Introduction to Major Field Crops

NRM 123

Practical Manual




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Preface

India has a diverse geographic area ranging from the Himalayas to its North, the Thar desert to its West, the Gangetic Delta to its East, and the Deccan Plateau to the South. The presence of diverse agro-climatic conditions enables the cultivation of various crops, including cereals (rice, wheat, maize, barley, oats) and millets (sorghum, pearl millet, finger millet, and other minor millets) pulses (chickpea, field pea, urd, moong, etc.), and oilseeds (soybean, groundnut, rapeseed & mustard, etc.).

The country is an agrarian economy in which the agriculture sector accounts for 18.8 percent of India's Gross Domestic Product and employs more than 50 percent of the total workforce. India is the world's largest producer of pulses, and jute, and ranks as the second-largest producer of rice, wheat, sugarcane, groundnut, vegetables, fruit, and cotton. It is also one of the leading producers of spices, fish, poultry, livestock, and plantation crops.

As of today, India supports 16.8% of the world's population 4.2% of the world's water resources, and 2.3% of global land. The per capita availability of resources is about 4 to 6 times less compared to the world average. This will decrease further due to increasing demographic pressure and consequent diversion of the land for non-agricultural uses.

While agriculture in India has achieved grain self-sufficiency but the production is, resource-intensive, cereal-centric, and regionally biased. The resource-intensive ways of Indian agriculture have raised serious sustainability issues too. Crop diversification by including different crops like millets, pulses, and oilseeds in various cropping systems could enhance crop productivity and strengthen resilience against changing climatic scenarios.

This manual has been prepared for the second-semester students of B.Sc. (Hons.) Horticulture according to the recommendation of the Fifth Dean's Committee Report. The manual comprises the identification of various economically important field crops: Cereals, pulses, and oilseeds, available herbicides, tools, and equipment for weed control, and an understanding of the main cropping system of the region.

Date: **(Sunil Kumar Chongtham)**

Acknowledgement

It gives me immense pleasure to avail myself this opportunity to express my immense sense of gratitude to Dr. A.K. Pandey, Dean of the College of Horticulture, Central Agricultural University (Imphal), Bermiok, South Sikkim, for his kind support in bringing out of this practical manual.

I express my heartfelt thanks to the college library for providing the necessary information and books for preparing this manual.

I am highly grateful to the PME cell and Dean, College of Horticulture, CAU (Imphal), Bermiok, South Sikkim for overall support to produce the manual.

I shall consider my efforts successful and worthwhile if the practical manual serves the main objective for which it has been prepared. Also, I would be delighted to receive suggestions/feedback for further improvement of the manual.

Prof. Anupam Mishra
Vice Chancellor

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FOREWORD

Our country has varied climatic conditions ranging from arid desert in the west, alpine tundra and glaciers in the north, and humid tropical regions supporting rainforests in the southwest and the island territories. Diverse climatic conditions in the country favour the cultivation of various field crops, including cereals, pulses, and oilseeds.

Agriculture is the main source of supporting livelihood for about 60% of the Indian population. However, the productivity of crops is much lower than in many countries, requiring significant enhancement to produce about 400 million tonnes of food grains for fulfilling the food demands of a population of 1.7 billion by 2050. Crop diversification along with large-scale adoption of improved agronomic practices could sustain high crop production with minimum environmental degradation. Understanding the nature of crops and inclusion in the cropping system as per the suitability of the local condition will help in boosting crop productivity while securing food, nutritional, and economic security.

This manual has been prepared to aid students and other users in identifying and understanding various field crops, the selection of appropriate herbicides, the computation of their dose and application with appropriate tools and equipment and comprehending the major cropping systems of the region. I extend my heartfelt congratulation to the author for developing this manual in the interest of students, teachers, readers, and all those involved in crop production.

(Anupam Mishra)

CERTIFICATE

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CONTENT

Practical No. 1 Identification of major field crops in India

Objective : To identify major field crops

S.No.	Crop Name	Botanical Name	Family
A. Cereals			
i.	**Major cereals**		
1	Paddy	*Oryza sativa*	Gramineae/Poaceae
2	Wheat	*Triticum aestivum*	Gramineae/Poaceae
3	Maize	*Zea mays*	Gramineae/Poaceae
4	Barley	*Hordeum vulgare*	Gramineae/Poaceae
ii.	**Millets**		
	a. Major millets		
5	Sorghum/Jowar	*Sorghum bicolor*	Gramineae/Poaceae
6	Bajra/Pearl millet	*Pennisetum glaucum*	Gramineae/Poaceae
7	Finger millet	*Eleusine coracana*	Gramineae/Poaceae
	b. Minor millets		
8	Foxtail millet	*Setaria italica*	Gramineae/Poaceae
9	Kodo millet	*Panicum sumatrense / P. miliare*	Gramineae/Poaceae
10	Little millet	*Panicum millare*	Gramineae/Poaceae
11	Proso millet	*Panicum miliaceum*	Gramineae/Poaceae
12	Barnyard millet	*Echinochloa frumentacea*	Gramineae/Poaceae
B. Pulses			
1	Pigeon pea/Arhar /Tur/Red gram	*Cajanus cajan*	Leguminoseae/Fabaceae
2	Green gram	*Phaseolus aureus / Vigna radiata*	Leguminoseae/Fabaceae
3	Black gram	*Phaseolus mungo / Vigna mungo*	Leguminoseae/Fabaceae
4	Moth bean	*Phaseolus aconitifolius*	Leguminoseae/Fabaceae
5	Cowpea	*Vigna sinensis*	Leguminoseae/Fabaceae
6	Horse gram	*Macrotyloma uniflorum*	Leguminoseae/Fabaceae
7	Chickpea	*Cicer arietinum*	Leguminoseae/Fabaceae
8	Lentil	*Lens esculenta*	Leguminoseae/Fabaceae
C. Oilseeds			
1	Groundnut	*Arachis hypogaea*	Leguminoseae/Fabaceae
2	Sesame	*Sesamum indicum*	Pedaliaceae
3	Niger	*Guizotia abyssinica*	Asteraceae
4	Sunflower	*Helianthus annus*	Compositae
5	Soybean	*Glycine max*	Leguminoseae/Fabaceae
6	Rapeseed and mustard	*Brassica* spp.	Cruciferae
7	Cotton	*Gossypium hirsutum*	Malvaceae
8	Castor	*Ricinus communis*	Euphorbiaceae
9	Linseed/Flax	*Linum usitatisium*	Linaceae
D. Forage crops			
1	Cowpea	*Vigna sinensis*	Leguminoseae/Fabaceae
2	Stylo	*Stylosanthes hamata*	Leguminoseae/Fabaceae
3	Rice bean	*Phaseolus calcaratus / Vigna umbellata*	Leguminoseae/Fabaceae
4	Para grass	*Brachiaria mutica*	Gramineae/Poaceae
5	Maize	*Zea mays*	Gramineae/Poaceae

6	Sorghum/Jowar	*Sorghum bicolor*	Gramineae/Poaceae
7	Guinea	*Panicum maximum*	Gramineae/Poaceae
8	Bajra/Pearl millet	*Pennisetum glaucum*	Gramineae/Poaceae
E. Fibre crops			
1	Cotton	*Gossypium* spp.	Malvaceae
2	Jute	*Corchorus* spp.	Tiliaceae
3	Sunnhemp	*Crotolaria juncea*	Leguminoseae/Fabaceae
4	Ramei	*Boehmeria nivea*	Urticaceae
5	Roselle	*Hibiscus sabdariffa*	Malvaceae
F. Sugar crops			
1	Sugarcane	*Sachharum officianarum*	Graminae/Poaceae
2	Sugarbeet	*Beta vulgaris*	Chenopodiaceae
G. Commercial crops			
1	Potato	*Solanum tuberosum*	Solanaceae
2	Tobacco	*Nicotiana* spp.	Solanaceae
3	Chilli	*Capscicum annum*	Solanaceae
4	Sugarcane	*Sachharum officianarum*	Graminae/Poaceae
5	Jute	*Corchorus* spp.	Tiliaceae
H. Green manure crops			
i.	***In situ* green manure crops**		
	a. Leguminous green manure crops		
1	Sunnhemp	*Crotolaria juncea*	Leguminoseae/Fabaceae
2	Dhaincha	*Sesbania aculeata*	Leguminoseae/Fabaceae
3	Green gram	*Phaseolus aureus / Vigna radiata*	Leguminoseae/Fabaceae
4	Black gram	*Phaseolus mungo / Vigna mungo*	Leguminoseae/Fabaceae
5	Horse gram	*Macrotyloma uniflorum*	Leguminoseae/Fabaceae
6	Cowpea	*Vigna sinensis*	Leguminoseae/Fabaceae
7	Wild indigo	*Tephrosia purpurea*	Leguminoseae/Fabaceae
	b. Non-leguminous green manure crops		
1	Maize	*Zea mays*	Gramineae/Poaceae
2	Sorghum/Jowar	*Sorghum bicolor*	Gramineae/Poaceae
3	Oat	*Avena sativa*	Gramineae/Poaceae
4	Bajra/Pearl millet	*Pennisetum glaucum*	Gramineae/Poaceae
ii.	***Ex situ* green manure crops/ Green leaf manure crops**		
	a. Leguminous green manure crops		
1	Glyrcidia	*Glyricidia maculata*	Leguminoseae/Fabaceae
2	Subabul	*Leucaena leucocephala*	Leguminoseae/Fabaceae
3	Agase	*Sesbania grandiflora*	Leguminoseae/Fabaceae
4	Pongamia	*Pongamia glabra*	Leguminoseae/Fabaceae
5	Cassia	*Cassia siamea*	Leguminoseae/Fabaceae
	b. Non-leguminous green manure crops		
6	Neem	*Azadirachta indica*	Meliaceae
7	Pride of India	*Melia azedarach*	Meliaceae

Practical No. 2 Identification of major *Kharif* cereal crops

Objective **:** To identify major *Kharif* cereal crops
Materials required **:** Cereal crop plants in the field for identification

A large number of cereal crops or varieties are grown in India. Many of these crops have great morphological similarities in their seeds and plants, although they belong to different taxonomic groups. Varieties also differ from each other in plant and seed characteristics. Therefore, it is necessary to identify these crops on the basis of the morphological characteristics, which are given below:

Important morphological characteristics

Leaf	:	Colour, size, shape, arrangement
Stem	:	Colour, size, nature (erect, prostrate, angular trailing, etc.) nodes and internodes, solid, hollow, woody, tender
Branch	:	Branched, unbranched, pattern and arrangement
Flower	:	Colour, size, type of inflorescence
Root	:	Shallow, deep, tap root, adventitious, root colour, rhizomes, ground parts: nuts, bulb, etc.
Juncture point	:	Note the colour, shape, and size of any plant part like hair, ligule, auricle, glands etc. present at the joining point of the stem with root, leaf with stem, inflorescence with the main stem / branch etc.
Fruit/Seed	:	Colour, size, shape
Special points	:	Nature of plant sap (milky, juicy, gum, etc.) and its colour, special modification on the plan,t etc.

Note down the important characteristics of major *Kharif* cereal crops (Rice, Maize, Sorghum, Bajra, Ragi, Foxtail millet):

Leaf	:
Stem	:
Branch	:
Flower	:
Root	:
Juncture point	:
Fruit/Seed	:

Special points :

Plant

Seed

Rice

Plant

Seed

Maize

Plant

Seed

Sorghum

Plant

Seed

Pearl millet

Plant

Seed

Finger millet

Plant

Seed

Foxtail millet

Fig. 2. Different types of cereal crops grown during *Kharif* season

Practical No. 3 Identification of major *Rabi* cereal crops

Objective **:** To identify major *Rabi* cereal crops
Materials required **:** Cereal crop plants in the field for identification

A large number of cereal crops or varieties are grown in India. Many of these crops have great morphological similarities in their seeds and plants, although they belong to different taxonomic groups. Varieties also differ from each other in plant and seed characteristics. Therefore, it is necessary to identify these crops on the basis of the morphological characteristics, which are given below:

Important morphological characteristics

Leaf	:	Colour, size, shape, arrangement
Stem	:	Colour, size, nature (erect, prostrate, angular trailing, etc.) nodes and internodes, solid, hollow, woody, tender
Branch	:	Branched, unbranched, pattern and arrangement
Flower	:	Colour, size, type of inflorescence
Root	:	Shallow, deep, tap root, adventitious, root colour, rhizomes, ground parts: nuts, bulb, etc.
Juncture point	:	Note the colour, shape, and size of any plant part like hair, ligule, auricle, glands etc. present at the joining point of the stem with root, leaf with stem, inflorescence with the main stem / branch etc.
Fruit/Seed	:	Colour, size, shape
Special points	:	Nature of plant sap (milky, juicy, gum, etc.) and its colour, special modification on the plan,t etc.

Note down the important characteristics of major *Rabi* cereal crops (Wheat, Barley, Oat):

Leaf	:
Stem	:
Branch	:
Flower	:
Root	:
Juncture point	:
Fruit/Seed	:
Special points	:

Plant

Seed

Wheat

Plant

Seed

Barley

Plant

Seed

Oat

Fig. 3. Different types of cereal crops grown during *Rabi* season

Practical No. 4 Identification of major *Kharif* pulse crops

Objective **:** To identify major *Kharif* pulse crops
Materials required **:** Pulse crop plants in the field for identification

A large number of pulse crops or varieties are grown in India. Many of these crops have great morphological similarities in their seeds and plants, although they belong to different taxonomic groups. Varieties also differ from each other in plant and seed characteristics. Therefore, it is necessary to identify these crops on the basis of the morphological characteristics, which are given below:

Important morphological characteristics

Leaf	:	Colour, size, shape, arrangement
Stem	:	Colour, size, nature (erect, prostrate, angular trailing, etc.) nodes and internodes, solid, hollow, woody, tender
Branch	:	Branched, unbranched, pattern and arrangement
Flower	:	Colour, size, type of inflorescence
Root	:	Shallow, deep, tap root, adventitious, root colour, rhizomes, ground parts: nuts, bulb, etc.
Juncture point	:	Note the colour, shape, and size of any plant part like hair, ligule, auricle, glands etc. present at the joining point of the stem with root, leaf with stem, inflorescence with the main stem / branch etc.
Fruit/Seed	:	Colour, size, shape
Special points	:	Nature of plant sap (milky, juicy, gum, etc.) and its colour, special modification on the plan,t etc.

Note down the important characteristics of major *Kharif* pulse crops (Green gram, Black gram, Cowpea, Pigeonpea, Cluster bean):

Leaf	:
Stem	:
Branch	:
Flower	:
Root	:
Juncture point	:
Fruit/Seed	:
Special points	:

Plant

Seed

Green gram

Plant

Seed

Black gram

Plant

Seed

Pigeonpea

Plant

Seed

Cowpea

Plant

Seed

Cluster bean

Fig. 4. Different types of pulse crops grown during *Kharif* season

Practical No. 5 Identification of major *Rabi* pulse crops

Objective : To identify major *Rabi* pulse crops
Materials required : Pulse crop plants in the field for identification

A large number of pulse crops or varieties are grown in India. Many of these crops have great morphological similarities in their seeds and plants, although they belong to different taxonomic groups. Varieties also differ from each other in plant and seed characteristics. Therefore, it is necessary to identify these crops on the basis of the morphological characteristics, which are given below:

Important morphological characteristics

Leaf	:	Colour, size, shape, arrangement
Stem	:	Colour, size, nature (erect, prostrate, angular trailing, etc.) nodes and internodes, solid, hollow, woody, tender
Branch	:	Branched, unbranched, pattern and arrangement
Flower	:	Colour, size, type of inflorescence
Root	:	Shallow, deep, tap root, adventitious, root colour, rhizomes, ground parts: nuts, bulb, etc.
Juncture point	:	Note the colour, shape, and size of any plant part like hair, ligule, auricle, glands etc. present at the joining point of the stem with root, leaf with stem, inflorescence with the main stem / branch etc.
Fruit/Seed	:	Colour, size, shape
Special points	:	Nature of plant sap (milky, juicy, gum, etc.) and its colour, special modification on the plan,t etc.

Note down the important characteristics of major *Rabi* pulse crops (Bengal gram, Pea, Lentil):

Leaf	:
Stem	:
Branch	:
Flower	:
Root	:
Juncture point	:
Fruit/Seed	:
Special points	:

Plant

Seed

Bengal gram

Plant

Seed

Pea

Plant

Seed

Rajmash

Plant

Seed

Lentil

Fig. 5. Different types of pulse crops grown during *Rabi* season

Practical No. 6 Identification of major *Kharif* oilseed crops

Objective **:** To identify major *Kharif* oilseed crops
Materials required **:** Oilseed crop plants in the field for identification

A large number of oilseed crops or varieties are grown in India. Many of these crops have great morphological similarities in their seeds and plants, although they belong to different taxonomic groups. Varieties also differ from each other in plant and seed characteristics. Therefore, it is necessary to identify these crops on the basis of the morphological characteristics, which are given below:

Important morphological characteristics

Leaf	:	Colour, size, shape, arrangement
Stem	:	Colour, size, nature (erect, prostrate, angular trailing, etc.) nodes and internodes, solid, hollow, woody, tender
Branch	:	Branched, unbranched, pattern and arrangement
Flower	:	Colour, size, type of inflorescence
Root	:	Shallow, deep, tap root, adventitious, root colour, rhizomes, ground parts: nuts, bulb, etc.
Juncture point	:	Note the colour, shape, and size of any plant part like hair, ligule, auricle, glands etc. present at the joining point of the stem with root, leaf with stem, inflorescence with the main stem / branch etc.
Fruit/Seed	:	Colour, size, shape
Special points	:	Nature of plant sap (milky, juicy, gum, etc.) and its colour, special modification on the plan,t etc.

Note down the important characteristics of major *Kharif* oilseed crops (Groundnut, Soybean, Sunflower, Sesame, Cotton):

Leaf	:
Stem	:
Branch	:
Flower	:
Root	:
Juncture point	:
Fruit/Seed	:
Special points	:


Plant


Seed

Groundnut


Plant


Seed

Soybean


Plant


Seed

Sunflower


Plant


Seed

Sesame


Plant


Seed

Cotton

Fig. 6. Different types of oilseed crops grown during *Kharif* season

Practical No. 7 Identification of major *Rabi* oilseed crops

Objective **:** To identify major *Rabi* oilseed crops
Materials required **:** Oilseed crop plants in the field for identification

A large number of oilseed crops or varieties are grown in India. Many of these crops have great morphological similarities in their seeds and plants, although they belong to different taxonomic groups. Varieties also differ from each other in plant and seed characteristics. Therefore, it is necessary to identify these crops on the basis of the morphological characteristics, which are given below:

Important morphological characteristics

Leaf	:	Colour, size, shape, arrangement
Stem	:	Colour, size, nature (erect, prostrate, angular trailing, etc.) nodes and internodes, solid, hollow, woody, tender
Branch	:	Branched, unbranched, pattern and arrangement
Flower	:	Colour, size, type of inflorescence
Root	:	Shallow, deep, tap root, adventitious, root colour, rhizomes, ground parts: nuts, bulb, etc.
Juncture point	:	Note the colour, shape, and size of any plant part like hair, ligule, auricle, glands etc. present at the joining point of the stem with root, leaf with stem, inflorescence with the main stem / branch etc.
Fruit/Seed	:	Colour, size, shape
Special points	:	Nature of plant sap (milky, juicy, gum, etc.) and its colour, special modification on the plan,t etc.

Note down the important characteristics of major *Rabi* oilseed crops (Rapeseed and Mustard, Linseed, Safflower):

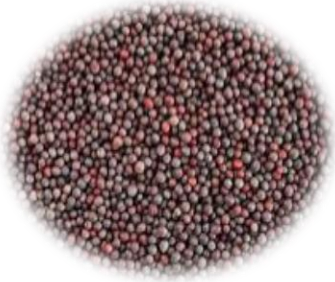
Leaf	:
Stem	:
Branch	:
Flower	:
Root	:
Juncture point	:
Fruit/Seed	:
Special points	:

Plant

Seed

Rapeseed

Plant



Seed

Mustard

Plant

Seed

Safflower

Plant

Seed

Linseed

Fig. 7. Different types of oilseed crops grown during *Rabi* season

Practical No. 8 Identification of weeds

Objective : To study different types of weeds infesting horticultural crops
Materials required : Manual, weed herbarium, pencil, eraser

Based on the morphology of the plant, the weeds are also classified into three categories. This is the most widely used classification by weed scientists.

10.1. Grasses:

All the weeds which come under the family Poaceae are called grasses which are characteristically having long narrow spiny leaves. Specific characteristics of this family are:

- They might be herbs or shrubs, annuals, or perennials.
- The roots can be fibrous, adventitious, branched, or stilt.
- The stem is cylindrical with conspicuous nodes and internodes, woody or herbaceous. It may be modified as stolons and rhizomes. (N.B.: A stolon is an underground connection between plants and it grows at or just below the soil surface while a rhizome is a root-like stem, which grows either horizontally or underground).
- The leaves are alternate, simple, and distichous. The leaf base forms a tubular sheath.
- The seeds are endospermic and monocotyledonous.
- Fruits include caryopsis, nut, and berry.

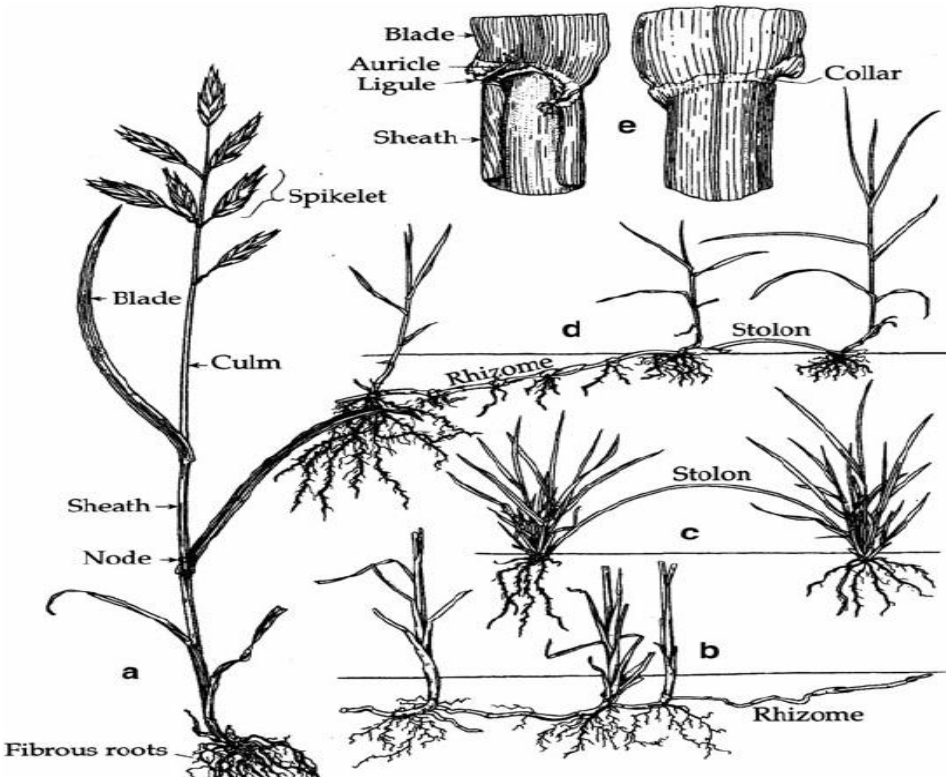


Fig.1.1. Typical structure of grasses.

10.2. Sedges:

The weeds belonging to the family Cyperaceae come under this group. The leaves are mostly from the base having modified stems with or without tubers. Specific characteristics of this family are:

- ❖ They are commonly perennial herbs rarely annual.
- ❖ The roots can be adventitious, fibrous, branched, or tuberous.
- ❖ Plants are usually herbs with 3 angled solid stems.
- ❖ Leaves are exstipulate, sessile, leaf base sheathing, sheath closed, arranged in three rows, alternate. They are simple, lamina linear, narrow, pointed, and sharply edged.
- ❖ The seeds are endospermic and monocotyledonous.
- ❖ Fruits include an achene or nut.

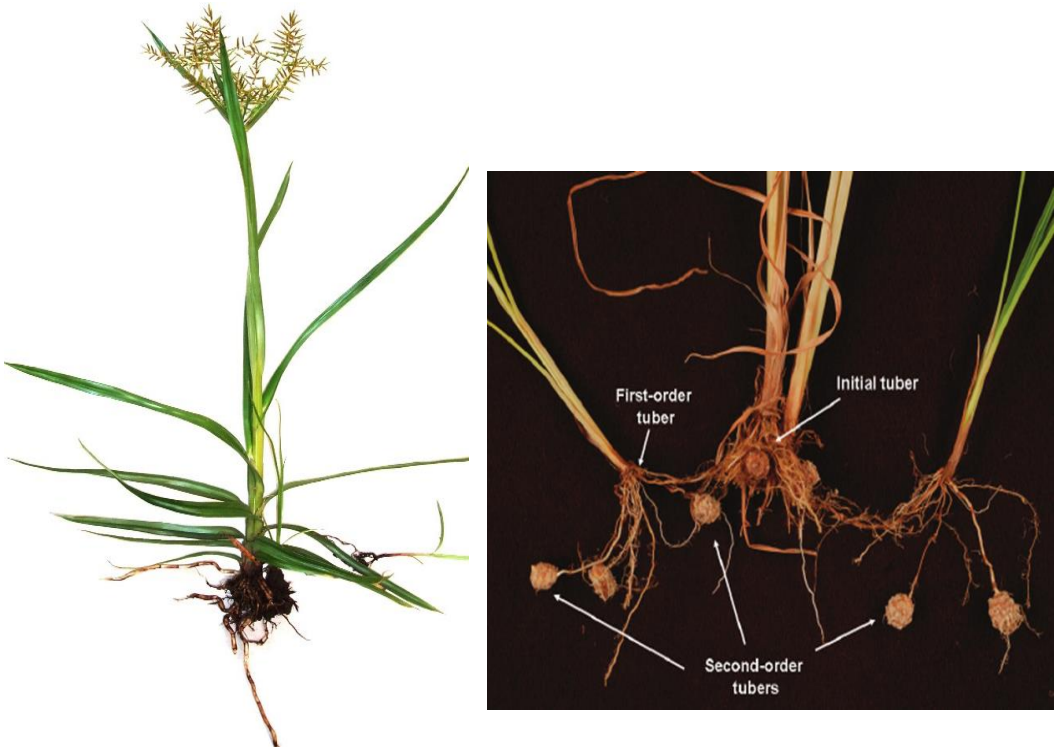


Fig.1.2. Typical structure of Cyperaceae weeds.

Difference between grasses and sedges

Sl. No.	**Sedges**	**Grasses**
1.	Leaves are deployed in a three-ranked arrangement	Leaves in a two-ranked arrangement
2.	Solid stems distinctly triangular in cross-section	Round stems, which are hollow between the nodes
3.	Family: Cyperaceae	Family: Poaceae
4.	Eg. *Cyperus rotundus*	Eg. *Cynodon dactylon*

Sedge

Grass

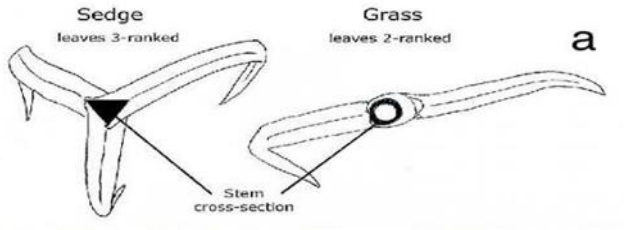


Fig. 1.3. Difference between grasses and sedges

10.3. Broad-leaved weeds:

This is the major group of weeds. All dicotyledon weeds are broad-leaved weeds. They belong to various families, including Asteraceae/Compositae, Mimosaceae, Umbelliferae, Amaranthaceae, Portulacaceae, etc. Specific characteristics of this family are:

- ❖ They can be annual, biennial, or perennial, making consistent management difficult.
- ❖ They have two seed leaves that emerge from the seed
- ❖ They have leaf veins that form a net pattern
- ❖ The floral petals are in multiples of four or five
- ❖ They have taproot system

10.4. Procedure:

- ❖ Make visual observation of the weed specimens preserved as per the previous exercise, and understand their basic characteristics.
- ❖ After locating different types of weeds again from where they are collected, study their habitat, morphology and mode of propagation.
- ❖ Take help of books, manuals, herbaria, exhibits, internet and other references for correct and scientific reporting of weed specimen.
- ❖ Plates of some of the weeds are given in this manual.
- ❖ Important scientific information may be tabulated as under:

Cynodon dactylon

Digitaria sanguinalis

Eleusine indica

Sorghum halepense

Setaria sp.

Paspalum conjugatum

Imperata cylindrica

Panicum dichotomiflorum

Phalaris minor

Avena fatua

Echinochloa crusgalli

Cyperus rotundus

Fig. 8.1. Major grasses and sedges infesting field crops

Brachiaria reptans

Ipomoea nil

Celosia argentea

Cirsium arvense

Phyllanthus niruri

Portulaca oleracea

Amaranthus spinosus

Chenopodium album

Convolvulus arvensis

Ageratum houstonianum

Parthenium hysterophorus

Tridax parviflora

Fig.8.2. Major broad-leaf weeds infesting major field crops

Practical No. 9 Identification of *Kharif* season weeds

Objective **:** To identify different types of weeds infesting *Kharif* crops

Materials required : Manual, weed herbarium, pencil, eraser

Table. List of some common weeds infesting major field crops in *Kharif* season

Sl. No,	Common name	Scientific name	Family
1.	Jungle grass	*Echinochloa colona*	Poaceae
2.	Barnyard grass	*Echinochloa crusgalli*	Poaceae
3.	Indian goose grass	*Eleusine indica*	Poaceae
4.	Crowfoot grass	*Dactyloctenium aegyptium*	Poaceae
5.	Crab grass	*Digitarias anguinalis*	Poaceae
6.	Red sprangletop	*Leptochloa chinensis*	Poaceae
7.	Running grass	*Brachiaria reptans*	Poaceae
8.	Wrinkle grass	*Ischaemum rugosum*	Poaceae
9.	Hedgehog sedge	*Cyperus compressus*	Cyperaceae
10.	Rice flat sedge	*Cyperus iria*	Cyperaceae
11.	Smooth pigweed	*Amaranthus viridis*	Amaranthaceae
12.	Spiny pigweed	*Amaranthus spinosus*	Amaranthaceae
13.	Alligator weed	*Alternanthera philoxeroides*	Amaranthaceae
14.	Plumed cockscomb	*Celosia argentea*	Amaranthaceae
15.	False amaranth	*Digera arvensis*	Amaranthaceae
16.	Day flower	*Commelina benghalensis*	Commelinaceae
17.	Cockle bur	*Xanthium strumarium*	Asteraceae
18.	Tridax daisy	*Tridax procumbens*	Asteraceae
19.	False Daisy	*Eclipta alba*	Asteraceae
20.	Pink node flower	*Caesulia axillaris*	Asteraceae
21.	Black nightshade	*Solanum nigrum*	Solanaceae
22.	Jimson weed	*Datura stramonium*	Solanaceae
23.	Purselane	*Portulaca oleracea*	Portulaceae
24.	Puncture vine	*Tribulus terrestris*	Zygophylaceae
25.	Seed-under-leaf	*Phyllanthus niruri*	Euphorbiaceae
26.	Indian sorrel	*Oxalis corniculate*	Oxalidaceae
27.	Arrowhead	*Sagittaria sagittifolia*	Alismaracese
28.	Indian hemp	*Cannabis sativa*	Cannabaceae
29.	Snake weed	*Euphorbia hirta*	Euphorbiaceae
30.	Blue morning glory	*Ipomoea nil*	Convolvulacea
31.	Blistering ammannia	Ammannia baccifera	Lythraceae

Exercise: Note down the *Kharif* season weeds observed in the field

Sl. No,	Common name	Scientific name	Family
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
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15.			

Practical No. 10 Identification of *Rabi* season weeds

Objective **:** To identify different types of weeds infesting *Rabi* crops
Materials required : Manual, weed herbarium, pencil, eraser

Table. 1. List of some common weeds infesting major field crops in *Rabi* season

Sl. No,	Common name	Scientific name	Family
1.	Wild oat	*Avena fatua*	Poaceae
2.	Sweet grass	*Poa annua*	Poaceae
3.	Beard grass	*Polypogonmon speliensis*	Poaceae
4.	Poison rye grass	*Lolium temulentum*	Poaceae
5.	Canary grass	*Phalaris minor*	Poaceae
6.	Wild onion	*Asphodelus tenuifolius*	Liliaceae
7.	Wild mustard	*Sisymbriu mirio*	Brassicaceae
8.	Garden cress	*Coronopus didymus*	Brassicaceae
9.	Common lambsquarter	*Chenopodium album*	Chenopodiaceae
10.	Mexican poppy	*Argemone mexicana*	Papaveraceae
11.	Sour dock	*Rumex dentatus*	Polygonaceae
12.	Dock/Sorrel	*Rumex spinosus*	Polygonaceae
13.	Blue daisy	*Cichorium intybus*	Asteraceae
14.	Wild safflower	*Carthamus oxyacantha*	Asteraceae
15.	Saw thistle	*Sonchus arvensis*	Asteraceae
16.	Little mellow	*Malvapar viflora*	Malvaceae
17.	Blue pimpernel	*Anagallis arvensis*	Primulaceae
18.	Fumatory	*Fumaria parviflora*	Fumariaceae
19.	Meadow pea	*Lathyrus aphacaora*	Fabaceae
20.	Grass pea	*Lathyrus sativus*	Fabaceae
21.	Wild fenugreek	*Trigonella polycerata*	Fabaceae
22.	Hairy vetch	*Vicia hirsuta*	Fabaceae
23.	Vetch	*Vicia sativa*	Fabaceae
24.	Yellow sweet clover	*Melilotus indicus*	Fabaceae
25.	White sweet clover	*Melilotus alba*	Fabaceae
26.	Corn spurge	*Euphorbia segetalis*	Euphorbiaceae
27.	Green field-Speedwell	*Veronica agrestis*	Scropulariaceae
28.	Wild dog flower	*Antirrhinum orontium*	Scropulariaceae
29.	Corn spurry	*Spergula arvensis*	Caryophyllaceae
30.	Chickweed	*Stellaria media*	Caryophyllaceae
31.	Cow cockle	*Saponaria vaccaria*	Caryophyllaceae
32.	Common chick weed	*Stellaria media*	Caryophyllaceae

Exercise: Note down the *Rabi* season weeds observed in the field

Sl. No,	Common name	Scientific name	Family
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
13.			
14.			
15.			

Practical No. 11 Identification of perennial weeds

Objective **:** To identify different types of perennial weeds infesting field crops

Materials required : Manual, weed herbarium, pencil, eraser

Table. 1. List of some perennial weeds infesting major field crops in field crops

Sl. No,	Common name	Scientific name	Family
1.	Bermuda grass	*Cynodon dactylon*	Poaceae
2.	Jhonson grass	*Sorghum halepense*	Poaceae
3.	Tiger grass	*Saccharum spontaneum*	Poaceae
4.	Thatch grass/ Congo grass	*Imperata cylindrica*	Poaceae
5.	Dallis grass	*Paspalum dilatatum*	Poaceae
6.	Goat weed	*Ageratum conyzoides*	Asteraceae
7.	Nut grass	*Cyperus rotundus*	Cyperaceae
8.	Field bind weed	*Convolvulus arvensis*	Convolvulaceae
9.	Blush morning glory	*Ipomoea carnea*	Convolvulaceae
10.	Kidney weeds	*Dichondra repens*	Convolvulaceae
11.	Prickly pear	*Opuntia dillenii*	Cactaceae
12.	Spiderling	*Boerhavia diffusa*	Nyctaginaceae

Exercise: Note down the *Rabi* season weeds observed in the field

Sl. No,	Common name	Scientific name	Family
1.			
2.			
3.			
4.			
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Practical No. 12 Preparation of weed herbarium

Objective	**:**	To study the method of preparation of weed herbarium
Materials required	**:**	Herbarium sheets, wooden block press, blotting papers or old newspapers, pencil or marker, glue/adhesive tape, thread

The scientific method of weed collection and preparation of herbariumconsists of the following important steps:

1. ***Collection of weed sample***

The weeds with height of about 15 to 20 cm are uprooted carefully along with roots. The specimen should contain all parts of the weed plant including root, stem, leaves, flowers and fruits. For good identification, no part of the plant should be excluded. If plants are too small or large, extra care may be taken in collecting a specimen. A large plant may be divided into 2 or more sections, each pressed separately. However, excess branches or leaves may be removed provided remaining leaves and branches truly represent the plant. If the plants are very small, more number of specimens of the sample plant should be collected.

2. ***Pressing and drying of collected specimen***

The weed specimens collected are kept soon on blotting paper by keeping theleaves, roots and flowers in proper position and covered by another blotting paper. Plants with long stem or leaves may be folded into V, N or W bends but should not be doubled back in such a way as to lie across itself. The paper is kept on a smooth surface and sufficient weight is kept on the upper blotting paper so that the weeds inside get pressed. All the moisture is absorbed by these two blotting papers from the weed sample over night. Next day the weight is removed and the weeds are transferred to another dry blotting paper, by changing the position of the sample exactly reverse and are covered with dry blotting paper. Again sufficient weight is kept to press the sample. In this way the paper is changed 2 to 3 times by changing the position, of weed every time to absorb moisture from all parts of weed plant. When the specimen dries completely, it is ready for preservation.

Fig. 3.1. Herbarium press

3. ***Poisoning***

The weed specimen once dried need chemical treatment to protect them from insect attack and other destructive organisms. Thus dipping of specimens in an insecticide solution is essential. The following solutions are used for the treatment.

i. Mercuric chloride (25 g) + cresol (25 g) in one litre industrial alcohol.

ii. Mercuric chloride (15 g) + phenol crystals (10 g) in one litre denatured alcohol.

iii. 20% lauryl pentachloro phenate in methylated sprits.

The plants are re-dried as discussed earlier. These solutions are corrosiveand proper care is needed to handle them.

4. ***Mounting on herbarium sheet.***

After the specimens are dried and poisoned, they are mounted on herbarium sheets. Generally the size of the herbarium sheet is 42 cm x 29 cm (A sample herbarium sheet is given in Appendix section). The herbarium sheet should be of good quality and medium in weight. The specimens are placed in the centre of the sheet. Glue or narrow strips of adhesive tape (preferably transparent) are used to mount the specimens on the herbarium sheet. Several herbarium glues are availablein the market. If these are not available prepare the following gum:

i. 500g gum Arabic, 200g sugar and 15g phenol dissolvedmethylated in 1 litre of 8% spirit solution.

ii. Dissolve the 500g gum Arabic in 800 ml boiling water. Add 30g mercuricchloride and 15g phenol.

iii. Glue is applied to plant specimen only.

5. ***Preparation and fixing of identification label***

It consists of following two steps:

(A) Collection of information

The collector of weed specimen should record maximum useful information at the time of the collection. The data may be written either on the edge of same newspaper in which weed specimen will be brought from field to laboratory or a diarymay be used citing some reference number for a particular weed specimen. The collector should record information in respect of the following parameters.

i. Location: Name of the village or town nearby the field and its distance and direction from the known town for exact location, the district may be mentioned.

ii. Date: The date should be clearly mentioned with day, month and year. It should be written as March 15, 2018.

iii. Habitat: Under this category, name of place with ecological conditions viz.,field, pasture, roadside weeds, hillside, sand dune, nallah (eroded stream), lightexposure (sun or shade), moisture conditions (dry, moist, wet. etc.) and denseness of community (bare ground, thin or dense population) should be pointed out.

iv. Occurrence of weeds: A weed under consideration should be described in relativity of number of other species of weeds. For this purpose, an arbitrary scale of comparison using terms like rare, occasional, frequent, common and abundant may be followed.

v. Noting of essential characteristics Nature - Annual, biennial, perennial
Root - Tap, fibrous, adventitious, shallow, deep

Stem/branches - Woody, herbaceous, erect, spreading, trailing, prostrateLeaves - Simple, compound, narrow, broad
Flower - Shape, colour, fragrance

vi. Features of special reference: Some plants in nature are known for their special characteristics in terms of fragrance, colour, leaf curling, stinging hairs, presence of thorns, double colour of leaves, milky juice of stem or leaves, habitat of growth, stickiness etc. The specific characteristics of plant along with right stage of growth and development of the plant should be mentioned.

vii. Miscellaneous points of interest: A collector by his own wisdom or discussion with local people may collect valuable and rare information about a weedspecimen.

This includes special use, preference shown by insect-pest, industry, special control measure, anything special about dissemination and propagation.

B. Format of identification label

The lower right hand corner of the herbarium sheet should bear the label containing the information as,

LABEL Ref. No. …
Location and Habitat:
Common name (English):
(Local):
Scientific name:
Description:
Collectors Address:
Date & Time:

6. ***Preservation***

The individually labelled specimens are then arranged in weed albums whenthe collections are small and or in herbarium cabinets for large collections and long-term preservationThe albumum is a book with blank pages for the insertion and preservation of weed collections. A weed herbarium (plural: herbaria) is a collection of preserved weeds mounted, labelled, and systematically arranged for use in scientific study. The term can also refer to the building or room where the specimens are housed, or to the scientific institute that not only stores but uses themfor research.

Certain weeds plants are soft, bulky, or otherwise not amenable to drying and mounting on sheets. For these plants, other methods of preparation and storage maybe used. For example,

conifer cones and palm fronds may be stored in labelledboxes. Representative flowers, fruits, fleshy roots or stems may be pickledin formaldehyde to preserve their three-dimensional structure. Weed seeds are often air-dried and packaged in small paper/polythene envelopes or kept in small glass jars. No matter the method of preservation, detailed information on where and when the plant was collected, habitat, colour (since it may fade over time), and the name ofthe collector is usually included.

Note: After having complete practical demonstration on weed preservation, each student of weed management will prepare weed album by his own. The students will also update the weed herbarium of the department.

Practical No. 13 Computation of herbicide dose

Objective	**:**	To compute herbicide dose for weed control
Materials required	**:**	Commercial herbicide product

Preparation of Herbicidal Sprays at Appropriate Concentrations

In order to achieve good results, it is not only necessary to use adequate quantities of recommended herbicides but the herbicidal sprays should be correctly prepared and properly applied. In this regard some important considerations are as follows:

1. ***Time of application****:*

The time of application of different herbicides varies with the crop. The right time for spraying 2,4-D in wheat is at fully tillered stage. It is sprayed earlier, the earswill be abnormal and if sprayed later, weeds may not be killed. There are three times of application viz. pre-planning, pre-emergence and post-emergence application.

2. ***Concentration of herbicides****:*

It should be just as per the recommendations and if necessary repeated sprays may be given.

3. ***Formulation of herbicides****:*

The herbicides are formulated in different ways to affect is solubility, volatility and toxicity to plats. The herbicides are formulated to be applied as solutions ofwater or oils, emulsions, wettable powders, granules and dusts.

4. ***Method of application****:*

Different methods of application of herbicides are possible e.g. broad cast orblanket application, band application, placement, direct sprays by adjusting the height of the nozzle and spot treatment for small specified area.

5. ***Application used their care and maintenance****:*

Equipments used for application of herbicides may be sprayers power Knapsac of foot paddle for spraying liquids. Adusters for dispersing solids, fumigators and injectors for distributing material on the soil surface or in the soil. In order to use all these equipments properly proper lubrication, cleaning, checking of nuts, filters and hoses, calibration, using clean, nozzles proper cleaning and washingafter use and proper storage in go down are necessary.

6. ***Calculating proper quantities of herbicides****:*

The herbicides are available either in solid or liquid form. The label of the containers will read a.e = Acid equivalent or a.i. active ingredient for solids and g/lit
a.e. or a.e. for liquids.

***Acid Equivalent**:*

It refers to that part of a formulation that theoretically can be converted into acid. In this case the acid equivalent is given as the active ingredient or acidequivalent is given on label.

***Active Ingredient**:*

It is that part of a chemical formulation which is directly responsible for herbicidal effect. Thus the commercial herbicide production is made up of two parts i.e. the effective part and the inert part. Since all the recommendations are made on the basis of a.e. or a.i. certain amount of calculations becomes necessary to find out the quantity of commercial product to be required for a given area. To calculate the weight of the commercial produce required, the formula used is:

$$\text{Weight of commercial material required} = \frac{\text{Weight of chemical to be applied a.i.}}{\text{\% of a.i. expressed as decimal}}$$

Example No. 1

If you buy a herbicide with 80% (0.80 a.i.) as diuron and want to apply one kg a.i. of Diuron per ha, then the quantity of commercial product required per ha will be

$$\frac{1000}{0.80} = 1250 \text{ g of diuron per ha}$$

The 1250 g of the commercial product is required to add to the amount ofwater required to cover a hectare.

Example No. 2

Suppose Na salt of 2.4-D contains 80% a.i. and if 1 ½ kg of a.i. per ha is to be sprayed. The quantity of Na salt required will be

$$\frac{1500}{0.80} = \frac{1500}{80} \times \frac{100}{1} = 1875 \text{ g/ha} = 1.875 \text{ kg/ha}$$

Example No. 3

The Na salt of 2,4-D with 80% a.i. is to be sprayed on 1/10 of ha at 0.75 kg a.i. /ha. The quantity of Na salt required will be:

$$\frac{0.75}{0.80} \times \frac{1}{10} = 0.09375 \text{ kg} = 93.75 \text{ g}$$

Example No. 4

If in area of 0.5 ha is to be sprayed with simazine (50% WP) at 2 kg a.i./ha,the quantity of commercial herbicide required will be.

$$\frac{2}{0.50} \times \frac{1}{2} = 2 \text{ kg for } 0.5 \text{ ha}$$

Practical No. 14 Study on equipment used for herbicide application

Objective	**:**	To study equipment used for herbicide application
Materials required	**:**	Different types of sprayers, Nozzles: Hydraulic, flat fan, cone nozzle (hollow cone and solid cone), centrifugal and pneumatic nozzle, Measuring containers, buckets and graduated cylinders

There are various application methods viz. spraying or broadcasting for treating weeds with herbicides. It's important to choose the right method for yourparticular weed problem and the types of chemicals you are using.

Different methods by which the herbicides are applied in the crop lands are

1. Soil application of herbicides*:*

(i) *Surface application*

Soil active herbicides are applied uniformly on the surface of the soil either by spraying or by broadcasting. The applied herbicides are either left undisturbed or incorporated in to the soil. Incorporation is done to prevent the volatilization and photo-decomposition of the herbicides. e.g. Fluchoralin – Left undisturbed under irrigated condition - Incorporated under rainfed condition.

(ii). *Subsurface application*

It is the application of herbicides in a concentrated band, about 7-10 cm belowthe soil surface for controlling perennial weeds. For this, special types of nozzles are introduced below the soil under the cover of a sweep hood. e.g. carbamate herbicides to control *Cyperus rotundus*; Nitralin herbicide to control *Convolvulus arvensis*.

(iii). *Band application*

Application to a restricted band along the crop rows leaving an untreated bandin the inter-rows. Later inter-rows are cultivated to remove the weeds. Saving in cost is possible here. For example when a 30 cm wide band of a herbicide applied over a crop row that were spaced 90 cm apart, then two-third cost is saved.

(iv). *Fumigation*

Application of volatile chemicals in to confined spaces or in to the soil to produce gas that will destroy weed seeds is called fumigation. Herbicides used for fumigation are called as fumigants. These are good for killing perennial weeds andas well for eliminating weed seeds. e.g. Methyl bromide, Metham.

(v). *Herbigation*

It is the application of herbicides with irrigation water both by surface and sprinkler systems. In India farmers apply fluchloralin for chillies and tomato, while in western countries application of EPTC with sprinkler irrigation water is very common in Lucerne.

2. Foliar application

(i) Blanket spray

It is the uniform application of herbicides to standing crops without consideringthe location of the crop. Only highly selective herbicides are used here e.g. Spraying 2,4-Ethyl

Ester to rice three weeks after transplanting.

(ii). *Directed spray*

It is the application of herbicides on weeds in between rows of crops by directing the spray only on weeds avoiding the crop. This could be possible by use ofprotective shield or hood. For example, spraying of glyphosate in between rows of tapioca using hood to control *Cyperus rotundus*.

(iii). *Protected spray*

It is a method of applying non-selective herbicides on weeds by covering the crops which are wide spaced with polyethylene covers etc. This is expensive and laborious. However, farmers are using this technique for spraying glyphosate to control weeds in jasmine, cassava, banana.

(iv). *Spot treatment*

It is usually done on small areas having serious weed infestation to kill it andto prevent its spread. Rope wick applicator and Herbicide glove are useful here.

Methods to treat shrubs and trees

Foliar spray:

In foliar spraying, the herbicide is diluted with water or diesel at a specific rate,and sprayed over the foliage to point of run-off (until every leaf is wetted, but not dripping). This method is most suited to shrubs, grasses and dense vines less than 6mtall. Advantages include quickness and economy. Disadvantages include the potential for spray drift and off-target damage.

Foliar spraying can be done a number of ways, including:

- blanket spraying using a boom spray from a tractor
- a hose and handgun spraying solution from a herbicide tank
- a backpack spray unit
- with splatter guns (larger droplets at higher concentrations) for regrowth.

Basal barking

This method involves mixing an oil-soluble herbicide in diesel and sprayingthe full circumference of the trunk or stem of the weed. Basal bark spraying is suitable for:

- thin-barked woody weeds
- undesirable trees
- saplings, regrowth, and multi-stemmed shrubs and trees.

Basal barking will usually destroy weeds as long as the bark is not wet or toothick for the diesel to penetrate.

Girdling

Girdling is often used to control trees or shrubs that have a single trunk. It involves cutting away a strip of bark several centimeters wide all the way around the trunk. The

removed strip must be cut deep enough into the trunk to remove the vascular cambium, or

inner bark, the thin layer of living tissue that moves sugars andother carbohydrates between areas of production (leaves), storage (roots), andgrowing points. This inner cambium layer also produces all new wood and bark.

Stem injection

The stem injection method involves drilling or cutting through bark into the sapwood tissue of woody weeds and trees to transport the chemical throughout the weed. It is essential to apply the herbicide immediately (within 15 seconds of drilling or cutting), as stem injection relies on the active uptake and growth of the weed to move the herbicide through its tissue.

Drill and fill method

The drill and fill method is used for trees and woody weeds with stems or trunks greater than 5 cm in circumference, and is also referred to as tree injection. This method uses a battery-powered drill to drill downward-angled holes into the sapwood approximately 5cm apart. Using a backpack reservoir and syringe can deliver measured doses of herbicide solution. Only trees and shrubs that can be safely left to die and rot, should be treated this way. If the tree or shrub is to be felled, allow it to die completely before felling.

Axe cut method

The axe cut method can be used for trees and woody weeds with stems or trunks greater than 5 cm in circumference. It involves cutting through the bark into the sapwood tissue in the trunk, and immediately placing herbicide into the cut. Theaim is to reach the tissue layer just under the bark, which will transport the herbicidethroughout the weed. Using an axe or tomahawk, horizontal cuts are made into the sapwood aroundthe circumference of the trunk at waist height. The axe is then leaned out to make a downward angled pocket to allow herbicide to pool. It's important not to entirely ringbark the trunk, as this will decrease the uptake of herbicide.

Cut stump

The cut stump method involves cutting off the weed completely at its base (no higher than 15 cm from the ground) using a chainsaw, axe, brush cutter or machete. Aherbicide solution is then sprayed or painted onto the exposed surface of the cut stump, with the objective of destroying the stump and the root system. It is essential that the herbicide solution is applied as soon as the trunk or stem iscut. A delay of more than 15 seconds for water-based herbicides and 1 minute for diesel-soluble herbicides will give poor results.

Cut and swab

This method is similar to the cut stump method, but is suited to vines and multi-stemmed shrubs. Here, the weed stems are cut through completely, close to the ground. Herbicide is then applied immediately to the cut surface emerging fromthe ground, via spray or brush application.

Stem scraper

Stem scraping is used for weeds and vines with aerial tubers. A sharp knife isused to scrape a very thin layer of bark from a 10cm section of stem. Herbicide is then immediately applied to the exposed, underlying green tissue.

Wick applicators

This method consists of a wick or rope soaked in herbicide from a reservoirattached to a handle, or assisted with 12-volt pump equipment. The wetted wick isused to wipe or brush herbicide over the weed.

Equipments used for application of herbicide spray equipments:

Herbicides are largely applied as spray. Several types of sprayers are available from small hand operated to large ground and aerial sprayers.

Components of Sprayers:

The important components are:

1. Pump
2. Power source
3. Tank
4. Agitator
5. Distribution system
6. Pressure gauge
7. Pressure regulator.

1. *Pump:*

Any spray liquid must be atomized before it leaves the spray nozzle. The pump provides the necessary pressure for this purpose.

Types of Pumps:

a. *Air Compression or Pneumatic pumps***:**

These pumps force air into an air tight tank containing spray liquids thusmoving the spray liquid under pressure through the nozzle for its atomization.

b. Hydraulic or Positive Displacement Pump:

These pumps take in a definite volume of spray liquid and force it through the delivery system under pressure. The pump differs in pressure they produce.

2. *Source of Power:*

It is needed to run the spray pumps.The source of power may be either

a) Manual
b) Traction
c) Motor
d) Tractor and air craft engines.

3. *Spray Tank:*

A sprayer may have either built in tank or a separate tank to carry spray liquid. The tank should be large enough to avoid frequent refilling but not unhandy tocarry. The tank is provided with a large opening fitted with a strainer and cap to fill inthe liquid. It is difficult to fill in liquid and clean the tank having small openings.

4. *Agitator:*

It may be either mechanical or hydraulic purpose, to keep liquid spray homogenous. Mechanical agitators may be of metal fan or rod etc. Hydraulicagitator consists of a pipe with several side holes and closed at its free end is placed in the tank and it is fed with spray liquid from the pump. From these holes the liquid emerses as jets to provide agitation to the whole body of the liquid. This is called as '**By pass system'.** Hydraulic agitation is not thorough but it is more convenient in power sprayers using on large tank size. Sprayer without agitator should not beused to apply pesticide emulsion and suspension.

5. *Distribution System:*

It includes

i) Nozzle

ii) Spray lance

iii) Spray boom

iv) Hose

i) *Nozzle:*

The function of spray nozzle is to break pressurized spray liquid into dropletsfor application to the target. Nozzles are identified by

a) Droplet size,

b) Delivery, and

c) Spray pattern that they produce spray pattern is fixed for a herbicide work, eightkinds of spray nozzles are common e.g.

1. Flat fan
2. Solid cone
3. Flooding
4. Tripe action
5. Broadcast fan
6. Blast
7. Low volume
8. Centrifugal (Sprinkler rotary).

- The "Flat fan" nozzles are available in two spray patterns viz. the tapped edgepattern and rectangular pattern. Tapped edge pattern to apply pre and post emergence herbicide broadcasting, while rectangular pattern for the pre emergence bank application of herbicides.
- Solid cone nozzle produces medium size droplets. Good for pre and post emergence spray. Also used for surface application of herbicides which gives fanlike spray.
- Triple action nozzles-diameter of the sprays can be easily changed during operating to produce either coarse or fine spry.
- Broad cast fan nozzles are used for spraying on unwanted vegetation, road side fence, rows etc. it gives wide coverage of 5 to 8 m with coarse droplets on emulsion to avoid drift.

- ❖ Motorized sprayers blowers employ blast nozzles. These nozzles feed the spray liquid into the air steam to split it into droplets and carry the droplets by the velocity of the wind.

ii) *Lance:*

It is brass rod or 90 cm length attached to a delivery hose pipe of sprayer andfitted to its free end with a replaceable nozzle. A herbicide spray lance is bent at its nozzle to form a goose neck. At the hose end it is provided with trigger mechanism to control flow liquid for specific purpose. The spray lance may be fitted with plastic shields to prevent chemical from drifting.

iii) *Spray bar or Boom:*

It consists of a horizontal pipe on which 2 or several nozzles are fitted and spaced at 50 cm apart. Boom length varies from 1 to 15 m. Short boom with 2-3 nozzles is used with manual sprayers, while longer ones with tractor sprayers. The main advantage of spray boom over spray lance is wide swath it covers in each tripof the sprayer over the field. Total width of land wetted by a boom can be adjustedto get either (i) Uniform spray (ii) Directed spray or (iii) Band spray

6. Pressure regulator:

It is fitted to heavy duty sprayers and tractor driven sprayers so as to run the sprayers at constant pressure. Pressure gauge is provided to check pressure.

Types of sprayers

A) Knapsack Sprayers:

They are loaded on the back of worker during operations. Tanks may be plastic or metal. Common Knapsack sprayers are

i) Hydraulic
ii) Manual pneumatic and
iii) Motorized pneumatic.

i) *Hydraulic Knapsack Sprayers:*

Manually operated, tank capacity is 15 liters, mechanical or hydraulic agitation, worked with a hand lever to maintain constant pressure, particularly used for spot treatment small holding farmer and hand treatment. Equipped with a boom.It is good for blanket application.

Drawbacks:

These sprayers are mounted on back of man. One hand to lever and other to lance with a lance, one sprays 0.4 ha/day and with a boom 0.8 ha/day. It is high volume spray but low volume nozzles can be fitted. Spray potential is 12 kg/cm^2. It sprayed at 3 to 4 kg cm^2 to prevent spray drift.

ii) *Pneumatic or compressed system Knapsack:*

Do not require pumping during operation / spraying. The tank is pressurized after filling the liquid to 2/3rd capacity with a built in hand pump. Undesirable for weedicide spray

pressure lower after some time spraying resulting into uneven spray. Tank cleaning is difficult. Used limited to spray on weeds in paddy and jute.

iii) *Motorised Pneumatic sprayers:*

As a low volume sprayer suitable for spraying concentrated spray liquid. A blast of air flows through spraying jet of delivery hose and nozzle tube and ejects spray liquid in this blast. Air blast atomizes spray liquid in to fine droplets. Air acts as carrier. Faster the air is pressured, more the atomization. These sprayers are also used as blowers. Mist blower cause considerable loss of herbicide by winds. The main advantages of Knapsack blower are:

1. Low volume spray (Less of time in refilling tanks)
2. Portable working.
3. Fast spraying suited to post-emergence translocated type herbicides as low volume. Spraying is not so uniform with Knapsack blowers. Liquid – 60 liters/ha and swath 7 to 8 m.

B. *Foot Sprayer / Pedal Pump Sprayers:*

They are popularly applied for pesticide application operated with foot. It has provision of 1 – 2 long delivery hoses. Fitted with either lance or 2-6 nozzle booms. Its potential spray pressure is 17 to 21 kg/cm^2. Output with lance is 1 ha/day. It can spray high volume spray and covers more area.

C. *Traction Pneumatic Sprayer:*

Indian Institute of Sugarcane Research, Lucknow has developed bullock drawn sprayer with size nozzle boom that of powered from the wheels of the frame.It is efficient, easy to operate and simple in its construction. It uses two pneumatic pumps and develops maximum pressure of 2-8 cm^2 which his suited to minimize spray drift. Area covered 2-3 ha/day equipment.

D. *Tractor mounted sprayers:*

With spray pressure of 1.4 to 2.8 kg cm^2 and fitted with multi nozzle boom are very useful in herbicide application for large holding of farmers. Tractor mounted sprayer fitted with booms are used to spray road side vegetation. Tractor run sprayers have.

1. High uniformity of sprayers.
2. High working efficiency.
3. Full utilization of tractor during idle time.

E. *Aerial sprayers:*

Herbicide application from air is limited to treat aquatic weeds like water hyacinth, paddy fields, large sugarcane plantation. Presence of obstacles like trees and diversified farming in India are bottle necks in its use.

As per Indian Standard Institute norms, on the basis of amount of solution required,the sprayers are classified as

S.No.	Class	Volume (l/ha)
i)	High volume (HV) or full coverage spray	>560
ii)	Medium Volume (MV) or semi low or semi-concentrated spray	56-560
iii)	Low volume (LV) or concentrated spray	5.6-56
iv)	Ultra Low Volume (ULV) spray	0.56-5.6
v)	Ultra-Ultra Low Volume (UULV) spray	<0.56

Sprays are also classified in the following ways

S.No.	Sprays	Symbols	Spray volume	
			Field crops	Trees and bushes
i)	High volume	HV	>600	>1000
ii)	Medium volume	MV	200-600	500-1000
iii)	Low volume	LV	50-200	200-500
iv)	Very low volume	VLV	5-50	50-200
v)	Ultra low volume	ULV	<5	<50

Droplet size plays a significant role in CPP application by minimizing environmental contamination. CPP sprays are generally classified according to droplet size. When drift is to be minimized, a medium or coarse spray is required irrespective of the volume applied. Droplet size will influence coverage and drift. The nozzles typically used to apply CPPs produce droplets that vary in size to a great extent. Large droplets, which will facilitate in mitigating spray drift, may not provide good coverage. Very small droplets lack the momentum needed towards the target and are prone to drift under windy conditions. Flow rate of liquid (size of nozzle orifice), liquid pressure, physical changes to nozzle geometry and operation are the factors determining the range of droplets from a nozzle.
Classification of sprays according to droplet size

Volume medium diameter of droplet $(\mu m)^{-1}$	Classification of droplet size
<50	Aerosol
51 - 100	Mist
101 - 200	Fine spray
201 - 400	Medium spray
>400	Coarse spray

The most widely used parameter of droplet size is volume medium diameter (Vmd)which is measured in micrometers (µm).
1 mic = 1/1000 mm.

Maintenance and Cleaning of SprayersMaintenance of Sprayers:

a. Use of clean water only.
b. Use of the screen at the inlet spray.
c. Use of metal object for cleaning the nozzles.
d. Flush new sprayers before their use.

e. With Phenoxy herbicide use separate barrels of tanks if possible.
f. Clean the sprayer thoroughly after each period of use.

Cleaning of Sprayers:

It is necessary to remove all residues of herbicides completely after spraying is completed. It is essential for prevention of following:

a. Damage to crop plants subsequently sprayed with different herbicides.
b. Undesirable action between herbicide residue and new herbicide used.
c. Corrosion of sprayer parts.

Procedure for Cleaning of Sprayers:

1. Remove and clean all screens and boom extensions with kerosene and a smallbrush.
2. Mix one box of detergent with 30 gallons of water in tank. Circulate through bypass system or 30 minutes and the drain out.
3. Replace the screens and the boom extensions.
4. Fill the tank 1/3 rd to ½ with one part of hose hold ammonia to 49 parts of water.Circulate this mixture through the pump and nozzles. Let the remaining solution stand overnight and then run it over through the nozzle.
5. Flush with two tanks full of clean waters spraying through the boom with the nozzle removed.

Practical No. 15 Calibration of the sprayer

Objective : To study how to calibrate sprayer for herbicide application

Materials required : Sprayer (Knapsack), buckets, water, measuring tape, graduated cylinders, timeclock

Accurate application of herbicides depends on the accurate calibration of spray pump. Calibration implies to adjust the sprayer to apply exact quantity of carrier (water) for spraying certain area under a set of conditions. Application rate is dependent on nozzle type, size of the nozzle orifice, spraying pressure, spraying speed etc. Care must be taken that speed and pressure should not vary from the calibration test to actual field spraying.

Procedure

1. Fill the spray tank to a desired level with clean water and note it.
2. Operate the spray pump and spray in a known size area.
3. Measure the amount of spray (water) applied.
4. Calculate the quantity of water required per hectare as below:

$$\text{Application rate (l/ha)} = \frac{\text{Amount of water applied (l) x 10000}}{\text{Area to be sprayed } (m^2)}$$

5. Calculate the number of spray loads per hectare as follow:

$$\text{No. of spray loads/ha} = \frac{\text{Application rate (l/ha)}}{\text{Tank capacity of sprayer (l)}}$$

6. Calculation of commercial dose

   Each herbicide carries a label. To calculate the weight of commercial product required, information on weight of chemical to be applied and its active ingredient content are required:

$$\text{Commercial dose (kg/ha)} = \frac{\text{Dose of herbicide a.i. to be applied (kg/ha)}}{\text{a.i. content in herbicide formulation (\% expressed as decimal)}}$$

   Example: A herbicide with 30% a.i. as pendimethalin. If 0.9 kg/ha of pendimethalin is to be applied then 0.9/0.3 = 3.0 kg/ha of commercial formulation of pendimethalin (Stomp 30 EC) is required.

7. Calculate the amount of herbicide to be mixed in each spray load as follow

$$\text{Amount of herbicide per load} = \frac{\text{Commercial dose (kg/ha)}}{\text{No. of loads per ha}}$$

Method of calibration: The method of calibration of a sprayer consists of following steps:

Preparation of sprayer

- Remove and clean the nozzle
- Rinse the pressure and fill up with clean water and build up pressure
- Flush pump, hoses and lance with the clean water after removing the nozzle and strainers.
- Readjust the nozzle and strainers.
- Refill tank
- Now sprayer is ready for spray operation

Determination of nozzle discharge

- Keep the sprayer on the ground, fill up it with water and build up pressure
- Now take a bucket and dip the nozzle in it. Spray water for 5 minutes into bucket. Shut off the valve exactly at the end of five minutes.
- Measure volume of water collected in bucket with the help of graduate cylinder
- Repeat the operation for three times.

Determine the average reading.

This is the nozzle discharge or flow rate expressed in litres / minute. Determination of spray volume, measure and mark an area of 50sq.m with the help of a measuring tape. Spray the water in this measured area of 50 m^2. Determine the volume of spray delivered from the tank.

Determination of walking speed

- Mark a starting point on bare soil surface with a stick.
- Adjust the prepared sprayer on the back and operate pumping, directing lance and nozzle within spray swath.
- Walk at a normal and constant speed exactly for five minutes.
- Measure the distance covered in five minutes.
- Repeat the operation for three times.
- Express the average walking speed in metres /minute.
- Do the same operation in the crop planted field and determine the average walking speed.

Determination of swath:

Mark in the field an area having width equal to the swath (the distance up to which the spray falls on the ground on a fixed height). The spray lance could be held constant while walking forward but could be swung from left to right.

Observation: For proper calibration of a sprayer, following observations should be recorded.

Total distance travelled = d metre

Time taken for travelling distance,„d‟metres = t min.

Swath width = x metres

Amount of water discharged at a given pressure = L litre.

Calculation Spray volume

$$\text{Spray volume (L/ha)} = \frac{\text{Water used in testing (L)}}{\text{Area covered during test run (m}^2\text{)}} \times 10000$$

Observations

Do calibration of knap-sack sprayer with different nozzles and note the following observations:

Type of nozzle	Area sprayed (m^2)	Water used (L)	Water required (L/ha)	Width of boom (cm)	Time needed (min/ ha)
Flat fan					
Flood jet					
Hollow cone					
Double spray lance					
Trople nozzle lance					

What type of nozzle will you recommend to the farmer for uniform application of herbicides?

The area covered per hour can be calculated as shown under

$$\text{Area (ha/hr)} = \frac{\text{Walking speed (km/hr) x m/km x spray width (m)}}{\text{m}^2\text{/ha}}$$

For example, if a person is walking at 1 km/hr covering a swath of 0.6 meters wide,the area covered/hr is

$$\frac{1 \times 1000}{10000} \times 0.6 = 0.06 \text{ ha/hr}$$

At this rate, it will take 16 hr 40 minutes to cover an area of one hectare. At a spraydischarge rate of 30 l/hr, it would require a spray volume of 500 l/ha.

Practical No. 16 Demonstration of different methods of herbicide application

Objective : To demonstrate various methods of herbicide application
Materials required : Sprayer (Knapsack), buckets, water, measuring tape, graduated cylinders, herbicide

Procedure:

- Selection of proper herbicide.
- Measure the cropped area.
- Calibrate the knapsack sprayer as explained in previous exercise.
- Compute the herbicide needed.
- Put on hand gloves, eye glass and a cloth around the mouth.
- Measure the amount of herbicide and put it in a bucket and stir well.
- Add this solution to the water container of sprayer and make the desired volume.
- Undertake spraying operation.

Results

Collect and systematically note down the information.

Particulars	**Description**
About herbicide	
Trade tame	
Quantity of formulated product for a given area and crop	
Stage of application	
About requirement	
Name of equipment	
Working condition	
Type of nozzle	
Walking speed	
Spray volume for given area	

Practical No. 17 Study on commonly used herbicides in field crops

Objective : To prepare a list of commonly available herbicides

List of trade names, formulations, and active ingredients of some common herbicides and approved combinations

S.No.	Common name	Trade name	a.i. content and Formulation
Herbicides			
1.	2,4-D (amine)	Zura	58% SL
2.	2,4-D (ester)	Weedmar	Ethyl ester 38% EC
3.	2,4-D (Na salt)	Weedmar	80% WP; 38% EC
4.	Acetachlor		50% SC, 60% SC 50% EC, 90% EC 80% WP 90% WG(WDG)
5.	Anilofos	Aniloguard	30% EC
6.	Alachlor	Lasso	50% EC
7.	Atrazine	Atrataf	50% SC; 50% WP; 80% WP
8.	Butachlor	Dhanuchlor	50% EC; 50% EW
9.	Bispyribac Sodium	Nominee Gold	10% SC
10.	Carfentrazone	Affinity	50% WG
11.	Chlorimuron-ethyl	Kloben	25% WP
12.	Clodinafop-propargyl	Topik	15% WP
13.	Cyhalofop-butyl	Clincher	10%EC, 10%WP,10%EW
14.	Diclofop-methyl	Iloxan	3% EC
15.	Diuron	Diurex	80% SC; 80% WP
16.	Ethoxysulfuron	Sunrise	15% WDG
17.	Fenoxaprop-P-ethyl	Whipsuper	10% EC; 9.3% EC
18.	Fluchloralin	Basalin	45% EC
19.	Glyphosate	Round up	41% SL; Ammonium salt 71% SG
20.	Imazethapyr	Pursuit	10% SL
21.	Isoproturon	Chemlon	50% WP; 75% WP
22.	Mestsulfuron- methyl	Algrip	20% WP
23.	Metolachlor	Dual	50% EC
24.	Metribuzin	Sencor	70% WP
25.	Oxadiargyl	Topstar	80% WP
26.	Oxadiazon	Ronstar	50% EC
27.	Oxyflourfen	Oxygold	23.5% EC
28.	Paraquat	Gramaxone	24% SL
29.	Pendimethalin	Stomp xtra	30% EC; 38.7% CS

30.	Pinoxaden	Axial	5.1% EC
31.	Pretilachlor	Rifit	50% EC; 37% EW
32.	Propaquizafop	Society	10% EC
33.	Pyrazosulfuron –ethyl	Saathi	10% WP
34.	Pyrithiobac	Hitweed	10% EC
35.	Quizalofop-ethyl	Tergasuper	5% EC
36.	Sulfosulfuron	SF_10	75% WG
37.	Trifulralin	Trifogan	48% EC
Formulated combinations			
1.	Bensulfuron + pretilachlor	Londox power	0.6 + 6% GR
2.	Clodinafop + metsulfuron	Vesta	15 % + 1% WP
3.	Imezethapyr + imazamox	Odyssey	35% + 35% WG
4.	Metsulfuron methyl + chlorimuron ethyl	Almix	10+10% WP
5.	Mesosulfuron + idosulfuron	Atlantis	3+0.6 WG
6.	Pendimethalin + imazethapyr	Valor	30+2% EC
7.	Sulfosulfuron + metsulfuron-methyl	Total	75+5% WDG

List of some herbicides and their use in field crops

Crop	Herbicide	Formulation available in market	Dose/ha		Dilution in water (L)	Time of application
			a.i. (g/kg)	Formulation (g/kg/mL/L)		
Rice (transplanted)	Pendimethalin	Pendimethalin 30% EC	0.75-1.25	3.3-5 L	500-700	Pre-emergence
	Anilofos	Anilofos 30% EC	0.3-0.45 kg	1.5 L	375-500	Pre-emergence
	Butachlor	Butachlor 50% EC	1.25-2 kg	2.5-4 L	250-500	Pre-emergence
	Pretilachlor	Pretilachlor 37% EW	0.6-0.75 kg	1.5-1.9 L	500	Pre-emergence, Post-emergence
	Bispyribac-sodium	Bispyribac-sodium 10% SC	20 mL	200 mL	300	Early post-emergence
	2,4-D	2,4-D ethyl ester 38% EC	0.85 kg	2.5 L	400	Post-emergence
	Ethoxysulfuron	Ethoxysulfuron 15% WDG	12.5-15 g	83.3-100 g	500	Post-emergence
Rice (direct seeded)	Paraquat	Paraquat dichloride 24% SL	0.3-0.8 kg	1.25-3.5 L	500	Pre-planting (zero-tillage)
	Pendimethalin	Pendimethalin 30% EC	0.75-1.25	3.3-5 L	500-700	Pre-emergence
	Bispyribac-sodium	Bispyribac-sodium 10% SC	20 mL	200 mL	300	Early post-emergence
Maize	Paraquat	Paraquat dichloride 24% SL	0.2-0.5 kg	0.8-2 L	500	Pre-planting (zero-tillage)
	Fluchloralin	Fluchloralin 45% EC(pre-planting)	1-1.5 kg	2.22-3.33 L	500-800	Pre-planting

	Alachlor	Alachlor 50% EC	2.5 kg	5 L	250-500	Pre-emergence
	Pendimethalin	Pendimethalin 30% EC	0.75-1.25	3.3-5 L	500-700	Pre-emergence
	Atrazine	Atrazine 50% WP	0.5-1 kg	1-2 kg	500-700	Pre-emergence, Early post-emergence
	2,4-D	2,4-D dimethyl amine salt 58% SL	0.5 kg	0.86 L	400-500	Pre-emergence, Post-emergence
Sorghum	Pendimethalin	Pendimethalin 30% EC	0.75-1.25	3.3-5 L	500-700	Pre-emergence
	2,4-D	2,4-D dimethyl amine salt 58% SL	1.8 kg	3.1 L	500-600	Pre-emergence, Post-emergence
Chickpea/Bengal gram	Fluchloralin	Fluchloralin 50% EC	0.75-1 kg	1.5-2 L	750-1000	Pre-planting
	Pendimethalin	Pendimethalin 30% EC	0.75-1.25	3.3-5 L	500-700	Pre-emergence
Field pea	Fluchloralin	Fluchloralin 50% EC	0.75-1 kg	1.5-2 L	750-1000	Pre-planting
	Pendimethalin	Pendimethalin 30% EC	0.75-1.25	3.3-5 L	500-700	Pre-emergence
	Metribuzin	Metribuzin 70% WP	0.25 kg	0.35 L	400-600	Pre-emergence, Post-emergence
Green gram/ Black gram/Pigeonpea	Fluchloralin	Fluchloralin 50% EC	0.75-1 kg	1.5-2 L	750-1000	Pre-planting
	Alachlor	Alachlor 50% EC	2-2.5 kg	4-5 L	250-500	Pre-emergence
	Pendimethalin	Pendimethalin 30% EC	0.75-1.25	3.3-5 L	500-700	Pre-emergence
Lentil	Fluchloralin	Fluchloralin 50% EC	0.75-1 kg	1.5-2 L	750-1000	Pre-planting
Soybean	Fluchloralin	Fluchloralin 50% EC	0.75-1 kg	1.5-2 L	750-1000	Pre-planting
	Imazethapyr	Imazethapyr 10% SL	100-150 g	1-1.5 L	500-700	Early post-emergence

Rapeseed/ Mustard	Fluchloralin	Fluchloralin 50% EC	1 kg	2 L	750-1000	Pre-planting
	Oxadiargyl	Oxadiargyl 6% EC	90 g	1.5 L	500	Pre-emergence
Groundnut	Fluchloralin	Fluchloralin 50% EC	0.75-1 kg	1.5-2 L	750-1000	Pre-planting
	Alachlor	Alachlor 10% Gr	1.5-2.5 kg	15-25 kg	-	Pre-emergence
	Imazethapyr	Imazethapyr 10% SL	100-150 g	1-1.5 L	500-700	Early post-emergence
	Oxyfluorfen	Oxyfluorfen 23.5% EC	100-200 g	425-500 mL	500-700	Pre-emergence
Sunflower	Fluchloralin	Fluchloralin 50% EC	1 kg	2 L	750-1000	Pre-planting
	Alachlor	Alachlor 50% EC	1-2 kg	2-3 L	250-500	Pre-emergence
	Pendimethalin	Pendimethalin 30% EC	0.75-1.25	3.3-5 L	500-700	Pre-emergence
Cotton	Fluchloralin	Fluchloralin 45% EC	0.9-1.2 kg	2-2.68 L	500-800	Pre-plant
	Alachlor	Alachlor 50% EC	2-2.5 kg	4-5 L	250-500	Pre-emergence
	Diuron	Diuron 80% WP	0.75-1.5 kg	1-2.2 kg	625	Pre-emergence
	Pendimethalin	Pendimethalin 30% EC	0.75-1.25	3.3-5 L	500-700	Pre-emergence
	Glufosinate	Glufosinate-ammonium 13.5% SL	375-450 g	2.5-3 L	500	Post-emergence
Linseed/Sesamum/Niger	Pendimethalin	Pendimethalin 30% EC	0.75-1.25	3.3-5 L	500-700	Pre-emergence

Practical No. 18 Study on various cropping systems of the region

Objective : To study various cropping systems of the region

Cropping System:

- It is a pattern of crops for a given piece of land.
- It is the order in which the crops are grown or cultivated on a piece of land over a fixed period.
- In simple words, it means cropping pattern and its management to derive benefits from a given resource base under a specific environmental condition:

  Cropping system = Cropping pattern + Management

Cropping Pattern:

- It is the yearly sequence and spatial arrangement of crops on the same piece of land over the same period of time.
- It is the proportion of area under various crops at a point of time in a unit area.

Cropping Scheme:

- It is the plan according to which crops are raised on individual plots of a farm with the objective of getting maximum returns from each crop without impairing the soil fertility.

Major cropping system of Sikkim

1. Maize - Rice/Soybean - Potato/Vegetables/Wheat/Mustard
2. Maize - Finger Millet/Rice Bean (Relay) +Vegetable
3. Maize + Soybean/Urd – Mustard/Toria
4. Maize - Maize + French Beans (Local)/Vegetables
5. Maize + Vegetables – Wheat/ Barley
6. Maize + Ginger/Tapoica
7. Maize + Cole crops
8. Maize + Soybean/Urd
9. Rice - Wheat/Barley/Mustard/Vegetables
10. Perennials crops –Mandarin orange, other fruits, L. cardamom
11. Rice + Urd/Soybean (Urd/Soybean in bunds)
12. Finger millet- Wheat
13. Rice
14. Ginger
15. Turmeric

Exercise:

Prepare a list of cropping system (Monocropping/Double cropping/Triple cropping/Intrecropping) of this region: