitude (Box 3-1). At low altitudes (below about 800 m) the main community is *sal* forest. At very high altitudes, *rai* and *morinda* forest are found (see Box 3-1).

In order to learn more about the nature of communities, let us do an imaginary experiment. Suppose we take a small area of oak forest, say 100 nalis. We cut down all the trees and also remove all shrubs, grass and other plants — we clear away all vegetation. Of course, plant life will again establish itself on this bare land. Now if we do not disturb the land again, but come once a year and observe the numbers and kinds of various plants which colonise the land, and if we do this for about 100 years, what do you think we would see?

In the first 2-3 years we would see a few plants, far apart from each other. These are annual plants, herbs and some grases. Slowly year by year they increase in number and cover the entire surface of the experimental area. After a few more years one will notice that some communities of perennial grass will come in and replace the annuals. At first there will be low-growing grasses, but gradualy more and more tall, bunch type grasses will come in, replacing the low growing types. Some shrubs may also come in with the perennial grasses, but when the tall bunch grasses come to cover the land entirely, the shrubs will tend to disappear.

After 10-15 years one will begin to find oak tree seedlings coming up among the grass plants. Gradually they will become more numerous, and as they grow taller, they will shade the grass, and it will disappear. After maybe 50 years the land will be covered with the dense stand of oak trees, and by 100 years there will be a dense oak forest that looks like the one that was originally cut down at the beginning of the experiment. After this there will be no change. Oak forest is said to be the climax of this process of progression of communities. Remember, this progression from bare land to oak forest will occur only if the vegetation is not interfered with by cutting trees, allowing cattle to graze, or fire.

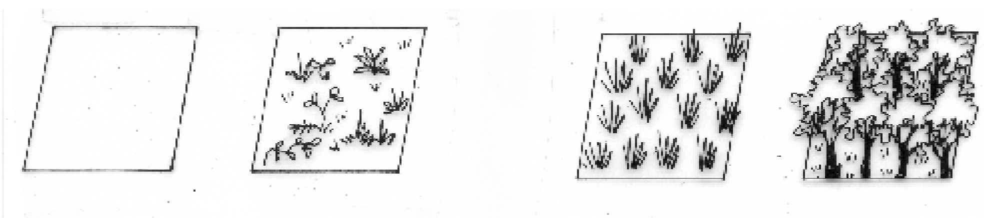
Experiments like this have been done with many communities in different parts of the world, including Uttarakhand. What occured in the above described imaginary experiment is a universal natural phenomenon. All naturally-occuring communities have the tendency to return to their original state when disturbed.

In the imaginary experiment we interfered drastically with the oak forest — we cleared the land completely and all at once. But the same thing happens, only more slowly due to grazing, fire and over_cutting.

The destruction occurs in recognisable stages — trees perennial bunch grasses, annual grassses and weeds, bare land. This sequence is just the opposite of the progresion of communities that we outlined above. It is termed 'regression of communities'.

It should be obvious that the land selected by you for your support area rehabilitaton project has suffered from regression as a result of improper management in the past. The possibility of natural rehabilitation is based on the tendency to the progression of communities.

The following diagram summarises what has been described above.



STAGE 1	STAGE 2	STAGE 3	STAGE 4
Bare land	Annual weeds and grasses (These plants are not useful as fodder	Perennial tall Bunch grasses	(Trees e.g. Oak)

P R O G R E S S I O N →

(RESULT OF GOOD MANAGEMENT)

← R E G R E S S I O N

(CAUSED BY GRAZING, EXCESSIVE CUTTING OF TREES, FIRE)

Three more general principles need to be mentioned concerning the progression and regression of communities. You will immediately see the practical implications of these principles.

1. A degraded community can rehabilitate itself through progression if the soil has not also been lost from the site through erosion.
2. A degraded community can rehabilitate itself through progression if there remain nearby populations of organisms making up the original community. For example, oak trees will not return if there is no source of seed nearby.
3. As a community progresses towards its climax, its productivity increases.

You may wonder where chir pine trees fit into the picture we have sketched. Originally in Uttarakhand, before any human settlement occured, pine forest (i.e., pine climax community) was found in only few places. Now we see chir pine also where we know that the original, natural community was oak forest. Therefore in most places where we see chir pine growing today we know that the site is degraded, chir pine is associated with grasses in stages 2 and 3. If such areas are allowed to regenerate naturally, the pine as well as the grass will be replaced by oak trees and other populations characteristic of oak forest.

Man_made communities

In general, our objective in rehabilitating our support area is to re-establish the natural climax community. In villages where oak forest is the original natural community, it will re-appear by itself if too much soil has not been lost, and if there is still some oak forest nearby. Where necessary we can speed up the return of the oak forest community by planting oak seedlings.

In some cases, however, we may not want the original, natural community. Maybe we want fodder trees that give fodder of better quality than oak (like *bhimal*), or we want faster growing trees than oak for fuelwood production (like *utis*, acacia or poplar). Again, we may make fodder bushes or coppice plants of the trees instead of letting them grow in a natural way. All these interferences by people create artificial communities. Obviously these communities will not have all the same populations as the natural ones, nor will populations in them exist in the same balance with each other.

Where we want to establish and then maintain an artificial community in our support area we should, however, be sure to use only species of trees that occur naturally in our locality, or which have become well adapted to our locality. Acacia, for example, is not a native of Uttarakhand, but has become well-adapted here over a period of 50 years.

When we establish an artificial community we should also ensure that it contains several tree populations, and not just one. Naturally-occuring communities always contain several populations of trees. Then if any one population suffers from a disease, the production of fodder from that community does not fall to zero. If one population dies out, other populations do not necessarily die also. It is like in a household in a flu epidemic not all the family members get flu, or at least not all at the same time, and so household activities are carried on more or less normally.

BOX 34-2

SOME IMPORTANT GRASSES OF UTTARAKHAND

Natural vegetation has a great capacity to regenerate itself. If we protect – degraded support area from grazing and fire, new grass plants will quickly grow in the bare spaces. Larger and more nutritious grass plants will also appear. In Box 34-1 it is said that this process is termed the "progression of communities" and the course of this progression is predictable. The ultimate or climax stage in this progression is forest. Before the forest stage, various grass communities predominate. In this box let use examine in more detail the way in which the predominant grass community changes during support area rehabilitation.

Surveys of the support areas of villages in Uttarakhand, and also Himanchal Pradesh and Jammu and Kashmir, reveal a common, regular pattern of progression. Between altitudes of about 700 and 2200 m, the sequence is given in Figure 34-2-1. In this diagram, the botanical names of the grasses are given to avoid confusion. The common name of a grass is usually not the same in all parts of Uttarakhand. Later some of the common names for each will be given.

At each stage of the progression the name of main grass community is given, just as when we say "oak forest" we mean that of the many tree communities in the particular forest, oak is predominant.

Thus at stage 2 the predominant communities are *Heteropogon* and *Bothriochloa*. Here is an example of a site at stage 2 in a reserved forest near Bilaspur in Himanchal Pradesh. The site has been badly degraded. But then protected. The altitude is 770 m. Plants cover 17 percent of the soil surface, or, we can say that 83 percent of the ground was bare. Eleven percent was covered by grasses, while 6 percent was covered by non-grass plants (herbs, shrubs and trees). Taking the total of all the grass plants as 100 percent, the relative proportions of different communities were as follows:

Cynodon	¾ ®	*Heteropogon* *and* *Bothriochloa*	¾ ®	*Chrysopogon*	¾ ®	*Arundinella*	¾ ®	*Themeda*
Stage 1		Stage 2		Stage 3		Stage 4		Stage 5

Figure 34-2-1. Diagram showing the stages in the progression of grass communities when support area is rehabilitated. Each stage is named for the species which form the predominant community/communities.

Cynodon	–	22 percent
Heteropogon	–	10 percent
Bothriochloa	–	42 percent
Chrysopogon	–	2 percent
Arundinella	–	2 percent
Total of all other communities (six)	–	22 percent

The *Heteropogon* and *Bothriochloa* communities together are the predominant community (52 percent), indicating stage 2.

From the example given above you will also realise that the various stages are not clear-cut, there are no sudden changes between one stage and another. In this example, plants from communities that characterise stage 1 (*Cynodon*), 3 (*Chrysopogon*) and 4 (*Arundinella*) are all present, but in relatively few numbers.

You can judge approximately the present degree of degradation of your project area by identifying the stage of the natural progression of grasses. Later in this box you will find drawings of each of the main grass species to help you identify the predominant community.

The entire progression from *Cynodon* to *Themeda* may take 5 to 10 years, depending upon the depth of the soil. On deep soils the rate of progression is faster. Here is the record of a site in Jammu at Nashiri slip, Batot (reserved forest) at an altitude of 1720 m where the entire

Year: 1952

Total plant cover	=	16%
Relative numbers of grass plants:		
Chrysopogon	=	less than 1%
Cynodon	=	82%
Total of three remaining species	=	18%
		100%

Year: 1958

Total plant cover	=	65%
Relative numbers of grass plants:		
Bothriochloa	=	less than 1%
Hereropogon	=	less than 1%
Themeda	=	84%
Total of five remaining species		16%
		100%

progression was completed in only six years. You will probably not be able to see the entire progression to stage 5 in your project area in only 3 years (up to 10th class). However, you can search for an area that has been protected for 10 years or more. When you find such an area, examine it carefully. You will get an idea how support area at stage 5 looks.

Now let us look in more detail at the main grass communities that make up each stage.

Stage 1

The main species of grass in heavily grazed support area is *Cynodon dactylon*. The most common local name for it is 'doob'. The stems of *Cynodon* lie along the ground and send out roots at each node. At flowering time, short erect shoots develop with seed heads at the top. See figure 34-2-2. Leaves are short, usually less than 10 cm long. Since it lies on the ground, it is not easily killed by animals walking on it. Also animals cannot easily eat all the leaves, and so the plants survive grazing.

Aside from *Cynodon*, you will usually see some grasses of annual species. You can identify annual species because they usually produce only one stem and flower head per plant. The stems are usually not more than 20 cm long. The stems do not lie on the ground like those

Figure 34-2-2. *Cynodon dactylon* (doob grass)

of *Cynodon*. Annual grass plants grow from seed at the beginning of the rainy season, and die after producing seed at the end of the rainy season. Pernnial grasses live for many years, though they go dormant during the dry season. They send up new stems from the same roots at the beginning of every rainy season. You can distinguish perennial grasses from annuals because they look like mats, as *Cynodon*, or are clumps with many stems per plant.

Annual grass species are relatively more common at stage 1 than at higher stages. At stages 4 and 5 you will find almost no annual grass plants.

Annual grass plants being very small, do not yield much fodder. *Cynodon* also does not yield much fodder since it grows close to the ground. Hence at stage 1, fodder yield is low.

Another reason for low fodder yield at stage 1 is that the density of plants is low. Usually not more than 20 percent of the ground is covered by plants at stage 1. (This is also one reason why soil erosion is high on stage 1 support area, and water absorption is low.)

Stage 2

Heteropogon and *Bothriochloa* together are the predominant community at stage 2. Both are perennial species.

A *Heteropogon* plant has about 20 stems. At the base it is about 5 cm in diameter. The stems are about 75 cm long. The leaves are 15-30 cm long and 2.5 to 5 mm wide. Flower heads are 4 to 7.5 cm long. A drawing of *Heteropogon* is given in figure 34-2-3. On thin soils, the plants are smaller than the diamensions given. The common name of *Heteropogon* is *Kumaria*.

Bothriochloa plants are tall with stems up to 110 cm. One plant has about 8 stems on an average, and the diametre of a plant at the base is about 7.5 cm. Leaves are up to 15 cm long. A drawing of a *Bothriochloa* plant is given in Figure 34-2-4. The common name is *Falwan*.

At stage 2, the average density of plant cover is about 30 percent.

Figure 34-2-3. ***Heteropogon contortus***

Figure 34-2-4. ***Bothriochloa pertusa***

Stage 3

Stage 3 is characterised by a predominance of *Chrysopogon*. It is a large plant with stems up to 120 cm long. The stems are cylindrical and smooth are up to 60 cm long. The flower heads are 15-22 cm long. A drawing of a *Chrysopogon* plant will be found in figure 34-4-4. Some common names are *hewaiya* and *survala*.

At stage 3, the average density of plant cover is about 40 percent.

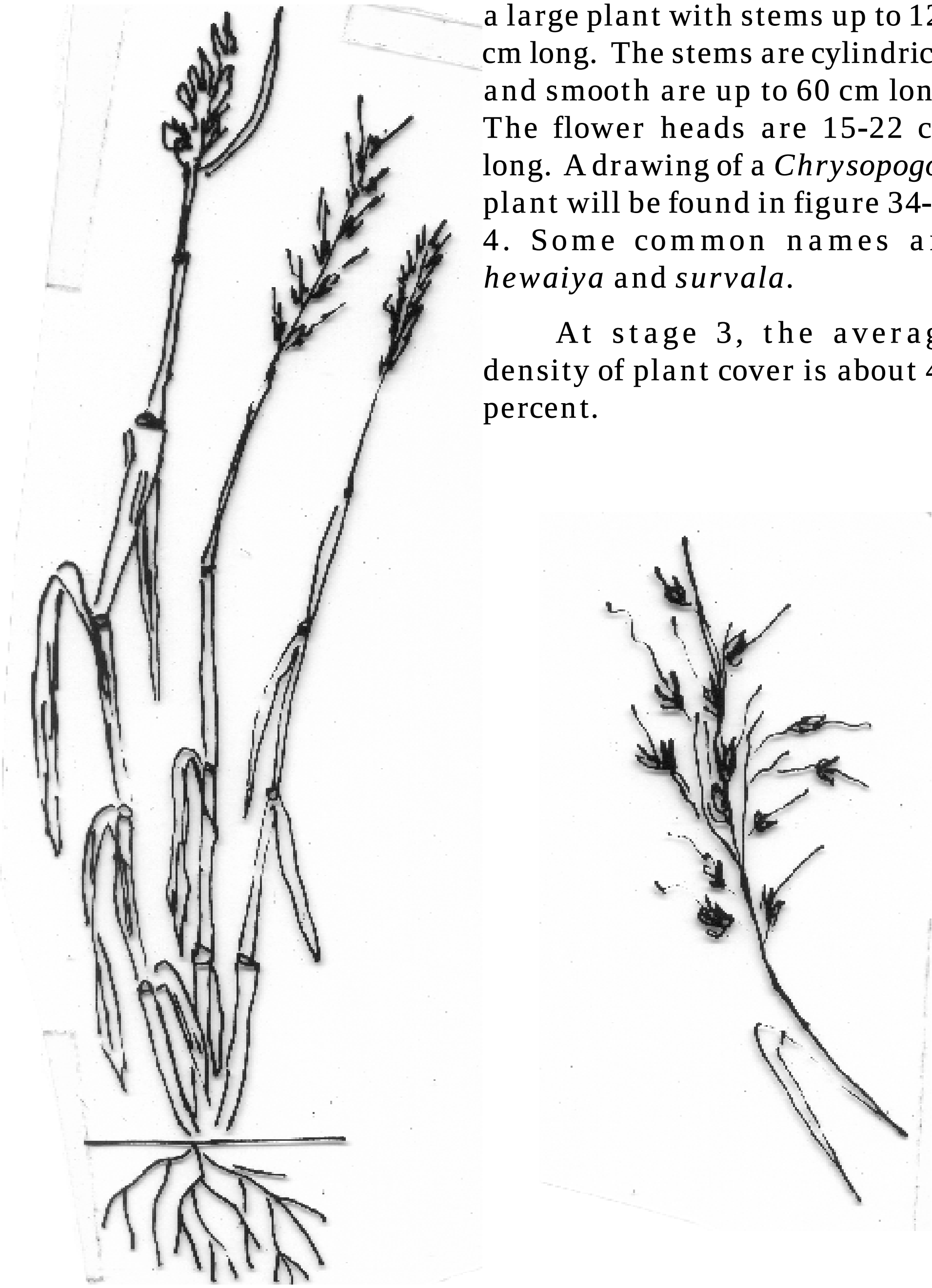


Figure 34-2-5. *Chrysopogon gryllus*

Stage 4

Arundinella is predominant at stage 4. There are two species commonly found. One is *Arundinella bengalensis*. It is a tall grass, with stems up to 1.3 m long. Leaves are 30-45 cm long. Each plant has 3 stems on an average. Flower heads are 15 cm long.

The other species, *Arundinella nepalensis*, is smaller, with stems upto 1 m in length. Leaves are 15 - 30 cm long.

A drawing of *Arundinella nepalensis*, is given in figure 34-2-6.

Common names are: *ullu*, *bimosia* and *daabo*.

At stage 4, the average density of plant cover is about 50 percent.

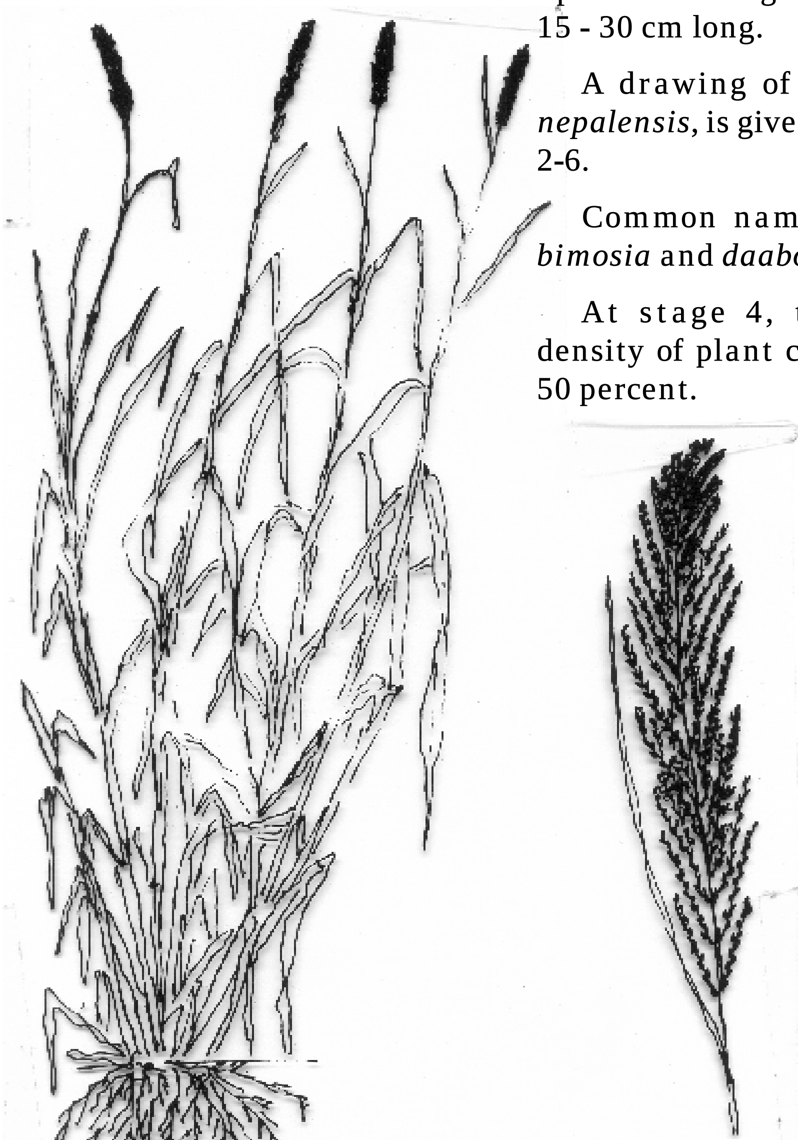


Figure 34-2-6. *Arundinella nepalensis*

State 5

Themeda is characteristic of the highest stage of grass cover (stage 5). After achieving this stage, the support area will gradually be taken over by forest if protection is continued.

Themeda plants have an average of about 8 stems per plant. The basal diametre of the plants is about 2.5 cm. Stems are between 40 and 120 cm long. Leaves are 20-30 cm long, and soft to touch. The flowers are borne in small bunches along the upper part of the stem. A diagram is given in figure 34-2-7.

Figure 34-2-7. *Themeda anathera*

Date: ....

Code : Fuel 1
Month: December

EXERCISE 35

ESTIMATING FUEL CONSUMPTION - 1

INTRODUCTION

In this exercise we will estimate the consumption of fuel in our study village in one day in the month of December, that is in the winter. To estimate this we will actually weigh the amount of fuel consumed in our assigned household. Here we will only measure those fuels which we obtain from our village ecosystem – wood, dung cakes and crop residues.

REQUIREMENTS

Spring balance, 50 kg capacity – one (all teams will share)

Gunny bag – one for each team

PROCEDURE

1. Each team should visit its assigned household, that is, the household that was assigned in class six.

2. Request the woman of the house to make a pile of the fuel equal to that which she expects to burn today. If she is expecting to burn more than one type of fuel (such as wood, dung cake, crop residues) then ask her to make a separate pile for each type. Weigh these separately. Wood and crop residues can be tied in bundles for weightment. Put dung cakes in a gunny bag and weigh the bag. Remember to take the weight of the empty gunny bag. Deduct the weight of the gunny bag from the total weight of dung cake plus gunny bag.

   Write the weights below.

   Fuel consumed in a day in the month of December:

   Dung cakes = ...kg
   Wood = ...kg
   Crop residues = ...kg

FOR THE TEACHER

Take up Box 35-1 after the completion of this exercise.

3. Enter your figures in Table 35-1 in the appropriate row. Exchange data with other teams and complete the table.

Table 35-1. Average daily consumption of different types of fuel per household in the month of December

Team No.	Name of head of assigned household	Fuel consumed in the day of visit, kg			
		Dung cakes	Wood	Crop residues	Total
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
Total					
Average					

4. Note below the average consumption of fuel per household per day in the month of December (from the last line of Table 35-1).

Dung cake	= ....kg
Wood	= ....kg
Crop residue	= ....kg
Total	= ....kg

5. To calculate the total consumption of fuel in the village in a day in the month of December, multiply the consumption of different types of fuel per household per day by the total number of households in the village, as:

Average consumption of dung cakes per household per day	x	Total number of households in the village	= ....kg
Average consumption of wood per household per day	x	Total number of households in the village	= ....kg
Average consumption of crop residues per household per day	x	Total number of households in the village	= ....kg
Total			= ....kg

6. Consumption of fuel varies with season. In winter, consumption is more compared to summer. The method of calculating fuel consumption in the winter can be applied for the summer. Ask the members of your assigned household to make piles of the fuel she will burn in one day during the month of June, each pile representing the amount she expects to burn. Weigh these piles and write the results below :

Dung cake	= ....kg
Wood	= ....kg
Crop residue	= ....kg

7. Enter your figures in Table 35-2 in the appropriate row. Exchange data with other teams and complete the table.

Table 35-2. Average daily consumption of different types of fuel per household in the month of June

Team No.	Name of head of assigned household	Fuel consumed, kg			
		Dung cakes	Wood	Crop residues	Total
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
Total					
Average					

8. Note below the average consumption of fuel per household per day in the month of June (from the last line of Table 35-2)

Dung cake	= ....kg
Wood	= ....kg
Crop residue	= ....kg
Total	= ....kg

9. To calculate the total consumption of fuel in the village in a day in the month of June, multiply the consumption of different types of fuel per household per day by the total number of households in the village.

Average consumption of dung cakes per household per day	x	Total number of households in the village	= ....kg
Average consumption of wood per household per day	x	Total number of households in the village	= ....kg
Average consumption of crop residues per household per day	x	Total number of households in the village	= ....kg
Total			= ....kg

10. Average the figures for total village consumption of fuel on one day in December and on one day in June. Multiply this average figure by 365 to obtain the amount of fuel consumed by the village in one year.

Write your answer here: .... kg/year

QUESTIONS

Answer the following questions with the help of the members of your assigned household:

1. What type of wood was burned on the day of your visit? That is, from what types of tree/shrub was it obtained?

2. In your opinion, what is the best type of fuelwood? Why? Consult the members of your assigned household for their opinion as well.

3. Ask the members of your assigned household, if they will burn dung cakes as fuel if there is sufficient fuelwood available.

4. If dung is not be used as fuel then where does it go? How does the burning or not burning of dung affect the village ecosystem?

5. Does your assigned family have a fuel efficient *chulha*? What are the advantages of this type of *chulha*?

Teacher's signature:....................

Date:...................

BOX 35-1

HOW TO BUILD A FUEL-EFFICIENT *CHULHA*

Smoke from the *chulha* is irritating to the eyes and lungs, especially for those doing the cooking. With a properly-made smokeless *chulha*, the smoke goes outside and does not collect in the room. This means greater comfort for everyone.

Also, a properly-built *chulha* can reduce a family's fuelwood consumption. A smokeless *chulha* is more efficient than an open one. This means that with less wood, the same amount of cooking and heating can be done.

Here is a general view of a smokeless *chulha*.

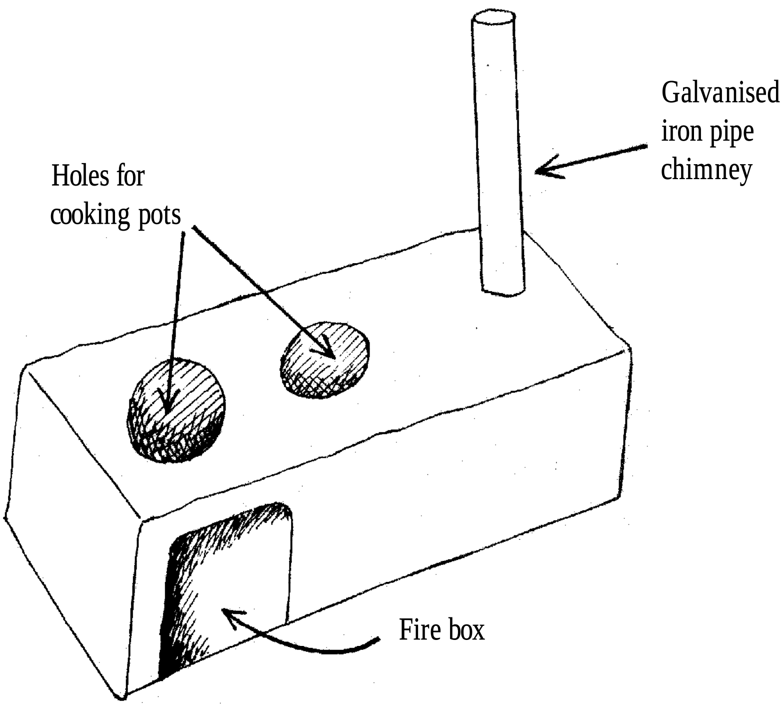


Figure 35-1-1. Over view of smokeless chulha

It is made of stones, bricks, clay, dung and straw.

The internal structure and dimensions of the *chulha* are shown in the following two diagrams.

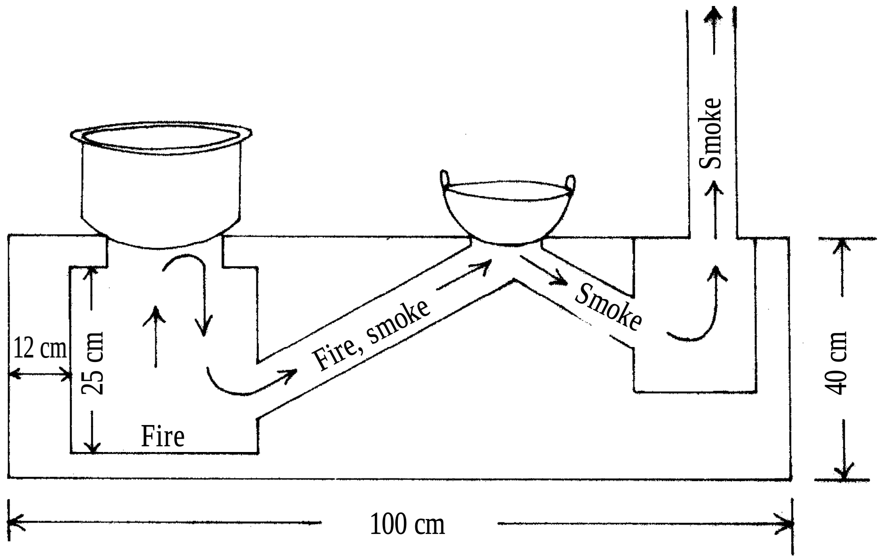


Figure 35-1-2. Front view of *chulha*

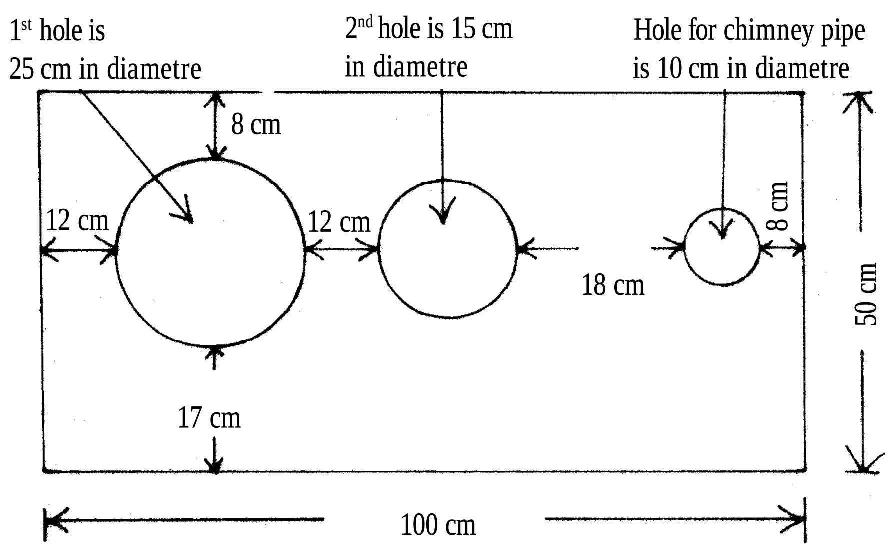


Figure 35-1-3. Top view of *chulha*

In a *chulha* made like this the smoke goes out of the house through the chimney. There may be a little leakage of smoke from the entrance to the fire box on starting the fire, but there should be none when the chulha is warm. The cooking holes should be made to fit the household cooking utensils (*patelas*, *kadais* and *tawa*) exactly, otherwise there may be leakage of smoke from the cooking holes. The dimensions given in the drawing are averages and only indicate the approximate size. The chimney must be cleaned periodically, otherwise smoke will come out from the entrance to the fire box. This may be done with a long stick, standing on the roof.

The reasons a smokeless *chulha* is more efficient than an ordinary one are mainly the following.

1. Cooking is done simultaneously in two vessels. Cooking must be planned so no hole is left idle. Water can be heated on an idle hole. Incidentally, both holes should have tin covers which can be place over them in case there is temporarily no vessel to put on them. If a hole is left uncovered, smoke will come out into the room.
2. In the front view of Figure 35-1-2, we see by the arrows the pathway that the smoke must take to get out of the *chulha*. It is essential to follow this design exactly, otherwise the *chulha* will not be fuel-efficient. If the *chulha* is built like the one shown in the Figure 35-1-4, its efficiency will be much lower than one made as shown in Figure 35-1-2.

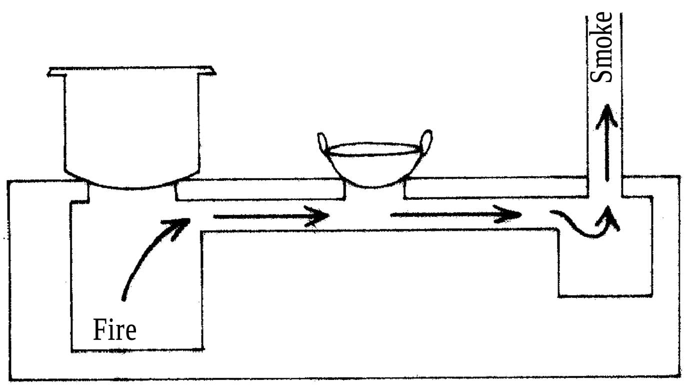


Figure 35-1-4. Front view of incorrectly-made *chulha*

In Figure 35-1-4 the fire and smoke race directly to the chimney. Much of the heat from the combustion of the wood is carried up the chimney. In a properly-designed *chulha* Figure 35-1-2, the fire and smoke first of all rise in the fire box, and then must turn downwards to enter the passage to the second hole. In doing so, additional heat is left in the fire box to heat the first vessel more quickly. Then the stream of fire and smoke rises again, striking the bottom of the second vessel at an angle, imparting more heat to it than in the case of the incorrectly-made *chulha*.

It is important to make a box under the chimney, as shown in Figure 35-1-2. The soot (*kalikh*) that falls down the chimney has a place to collect where it will not impede the exit of the smoke. Of course, we must remove this soot from time to time by reaching into the chimney box through the second hole. We can do this every time we clean the chimney pipe.

Now let us look at the chimney. We can use a galvanised iron (GI) pipe made from 20-22 gauge GI sheets. A 10 cm diameter pipe is about right for a *chulha*. GI pipes come in 1 m lengths. Join the number of GI pipes to get the required length as shown in the Figure 35-1-5a.

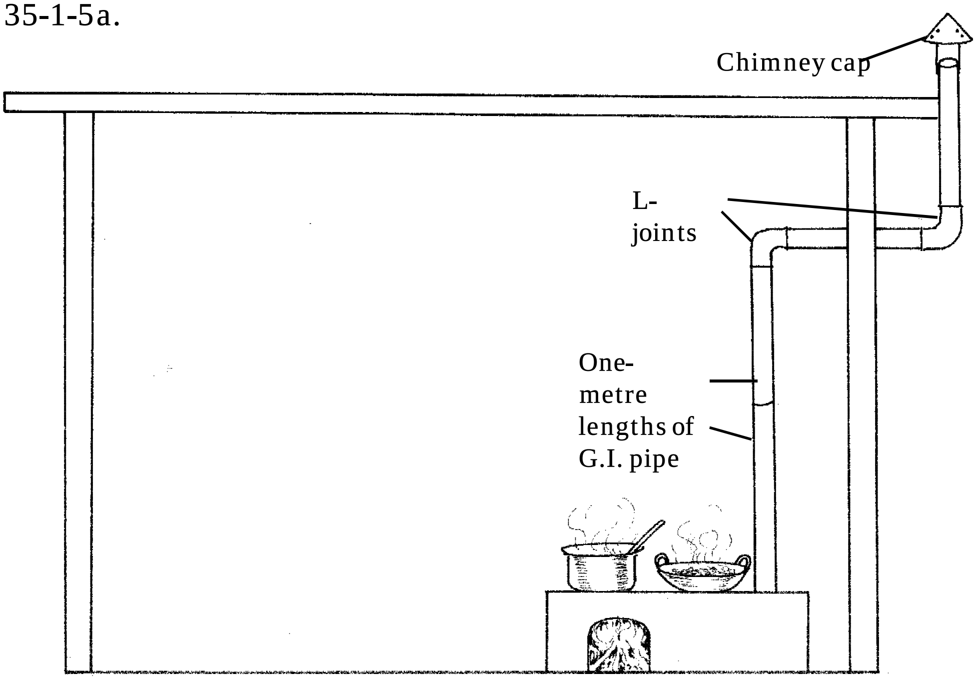


Figure 35-1-5a. Details of chimney

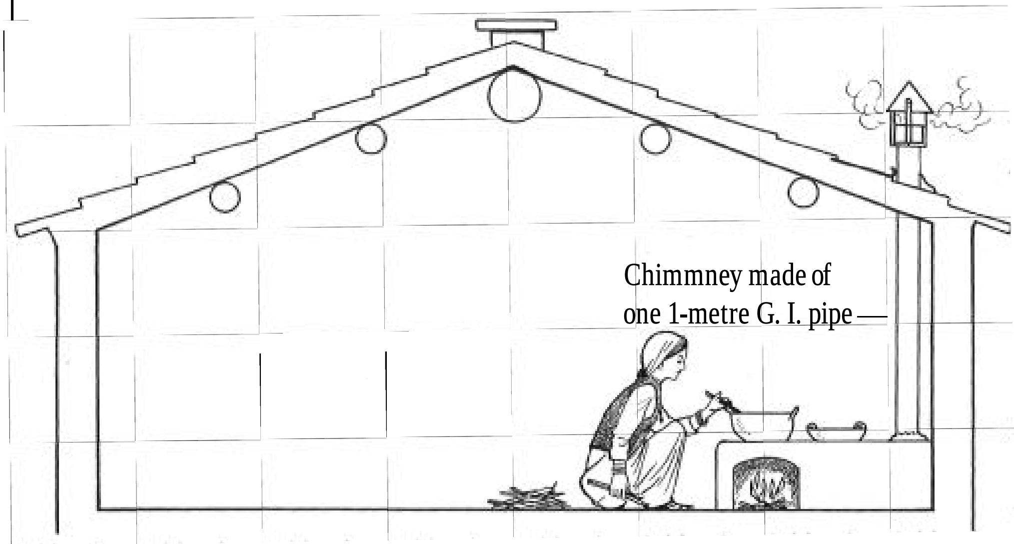


Figure 35-1-5b

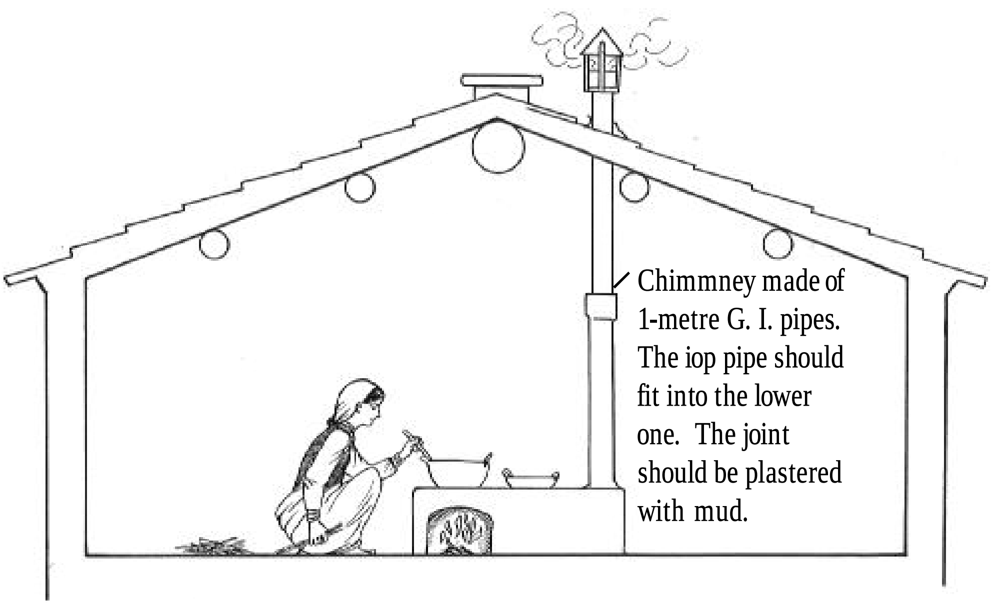


Figure 35-1-5c

In joining two pipes the top pipe must fit into the bottom one. Then, when coaltar runs down the inside of the top pipe, it will continue to run down the inside of the bottom one, and not on the outside. All joints must be tightly plastered with clay. The entire chimney should be plastered with clay from time to time to prevent rusting.

To prevent rain from entering the chimney, make a cap for it as shown in figure 35-1-6.

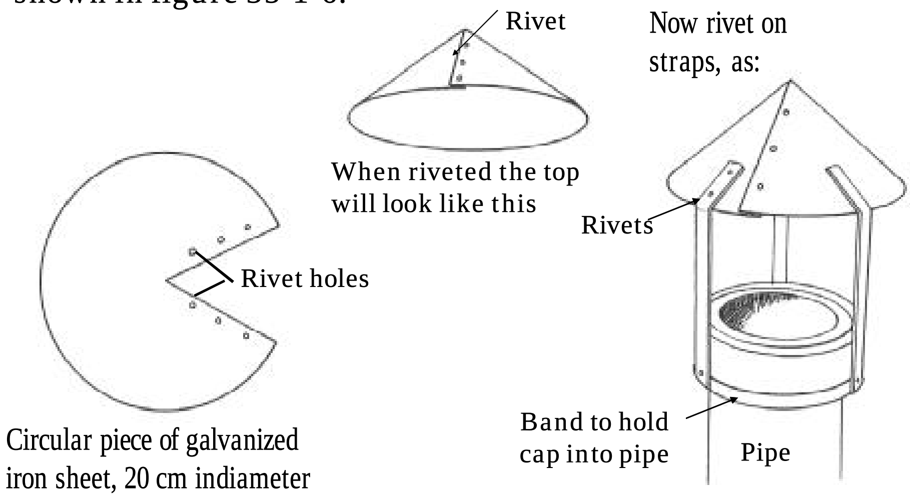


Figure 35-1-6. Details of chimney cap

From time to time it is necessary to remove the chimney cap and clean the chimney. In cleaning the chimney the soot accumulated on the inner surface will fall down and collect in the box below. Remove this collected soot with a *kurchi* (ladle), reaching through the second hole (as shown in the diagram at the right). Put this shoot in the fire box where it will burn

Points to remember

Remember, the dimensions given in the above drawing may be varied to suit the size of cooking vessels in a particular household. If the holes do not fit the household cooking pots exactly, there can be leakage of smoke, and more wood will be used than is necessary.

The *chulha* described here contains much more stone, brick and clay than an ordinary *chulha*. Therefore, it takes longer to heat up, and to cool down. Remember this when using the smokeless *chulha*. It is uneconomical of fuel to light this *chulha* for only a small amount of cooking – like making tea.

Date: ....

Code : Compost 2
Month: January

EXERCISE 36

ESTIMATING THE CONSUMPTION OF ANIMAL BEDDING

INTRODUCTION

Bedding keeps animals comfortable and clean. If animals do not have enough bedding they become wet and, in the winter they may get cold and sick. They may also may get caked with dung.

Dry bedding, in soaking up animal's urine, collects and conserves valuable plant nutrients. If we do not put enough dry bedding under the animals, nutrients are lost as the urine drains away or soaks into the earth beneath the cow house or courtyard (*angan*).

In this exercise we will actually measure the consumption of bedding per household per day in the month of December. In high altitude villages bedding is used year around, though the amount used in the summer and in the rainy seasons is less than in the winter.

REQUIREMENTS

1. Gunny bags – one bag per team
2. String – one piece for each team
3. Spring balance, 50 kg capacity – one (all team will share)

PROCEDURE

1. Each team should visit its assigned household. Request the householders to make a pile of animal bedding equal to the amount they are currently putting for their animals each day. Tie it with string and weigh it on your spring balance. Alternatively put it in a gunny bag and weigh it. Remember not to forget to deduct the weight of empty gunny bag.

FOR THE TEACHER

This exercise is to be taken up with the families assigned to the different teams in your class. Box36-1 can be taken up after completing this exercise.

Table 36-1. Average daily consumption of animal bedding per household in the month of December

Team No.	Name of head of assigned household	Animal bedding consumption in a day, kg
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
Total		
Average		

Write the weights below:

Weight of the bedding used = …………………….. kg

Enter your figure in Table 36-1 in the appropriate row. Exchange data with the other teams and complete the table.

2. Average consumption of bedding per day per household (From Table 36-1) = …………….. kg

3. To calculate the total consumption of bedding in the village in a day multiply the consumption of bedding per household per day (from 2 above) by the total number of households in the village.

Total village bedding consumption per day, kg	=	Average consumption of animal bedding per household	x	Total number of households in the village per day, kg

Total village bedding consumption per day = ……………………….. kg

QUESTIONS

Answer the following questions with the help of the members of your assigned household.

1. Looking at the cow house and the animals do you think the amount of bedding currently used is enough? If not, what do you think would be a sufficient amount?

2. If the amount of bedding is insufficient, what is the reason?

3. What type of animal bedding was being used by your assigned household on the day of the visit? In your opinion, is it good for bedding? Which is the best type of animal bedding?

4. Ask the members of your assigned household what they do with paddy straw? How does this practice affect the village ecosystem?

5. Ask the members of your assigned household what they do with the dry leaves of sugarcane? How does this practice affect the village ecosystem?

6. From the point of view of the usefulness of used bedding which do you think is better, oak or chir pine leaves? Why?

Teacher's signature:....................

Date:....................

BOX 36-1

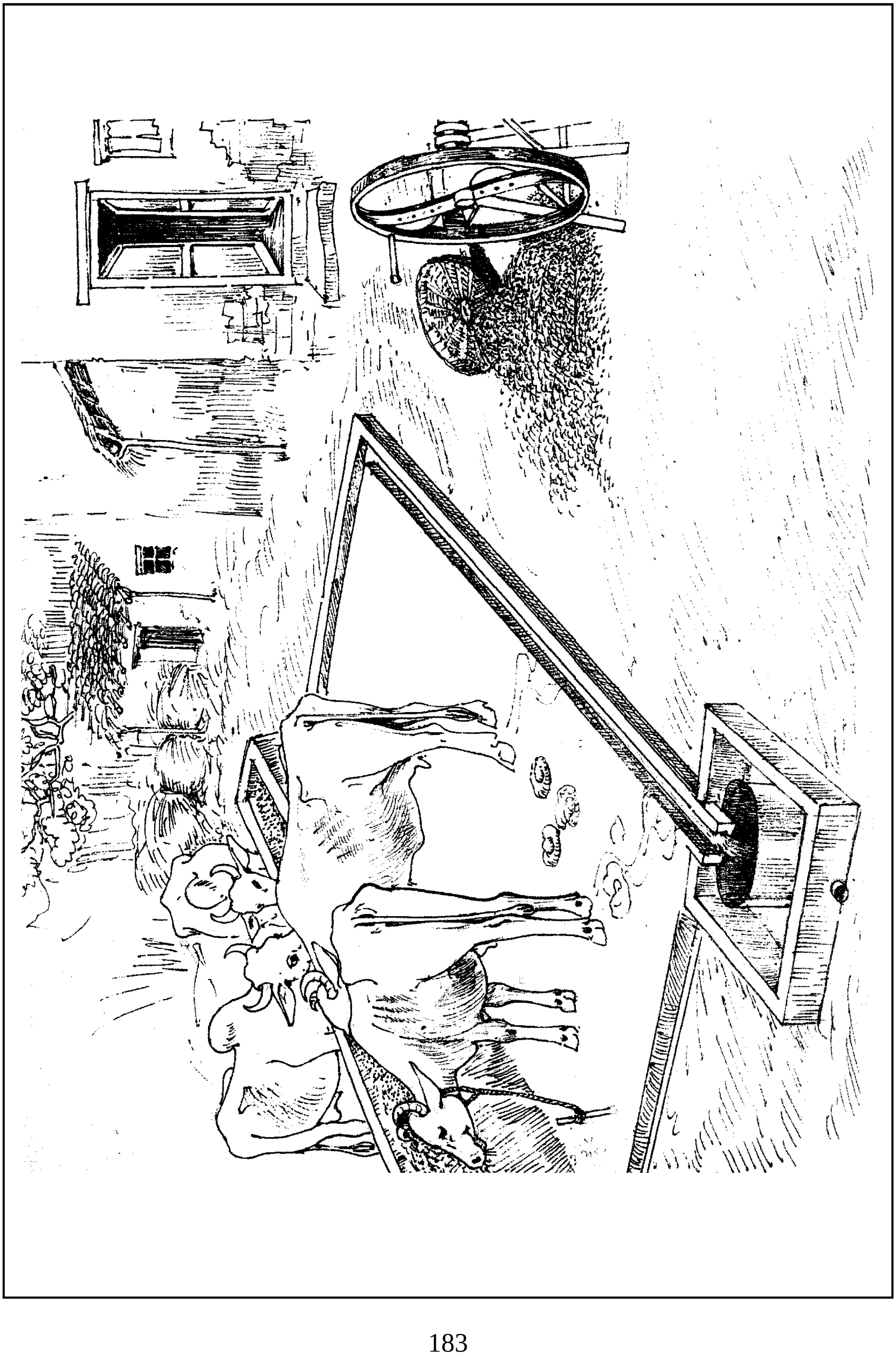
A METHOD OF COLLECTING ANIMAL URINE

For making good compost animal urine is an essential ingredient. Animal bedding soaks up the urine and transfers it to the compost pile. A cow produces about 10 liters of urine every day and a buffalo 20 liters. If all this urine goes into the compost pile it ensures sufficient moisture in the pile and conserves the nutrients which are essential for our crops.

At present much of the animal urine produced does not go to the compost pile because in the summer we may not use bedding. And in the winter we tie our animals in the *angan* during the day time without bedding.

If the floors of our *angan* and cow house are not *pucca* most of the urine produced soaks into the earth and is lost.

To collect all urine it is essential that the floor of the place where we tie our animals is made *pucca*. The *pucca* area must have a proper slope and a drain leading to a collection pit, as shown in the following diagram.



WHAT WE HAVE LEARNED THIS YEAR

Answer these questions working in teams.

1. What important lesson does the story of the women of Tangsa village and Sukhomajri give us?

2. What is soil texture? How do you account for differences in soil texture in different fields?

3. What benefit can trees growing on terrace risers give?

4 What are the essential features of a smokeless chulha?

5 What is humus? How does it affect the growth of plants?

6. What is the significance of trees in the crop mixture?

7. What happens when human beings interfere in an ecosystem such as by cutting trees to make cultivated fields?

8. a) Which of the following organisms are decomposers?

(1) cow (2) earthworm (3) fungi (4) moss (5) fern?

b) What is the role of decomposers in the ecosystem?

9. Explain how greater species diversity in the village ecosystem produces greater biomass.

10. Why is *lantana* called an indicator species?

11. What are the principles of making crop mixtures?

12. Why it is said, “To get good crop yields we have to feed our soil properly”?

13. What are the various methods of recycling crop residues?

14. Describe the niches of domestic animals in the village ecosystem.

15. What do you think is the most important thing we can learn from in the experiences of Shoor Vir Singh?

16. What are the environmental problems of cities and villages, and how are they related? Explain this with two examples.

Teacher's signature:....................

Date:....................

WELCOME

WORK DISPLAY DAY

CLASS EIGHT

TOPICS FOR DISPLAY

It is now time for your annual work display day when you will display this year's work for your parents and the residents of your study village. The display will be organised in the same way as in classes six and seven. Here are the topics for the display.

1. Seedling production plan for barren land rehabilitation project: Present charts listing different types of trees selected for each parts of project area. Explain why these types have been selected. Also display charts showing numbers of each type of seedlings to be raised, time of planting seeds for different types of tree, and methods of planting. Put separate labels on each class's part of the nursery, as well as your own part which you are displaying (Exercise 25 and Box 25-1).

2. Tree management for wood: Charts (live specimens if possible) showing how to manage trees and shrubs for fuelwood production should be displayed. Explain the advantages of the pollarding method of fuelwood production. List the trees and shrubs which pollard, and trees and shrubs which are shade-tolerant. Explain why mixtures of trees are healthier. Describe procedures for establishing a fuelwood stand and the management of existing trees (Boxes 28-1, 28-2 and 28-3).

3. Soil texture: Explain what soil texture is. Display with labels, samples of soils with different textures. Demonstrate the method of soil particle analysis. (Also prepare some bottles one week in advance and label the different layers.) Explain with charts, the relation of soil texture to crop yield. Present data for your own analysis with labels indication texture. (Box 32-1, Exercise 32)

4. Feeding our soil: Make drawings and display live specimens of living beings in the soil. What do living organisms do in the soil? Explain what humus is and what it does. Explain the role of mycorrhizae in plant growth and health with diagrams on chart

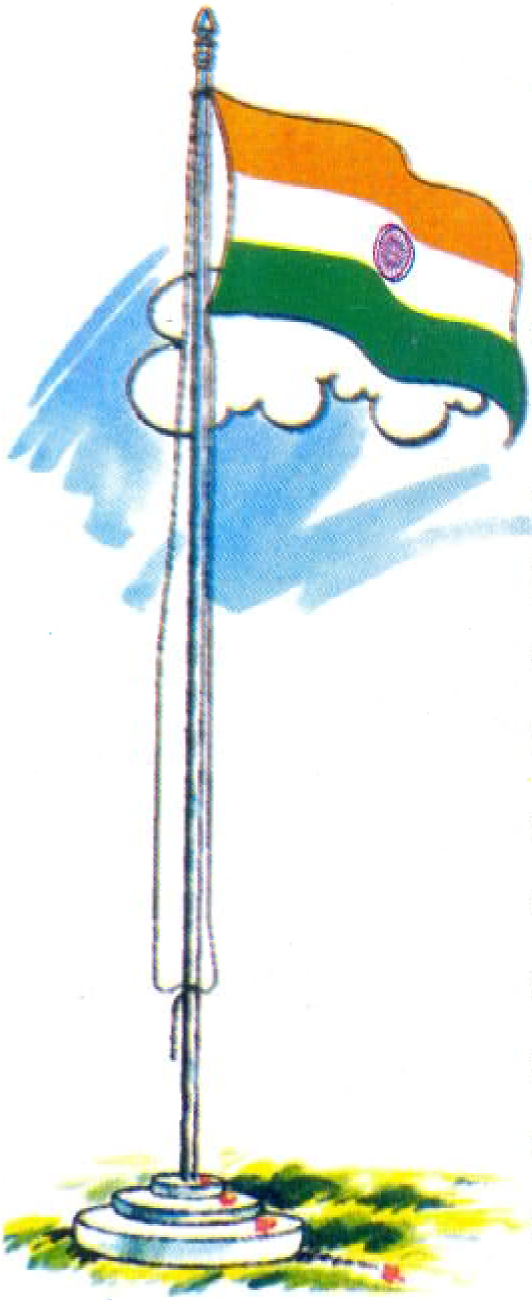
paper. Describe nitrogen fixation by legumes with drawings and live plants (uproot a bean or pea plant from your kitchen garden) (Box 26-1).

5. How to make good compost: Demonstrate on a small scale with materials brought from home (i.e., cow-house waste, soil, ash, kitchen waste and animal urine) the best way to make compost. Show drawing of complete piles. Explain the importance of adding soil, ash, and urine. Also explain why the pile must be kept moist in the dry season and why it must be thatched in the rainy season. Display samples of good compost (start preparing this at home three-four months in advance). (Box 26-2).

6. Biomass recycling: Explain the necessity for recycling all available biomass produced from the fields. Explain the different ways of biomass recycling: mulch, compost (animal bedding and fodder), natural leaf fall from trees, wood ash and human waste. Make a flow diagram on chart paper. Display with charts the results of Exercise 26. Give your suggestions how to increase recycling in your study village. (Boxes 26-1 and26-2)

7. Principles of mixed cropping: Explain with charts the benefits of mixed crops over single-species crops and the principles of forming crop mixtures. (Exercises 11 and 31, Boxes 11-1 and 31-1). Possible new mixtures (Take examples from Box 31-1).

8. Management of fruit trees: Explain the importance of mixed cropping in orchards. Describe the management of orchards. Give examples of mixtures (Box 31-3).



राष्ट्रगान

जन–गण–मन–अधिनायक जय हे।
भारत भाग्य विधाता।।
पंजाब सिंधु गुजरात मराठा।
द्राविड़ उत्कल बंग।।
विंध्य हिमाचल यमुना–गंगा,
उच्छल जलधि तरंग।।
तव शुभ नामे जागे,
तव शुभ आशिष माँगे।।
गाहे तव जय गाथा।।
जन–गण–मंगलदायक जय हे,
भारत भाग्य विधाता।।
जय हे, जय हे, जय हे,
जय जय जय जय हे।।