**A Practical Manual For The Course**

# "*Weed management in horticultural crops*"

**FSC 213 2(1+1)**


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*The views expressed in the manual are the personal opinion of the contributors.*

# Preface

Weeds are the most severe and widespread biological constraint to agricultural production systems and cause damage in cropped and non-cropped lands. They reduce crop yield and degrade the quality of the produce besides raising the cost of production. In addition to yield and nutrient losses, weeds also harbour and serve as alternate hosts to various insect pests and diseases and may reduce land value. In non-cropped lands, the weeds also cause health hazards and loss of biodiversity.

Weeds account for about one-third of the total losses caused by agricultural pests. For this reason, significant efforts are required to decrease economic losses caused by weeds in Indian agriculture. Indian farmers continue to experience heavy crop yield losses due to weed interference despite the progress made in research and extension of weed science. Losses caused by weeds in crops vary because the nature, extent, and intensity of weed problems depend on the ecology in which the crop is grown and situations such as hydrology, land topography, associated environment, establishment methods, and the cultural practices used. It is obligatory to bring awareness about the importance of weeds and weed management in enhancing crop productivity and sustainability.

This manual has been prepared for the third-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 weeds, their biology, available herbicides, tools, and equipment for weed control, measuring economic losses due to weeds, computation of economics of weed management practices, and their interpretations.

**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

Agriculture is the chief source of livelihood for nearly half 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. Diverse climatic conditions in India favour the most adopted weeds to prevail and cause severe crop yield losses. Weeds also degrade the quality of the produce, raise the cost of production, harbour and serve as alternate hosts to several insect pests and diseases. In this context, weed management is critical to improving crop productivity by minimizing weeds that caused crop yield losses and alleviating other adverse effects of weeds in different ecosystems.

This manual has been prepared to aid students and other users in identifying and understanding the biology of various weeds, the selection of appropriate herbicides, the computation of their dose and application with appropriate tools and equipment, and analysis of the economics relevant to weed control practices. 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.

**Date:**

**(Anupam Mishra)**
**Vice Chancellor**
**CAU, Imphal**

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# CERTIFICATE

This is to certify that Mr./Ms ……..

Reg. No……has performed Practical for the semester……

B. Sc. (Hons.) Horticulture in the Course No…… Title……

during the academic year……

He/She has performed…….practical out of ……

**Registration No**…….

**Course teacher** **Assistant Registrar (Academic)**

**Examiner**

# CONTENT

**Practical No. 1 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.

**1.1. 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.

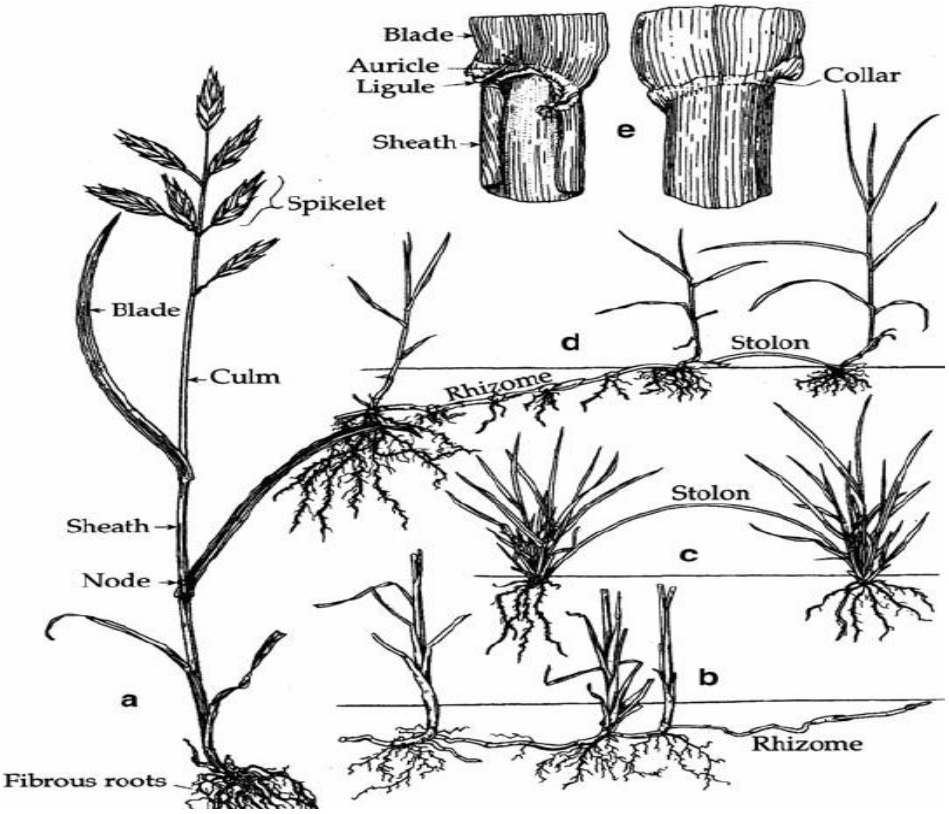



Fig.1.1. Typical structure of grasses.

**1.2. 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.

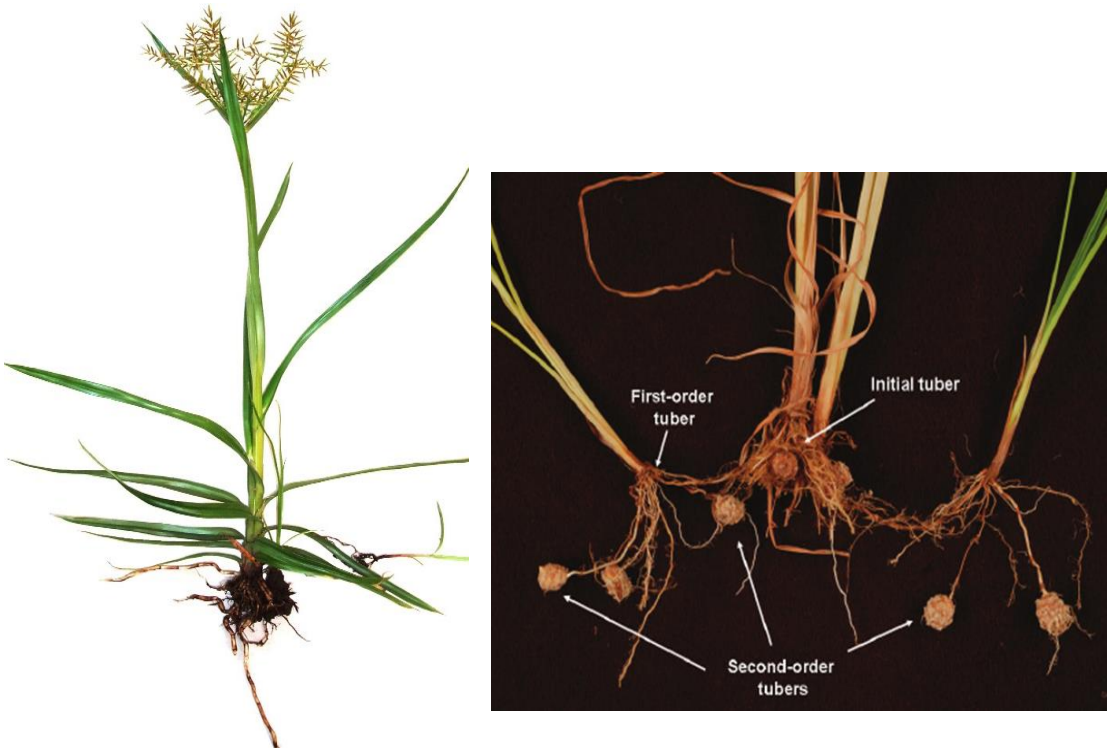



Fig.1.2. Typical structure of Cyperaceae weeds.

**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

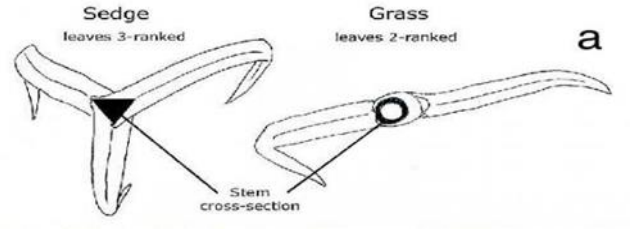



**Fig. 1.3. Difference between grasses and sedges**

**1.3. 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

**1.4. 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:

| Sl. No. | Common name | Scientific name | Family | Salient characteristics |
|---|---|---|---|---|
| 1. | Bermuda grass | *Cynodon dactylon* | Poaceae | Perennial, adventitious roots, stolon |
| 2. | | | | |
| 3. | | | | |
| 4. | | | | |

*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. 1.4. Major grasses and sedges infesting horticultural crops**

*Lantana camara*

*Cannabis sativa*

*Celosia argentea*

*Cirsium arvense*

*Phyllanthus niruri*

*Portulaca oleracea*

*Amaranthus spinosus*

*Chenopodium album*

*Convolvulus arvensis*

*Ageratum houstonianum*

*Parthenium hysterophorus*

*Tridax parviflora*

**Fig.1.5. Major broad leaf weeds infesting horticultural crops**

**Table. 1. List of some common weeds infesting horticultural crops**

| Sl. No, | Common name | Scientific name | Family |
|---|---|---|---|
| 1. | Bermuda grass/Indian Dhoob | *Cynodon dactylon* | Poaceae/Gramineae |
| 2. | Large crabgrass | *Digitaria sanguinalis* | Poaceae/Gramineae |
| 3. | Paspalum | *Paspalum conjugatum* | Poaceae/Gramineae |
| 4. | Johnson grass | *Sorghum halepense* | Poaceae/Gramineae |
| 5. | Crowfoot grass/ Indian goosegrass | *Eleusine indica* | Poaceae/Gramineae |
| 6. | Cogon grass/ Thatch grass | *Imperata cylindrica* | Poaceae/Gramineae |
| 7. | Wild oat | *Avena fatua* | Poaceae/Gramineae |
| 8. | Barnyard grass | *Echinochloa crusgalli* | Poaceae/Gramineae |
| 9. | Foxtail weed | *Setaria glauca* | Poaceae/Gramineae |
| 10. | Quack grass | *Agropyron repens* | Poaceae/Gramineae |
| 11. | Purple nutsedge | *Cyperus rotundus* | Cyperaceae |
| 12. | Yellow nutsedge | *Cyperus esculentus* | Cyperaceae |
| 13. | Purslane | *Portulaca oleracea* | Portulacaceae |
| 14. | Lamb's quarters | *Chenopodium album* | Amaranthaceae |
| 15. | Spiny amaranth | *Amaranthus spinosus* | Amaranthaceae |
| 16. | Pigweed | *Amaranthus viridis* | Amaranthaceae |
| 17. | Gale of the wind/ Seed-under-leaf | *Phyllanthus niruri* | Phyllanthaceae |
| 18. | Goatweed | *Ageratum conyzoides* | Asteraceae |
| 19. | Quickweed | *Tridax parviflora* | Asteraceae |
| 20. | Carrot grass/ Congress grass | *Parthenium hysterophorus* | Asteraceae |
| 21. | Black nightshade | *Solanum nigrum* | Solanaceae |
| 22. | Lantana | *Lantana camara* | Verbenaceae |
| 23. | Water hyacinth | *Eichhornia crassipes* | Pontederiaceae |
| 24. | Field bindweed/ *Hiran khuri* | *Convolvulus arvensis* | Convolvulaceae |
| 25. | Dodder | *Cuscuta* spp. | Convolvulaceae |
| 26. | | *Loranthus* spp. | Loranthaceae |
| 27. | Broomrape | *Orobanche* spp. | Orobanchaceae |
| 28. | Witchweed | *Striga* spp. | Orobanchaceae |
| 29. | Broadleaf woodsorrel | *Oxalis latiflora* | Oxalidaceae |
| 30. | Mexican poppy | *Argemone mexicana* | Papaveraceae |

**Practical No. 2 Survey of weeds in crop fields and other habitats**

**Objective** : To survey various weeds crop fields and other habitats
**Materials required** : Quadrat, manual, weed herbarium, pencil, eraser

**2.1. Procedure**:

- First select the crops and cropping systems for the weed survey.
- The study must be started before weeding or weed control practices and after weeding or application of treatment during crop season.
- Random quadrat sampling is a most common method for obtaining various types of data on weed cover generally a square quadrat measuring 1 m x 1 m is sufficient to represent the composition of an agricultural field.
- In each field site, lay down 5-10 or more quadrats of 1 $m^2$ for each crop and cropping system.
- Collect and identify all the weeds from each quadrat and kept them in polythene bags separately

**Formulas for estimation of quantitative parameter**:

Weed density: Count the number of individuals of particular weed species per unit area and determine the relative density.

$$\text{Density (D)} = \frac{\text{Total no. of weeds in all quadrats}}{\text{Total no. of quadrats studied}} \times 100$$

$$\text{Relative Density (RD)} = \frac{\text{No. of individuals of a given weed species}}{\text{Total no. of individuals of all weed species}} \times 100$$

Weed frequency: This parameter determines the degree of dispersion of a given weed species in an area.

$$\text{Weed frequency (F)} = \frac{\text{No. of quadrats of occurrence of a species}}{\text{Total no. of quadrats studied}} \times 100$$

Weed dominance: It refers to the ground coverage of a given weed species in relations to density of the given weed species.

Weed frequency (F) = Average basal area of a given weed species x density

$$\text{Weed abundance} = \frac{\text{Total no. of weed species in all quadrats}}{\text{No. of quadrats occurrence of a species}} \times 100$$

**Practical No. 3 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 herbarium consists 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 corrosive and 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 available in the market. If these are not available prepare the following gum:

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

ii. Dissolve the 500g gum Arabic in 800 ml boiling water. Add 30g mercuric chloride 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 diary may 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), light exposure (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 individual labelled specimens are then arranged in weed albums when the collections are small and or herbarium cabinets for large collections and long term preservation. Album 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 labelled boxes. Representative flowers, fruits, fleshy roots or stems may be pickled in 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. 4 Study on herbicide label information**

**Objective** **:** To study the herbicide label information
**Materials required** **:** Commercial herbicide product

The label is the information printed on or attached to the pesticide container; it has several interpretations. The label should be considered as the main source of information by user on how to use the product correctly, legally and safely. A herbicide label is a legal document providing important information about a herbicide, its appropriate use, and the precautions needed to avoid off-target movement and to protect environmental quality. A herbicide label answers the "what, where, when," and "how" questions about the product. Finding answers to these important questions is indispensable for achieving the economical use and optimum results from a product, and obligatory to avoid violation of state or federal law. The following points should be considered while reading the label:

- The active ingredient in the product
- The allowed use rate of the product
- The recommended crops, appropriate time and crop stage to apply the product
- Safety measures needed while using or disposing of the product
- Disposal of the container or left-over
- Who should be called in case of emergency?
- When to avoid the use of product

**Understanding Herbicide Labels**

Herbicide labels offer important, practical information. While the format may vary from product to product, all include key information necessary for safe use and better pest management:

**a) Product Information:**

This section provides detailed information about the brand name, active ingredient, name and address of manufacturer, the registration number, recommended crops, spectrum of weed control, formulation and date of manufacture and expiry.

***Brand name*:** Each manufacturer has a brand name for each of its products. Different manufacturers may use different brand names for the same pesticide active ingredient. For example, Green label and Nominee gold are trade names for the same herbicidal active ingredient, bispyribac.

***Registration number*:** This number identifies a specific product and signifies that the product has met the registration requirements through all of the testing phases.

***Ingredient and formulation***: Ingredient is normally displayed on the front panel of the label, It identifies the name and percentage by weight of each active ingredient. The front panel of some pesticide labels will describe the product formulation. The

formulation name may be either spelled out or designated by an abbreviation, such as G for granular materials, WP for wettable powders, D for dusts or E or EC for emulsifiable concentrates.

***Name and address of manufacturer***: This enables consumers to know who made or sold the product. In many cases, the manufacturer will also list a customer care telephone number and/or web address where users of the product may seek technical advice or lodge complaints.

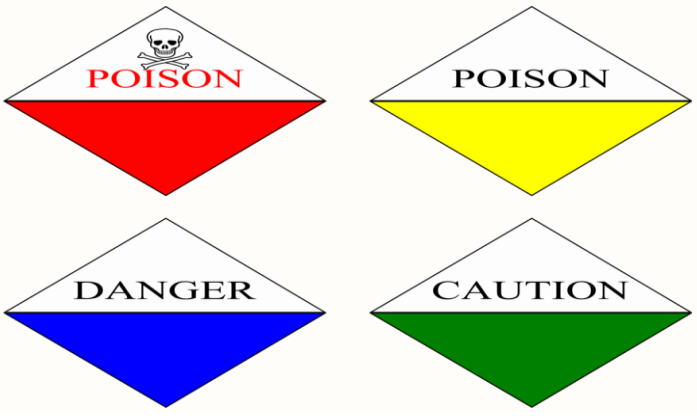
***Recommended crops and spectrum of weeds***: This information can help in determining the suitability of herbicide for weed control in the certain crops. It can also help in deciding whether an additional herbicide should be tank-mixed in to achieve effective control of all weed species present in a field.

***Date of manufacture and expiry*:** This information provide when the product was manufactured and how long it can be used for agricultural use.

**b) Safety information and signal words:**

The front panel of every pesticide label must bear the statement, "KEEP OUT OF REACH OF CHILDREN." Poisoning is a major cause of injuries to children. One of three words (Poison, Danger, Caution) found on herbicide labels to indicate the relative hazard of the chemical. A signal word is displayed in large letters on the front of the label to indicate approximately how acutely toxic the pesticide is to humans by ingestion. The signal word is based on the entire contents of the product, not the active ingredient alone, but takes into account the inert ingredients. The signal word does not indicate the risk of delayed or allergic effects.

| **Classification of herbicides** | **Colour of the lower triangle** | **Symbol abs signal word on the upper triangle** |
|---|---|---|
| Extremely toxic | Bright red | Skull and cross bone "POISON" in red |
| Highly toxic | Bright yellow | "POISON" in red |
| Moderately toxic | Bright blue | DANGER |
| Slightly toxic | Bright green | CAUTION |



**c) Direction for use:**

The directions for use section will contain information such as plants where the product may be applied, the amount of product to use (amount per unit area, amount to mix per unit volume of water), how the product should be applied and by which type of application equipment it is most effectively applied, the timing and frequency of application.

**d) First Aid and Precautionary Statements**:

The best way to take care of emergency situations arising while working with a product is to keep the herbicide label and a first aid kit available all the time. Highlight the emergency contact information on the herbicide label because doctors may need to seek additional information in case of an emergency.

**e) Storage and disposal:**

Generally, herbicide labels contain a general statement in this section to the effect “do not contaminate water, food, or feed by storage, disposal, or cleaning of equipment” and “store in original containers only.” Label information about storage generally includes temperature requirements. Moisture is a critical concern with dry pesticides, including granular materials and wettable powders, which have a strong affinity for water. When this is the case, the label may have the statement, “store in a dry place.” Labels include information on disposal of pesticide containers as well as excess quantities of diluted pesticide mixtures. The label will inform users that leftover mixtures that can't be applied to a labeled site may be disposed of in an approved waste disposal facility that is in accordance with appropriate federal, state and local procedures. With disposal of liquid pesticide containers, the triple-rinse procedure will be stated in this section of the label and options such as recycling or disposal of punctured containers in a sanitary landfill will be given. Manufacturers of returnable and refillable containers will remind the user to return the containers promptly and intact to the point of purchase. The label will state that bags containing dry pesticide products should be emptied thoroughly into the application equipment and incinerated or discarded into a sanitary landfill.

**Practical No. 5 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 ears will 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 of water 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 washing after 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 acid equivalent 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 of water 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. 6 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 band in 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 and as 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 considering the 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 of protective 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 and to 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 and other carbohydrates between areas of production (leaves), storage (roots), and growing 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. The aim is to reach the tissue layer just under the bark, which will transport the herbicide throughout the weed. Using an axe or tomahawk, horizontal cuts are made into the sapwood around the 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. A herbicide 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 is cut. 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 from the ground, via spray or brush application.

*Stem scraper*

Stem scraping is used for weeds and vines with aerial tubers. A sharp knife is used 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 thedelivery 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. Hydraulic agitator 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 droplets for 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, eight kinds 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 edge pattern 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. 7** **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

| | | |
|---|---|---|
| | | Water used in testing (L) |
| Spray volume (L/ha) | = | …… x 10000 |
| | | Area covered during test run ($m^2$) |

**Observations**

Do calibration of Knap-sack sprayer with different nozzles and note followingobservations

| Type of nozzle | Area sprayed ($m^2$) | Wate r used (l) | Water require dl/ha | Width of boom (cm) | Time needed/ha (min) |
|---|---|---|---|---|---|
| Flat fan | | | | | |
| Flood jet | | | | | |
| Hollow cone | | | | | |
| Double spray lance | | | | | |
| Triple nozzle lance | | | | | |

---

**Conclusions:** 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

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

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 spray discharge rate of 30 l/hr, it would require a spray volume of 500 l/ha.

**Practical No. 8 : 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. 9 : Calculation of weed control efficiency and weed index**

**Objective :** To study weed control efficiency and weed index

Weed control efficiency (WCE), weed control index (WCI) and weed index provide a logistic support in impact assessment, interpretations and drawing appropriate conclusions in weed management research.

$$WCE = \frac{\text{Weed count in control (unweeded)} - \text{Weed count in a treatment}}{\text{Weed count in control (unweeded)}}$$

Weed control index is calculated by replacing weed count with weed dry weight.

$$\text{Weed index} = \frac{\text{Yield from weed free plot} - \text{Yield of treated plot}}{\text{Yield of weed free plot}} \times 100$$

Weed index is the measure of the efficiency of a particular treatment when compared with a weed free treatment. It is expressed as percentage of yield potential under weed free. More conveniently weed index is the percent yield loss caused due to weeds as compared to weed free check. Higher weed index mean greater loss.

Example 1. Calculate weed index (WI), and weed control index (WCI) of alltreatments, from the data given in Table below

| Treatment | Weed dry weight ($g/m^2$) | Grain yield (t/ha) |
|---|---|---|
| T1- Bispyribac 20 g/ha | 50.9 | 2.8 |
| T2- Bispyribac 30 g/ha | 46.9 | 2.93 |
| T3- Bispyribac 40 g/ha | 33.4 | 3.37 |
| T4-Weed free | 27.5 | 3.56 |
| T5- Butachlor 1.5 kg/ha | 37.8 | 2.86 |
| T6- Pretilachlor 0.6 kg/ha | 56.9 | 2.55 |
| T7- Weedy check | 100.6 | 0.98 |

***Solution***

(a) Calculation of Weed Index (%)

(i) WI of T1 = $\frac{3.56 - 2.8}{3.56} \times 100 = 21.3$

(ii) WI of T2= $\frac{3.56 - 2.93}{3.56} \times 100 = 17.7$

(iii) WI of T3 = $\frac{3.56 - 3.37}{3.56} \times 100 = 5.3$

(iv) WI of T5= $\frac{3.56 - 2.86}{3.56} \times 100 = 19.7$

(v) WI of T6= $\frac{3.56 - 2.55}{3.56} \times 100 = 28.6$

(vi) WI of T7= $\frac{3.56 - 0.98}{3.56} \times 100 = 72.4$

(b) Calculation of Weed Control index (%)

(i) WCI of T1= $\frac{100.6 - 50.9}{100.6} \times 100 = 49.4$

(ii) WCI of T2= $\frac{100.6 - 46.9}{100.6} \times 100 = 53.4$

(iii) WCI of T3= $\frac{100.6 - 33.4}{100.6} \times 100 = 66.8$

(iv) WCI of T4= $\frac{100.6 - 27.5}{100.6} \times 100 = 72.7$

(v) WCI of T5= $\frac{100.6 - 37.8}{100.6} \times 100 = 62.4$

(vi) WCI of T6= $\frac{100. - 56.9}{100.6} \times 100 = 43.4$

**Practical No. 10 Preparation of a list of commonly available herbicides**

**Objective :** To prepare a list of commonly available herbicides

**List of trade name, formulation 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<br>50% EC, 90% EC<br>80% WP<br>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 horticultural crops**

| **Chemical name** | **Trade name** | **Dose (kg/ha)** | **Time of application** | **Suitable crops** |
|---|---|---|---|---|
| Pendimethalin | Stomp 30% EC | 0.75-1.25 | Pre-emergence | Root crops, Garlic, Brinjal, Cabbage, Broccoli, Onion (transplanted), Chilli, Peas, Tomato, Turmeric, Coriander, Cumin, Gladiolus, Gerbera, Winter annuals |
| Metolachlor | Dual 50% EC | 1.5 | Pre-emergence | Garlic, Onion, Tuberose |
| Oxadiazon | Cropstar 25% EC | 1.5 | Pre-emergence | Garlic, Brinjal, Cabbage, Chilli |
| Alachlor | Lasso 50% EC | 1.25-2.5 | Pre-emergence | Root crops, Brinjal, Cabbage, Onion, Gladiolus, Gerbera |
| Oxyfluorfen | Goal 23.5% EC | 0.15-1.0 | Pre-emergence | Root crops, Brinjal, Cabbage, Onion (transplanted), Chilli, Bell pepper, Gladiolus, Rose |
| Butachlor | Weedar 50% | 1.0-2.0 | Pre-emergence | Root crops, Brinjal, |

| | | | | |
|---|---|---|---|---|
| | EC | | | Gladiolus |
| Metribuzin | Sencor 70% WP | 0.25-0.75 | Pre-emergence | Potato, Tomato, Turmeric, Gladiolus, Rose |
| Atrazine | Atratop 50% WP | 0.35-1.0 | Pre-emergence | Potato, Turmeric, Gladiolus, Rose |
| Diuron | | 1.0 | Pre-emergence | Brinjal, Gerebera |
| Trifluralin | | 0.90 | Pre-emergence | Cabbage, Marigold |
| Fluchloralin | Basalin 45% EC | 0.8-1.5 | Pre plant incorporation | Cauliflower, Chilli |
| Pendimethalin | Stomp 30% EC | 1.0 | Pre plant incorporation | Bell pepper, |
| Oxadiargyl | Top Star 80% WP | 0.09-0.6 | Pre-emergence | Chilli, Onion |
| Imazethapyr | Pursuit 10% SL | 0.15-1.5 | Post-emergence | Peas |
| Quizalofop-ethyl | Targa Super 5% EC | 0.05 | Post-emergence | Peas |
| Glyphosate | Roundup 41% SL | 0.5-2.0 | Post-emergence (directed) | Gladiolus, Rose, Banana, Grapes, Coconut |

**Practical No. 11** **Study on phytotoxicity symptoms of herbicides in different crops**

**Objective :** To study phytotoxicity symptoms of herbicides in different crops
**Materials required :** Sprayer, water, 2,4-D, paraquat, bucket, measuring cylinder etc

Application of herbicides on field crops results some phytotoxicity symptoms. Higher doses of herbicides are also responsible for phytotoxicity. While conducting herbicidal spray utmost care should be taken regarding spray concentration and drift hazard.

**Methodology**:

**Quantitative observation**: These are related observations on the plant height, number of leaves, leaf area, dry matter, time of flowering, ear head size, yield etc.

**Qualitative observations**: These are visual observations on greenness of crop/weeds yellowing necrosis, damaged parts. On the weeds, the observations are quantitative and also qualitative. Quantitative observations are related to weed species associated, their initial numbers and their increase in number (or) frequency, predominant / and dry matter at different time intervals. Qualitative observations like discoloration of leaves, drying of leaves, stunted growth, scorching of leaves, necrosis and drying of entire plants etc. and on their intensity.

Some of the characters on the crop plants are also rated with the observations visually made on the effect of herbicide applied. Another way of rating of damage to herbicide (in %) is given by European Weed Research Council (1976) ratings both on the crops & weeds and is presented in table:

| Ratings | % of crop injury | Verbal description |
|---|---|---|
| 1. | 0 | No injury, no reduction in crop plant number |
| 2. | 1-3.5% | Slight discoloration in the crop |
| 3. | 3.5-7% | Moderate but not lasting damage |
| 4. | 7-12.5% | Moderate and more losing, they need more time to recover |
| 5. | 12.5-20% | Medium and lasting |
| 6. | 20-30% | Heavy damage |
| 7. | 30-50% | Very heavy in reduction in crop stand |
| 8. | 50-90% | Nearly destroyed |
| 9. | 100% | Completely destroyed |

To quantify the herbicide effect like phytotoxic symptoms either on crop or weeds are generally projected with rating starting from 0 to 10 as indicated below: (European weed Research Council (1976)

| Effect or damage observed | Ratings | Description of Phytotoxicity | |
|---|---|---|---|
| | | Weed | Crop |
| No effect | 0 | No weed control | No injury |
| Light effect | 1 | Poor control | Slight leaf discoloration |
| | 2 | Poor control | Some stanch has lost |
| | 3 | Poor deficient control | Injury root pronounced, recovery is possible |
| Moderate | 4 | Deficient Control | Moderate injury, injury is distinct, but recovery is possible |
| | 5 | Deficient-moderate control | Recovery is doubtful, near severe injury |
| | 6 | Moderate control | No recovery is possible |
| Severe | 7 | Satisfactory control | Severe in dry and stand least |
| | 8 | Good control | Almost destroyed s very few plants left |
| | 9 | Good excellent control | Plant may be removed or ploughed |
| | 10 | Complete control | Complete crop destruction. |

**Procedure**

- Carry out spray operation in standing tomato crop with 2,4-D recommended dose.
- Spray paraquat on fenugreek in *Cuscuta* infested field or blanket spray.

**Practical No. 12 : Study on the biology of Purple nutsedge**

**Objective :** To understand the biology of purple nutsedge

- **Common name**: Java grass, nut grass, or purple nutsedge
- **Scientific name**: *Cyperus rotundus*
- **Family**: Cyperaceae
- **Type**: C4 plant
- **Origin**: Native to Africa, southern and central Europe (north to France and Austria), and southern Asia.
- **Means of propagation:** Mainly through the rhizomes and stolons. Through seeds, this weed can reproduce and multiply

**Weed description:**

A perennial from rhizomes and tubers that may reach 2 1/2 feet in height. The stems are 3-sided and triangular in cross section and the leaves are yellow to green in color with a distinct ridge. Found throughout the country as a common weed of agronomic and horticultural crops, nurseries, turfgrass, and landscapes.

**Seedlings**: Seedlings rarely occur. Most plants from rhizomes and/or tubers. Leaves do not have ligules or auricles and have a distinct ridge along the mid-vein, but are nevertheless often mistaken for grasses.

**Leaves**: Dark green in color and have a distinctly shiny appearance. Leaves are 5 to 8 mm wide and have a distinct ridge along the midvein. Leaves are produced in groups of 3 from the base of the plant. Leaves are without hairs (glaucus) and no auricles or ligules are present. The leaves of purple nutsedge taper abruptly to a sharp point, unlike the gradual taper of yellow nutsedge leaves.

**Stems**: Erect, unbranched, and 3-sided and triangular in cross section. Stems are usually solitary and produce terminal spikelets.

**Flowers**: Spikelets occur at the ends of the solitary stems in a cluster where the flower stalks arise from a common point (umbel-like). Individual spikelets are reddish-purple to reddish-brown in colour.

**Roots:** Rhizomes and tubers occur on the same plants. Tubers are oblong, ridged, initially white in color, eventually turning brown or black, and are bitter to the taste. Purple nutsedge produces chains of tubers that develop along the entire rhizome.

**Identifying characteristics**:

Yellow Nutsedge (*Cyperus esculentus*) is very similar in appearance and growth habit to purple nutsedge, and the two are often confused. However, the leaves of yellow nutsedge taper to a point gradually whereas those of purple nutsedge taper to a point abruptly. Additionally, the seedhead of yellow nutsedge is yellow in color, while that of purple nusedge

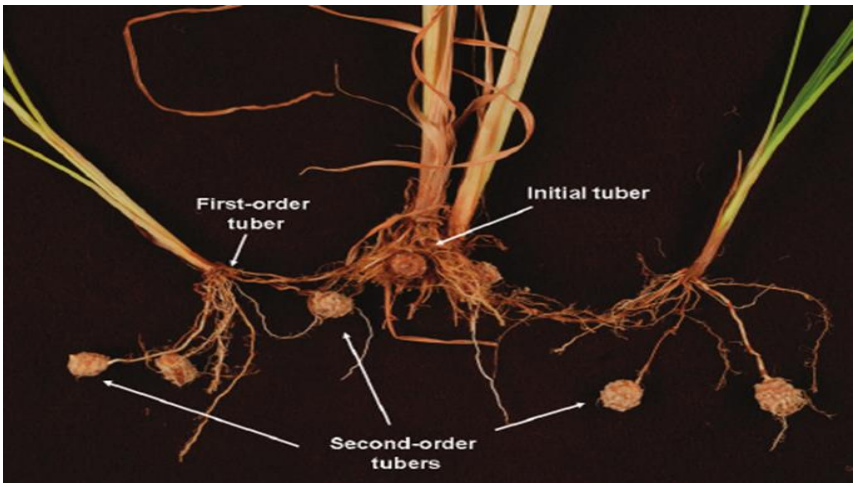
is purple. Lastly, the tubers of purple nutsedge are often connected in chains and bitter to the taste, while those of yellow nutsedge are solitary and sweet to the taste. Rice flatsedge (*Cyperus iria*) and Green Kyllinga (*Kyllinga brevifolia*) are also similar when young, however rice flatsedge has a fibrous root system and green kyllinga has rhizomes that are usually red to purple in color.

**Leaves**

**Stems (cross-section)**

**Flower**

**Seedling**




**Root**

**Fig. 12.1. Different parts of Purple nutsedge**

**Practical No. 13 : Study on the biology of Bermuda grass**

**Objective :** To understand the biology of Bermuda grass

- **Common name:** Bermuda grass, *Dhoob, dūrvā* grass, Bahama grass, Indian doab, etc.
- **Scientific name:** *Cynodon dactylon*
- **Family:** Poaceae
- **Type:** $C_4$ plant
- **Origin:** Europe, Africa, Australia, and Asia. It has been introduced to the Americas.
- **Means of propagation:** Mainly through the rhizomes and stolons. Through seeds, this weed can reproduce and multiply

**Weed description**:

A perennial grass that has both rhizomes and stolons and is capable of forming a turf or mat of fine leaves. Several varieties of Bermuda grass are cultivated for use as lawn and pasture grasses, however this weed has developed into a very troublesome and hard-to-control weed in agronomic crops, landscapes, nurseries, and turf grass.

**Seedling**: Leaves are rolled in the bud, leaf blades are smooth on both surfaces, and the ligules are a row of hairs approximately 1/2 mm long.

**Leaves**: Leaves are rolled in the bud, without auricles, and have a ligule that is a fringe of hairs approximately 1/2 mm long. Hairs occur at least on the leaf margins in the collar region (the region where the leaf blades into the sheath). Leaf blades are approximately 2 to 7 inches long by 2 to 5 mm wide and smooth to only sparsely hairy above but usually only with a few hairs near the leaf base. Leaves emerge from opposite sides of the stem and have margins that are slightly rough.

**Stems**: Leaf sheaths are usually distinctly flattened with relatively long hairs (1 to 3 mm) near the collar only.

**Roots**: Rhizomes and stolons both occur on the same plant. Rhizomes are scaly and often form an almost impenetrable mat. Stolons are flat, smooth, usually bent and root at the nodes.

**Flowers**: Inflorescence consists of 3 to 7 fingerlike spikes that originate from a single point. Individual spikes are approximately 1 to 3 inches long and flattened. Spikelets are arranged in 2 rows on each spike and each of these spikelets produces a single lance-shaped seed (1 -1/2 mm long).

**Identifying characteristics**:

- A persistent grass weed with both scaly rhizomes and stolons that root at the nodes.
- Additionally, the tuft of hairs in the collar region helps to distinguish this weed from most

other grasses.

**Leaves**

**Stems**

**Flower**

**Ligule**

**Nodes**

**Root**

**Fig. 13.1. Different parts of Bermuda grass**

**Practical No. 14 : Study on the biology of Parthenium**

**Objective :** To understand the biology of parthenium

- **Common name:** Carrot grass, Congress grass, or *Gajar Ghas*
- **Scientific name:** *Parthenium hysterophorus*
- **Family:** Asteraceae
- **Type:** $C_3$-$C_4$ intermediate plant
- **Origin:** Native to the American tropics**.**
- **Means of propagation: Seed**

**Weed description**:

It infests pastures and farmland, causing often disastrous loss of yield, as reflected in common names such as famine weed. In some areas, heavy outbreaks have been ubiquitous, affecting livestock and crop production, and human health. The plant produces allelopathic chemicals that suppress crop and pasture plants, and allergens that affect humans and livestock. It also frequently causes pollen allergies. The main substance responsible is parthenin, which is dangerously toxic. It also is responsible for bitter milk disease in livestock when their fodder is polluted with Parthenium leaves. It reproduces by large numbers of seed (10 - 25, 000 per mature plant). These seeds are dispersed by wind, water, animals, vehicles, tools and machinery and on clothing.

**Seedlings**: Normally germinate in spring and early summer with the onset of rain. A young seedling showing expanded cotyledons and with the first true leaves emerging.

**Rosette Stage**: Showing radial arrangement of leave sat ground level.

**Mature Plant**: Parthenium weed is an annual herb with a deep tap root and an erect main stem that becomes woody with age. As the plant matures, it produces many branches with flowers and may eventually reach a height of 2 m. Under favorable conditions it can germinate, mature and set seed in 4 weeks.

**Flowers**: Are star-shaped with a white to creamy-white appearance. They are produced at the tips of the upper branches. Colour changes to light brown when seeds are mature and about to shed. Flowers have five petals like ray florets, each bearing a single seed. Ribbed Stem: Mature stems are longitudinally grooved and covered with fine hairs.

**Juvenile Leaves**: A newly-emerged pubescent leaf (covered with fine hairs). Young leaves typically show prominent veins.

**Ribbed Stem**: Mature stems are longitudinally grooved and covered with fine hairs. Mature

**Leaf**: A mature, pale green and deeply-lobed lower leaf. Mature leaves are branched alternately on the stems and are less hairy than young leaves.

**Fruit and Seeds**: Seeds are flattened achenes, dark brown to black in colour with white appendages. The seeds are protected in a straw-coloured fruit covering. A single plant can produce up to 28,000 seeds which are spread by vehicles, machinery, animals, pasture and crop seed lots, stock feed, wind and water.

**Leaves**

**Seedling**

**Flower**

**Seed**

**Mature plant**

**Fig. 14.1. Parts of Parthenium**

**Practical No. 15 : Study on the biology of Celosia**

**Objective :** To the biology of Celosia

- **Common name:** White cock's comb
- **Scientific name:** *Celosia argentea*
- **Family:** Amaranthaceae

**Weed Description:**

*Celosia argentea* (Syn. *C. plumosa, C. argentea. var plumosa*) is a tender annual that is often grown in gardens. It is propagated by seeds. It is erect plant and grows to a height of 1.0 to 1.6 m under favorable condition.

**Stem:** Ridged, glabrous, branches up to 25 per plant, ascending**.**

**Leaves:** Alternate, simple and decreasing in size with height of the plant**.**

**Root:** It has numerous lateral roots below the soil surface. These enable it to efficiently absorb nutrients from the soil. Inflorescence: a dense, many-flowered spike, at first conical but becoming cylindrical, up to 20 cm long, bracteate, silvery to pink, in ornamental forms completely or partly sterile and in many colours**.**

**Seeds:** The seeds are extremely small. It produces 2,000 to 3,000 seed/ plant which add to the soil seed bank.

**Fig. 15.1. Plant and flower of Celosia**

**Practical No. 16 : Calculation of economics of the weed control practices**

**Objective :** To analyse the economics (returns and benefit cost ratio) of weed control practices

For calculating total variable costs, the total costs of cultivation (i.e. total variable costs) were taken into account for both the experiments. Cost of cultivation varied with the treatments applied. The cost of cultivation included money spends on seed, fertilizers, seed inoculation, weed management practices, human labour, insecticides, irrigation etc.

| **Variable inputs** | **Quantity /ha** | **Price (Rs) /unit** | **Total** |
|---|---|---|---|
| a) Seed & seed treatment<br>i) Seed<br>ii) Fungicide/Insecticide<br>iii) Biofertilizer | | | |
| b) Fertilizer<br>i) Urea<br>ii) SSP | | | |
| c) Plant Protection<br>i) Indocarb<br>ii) Triazophos | | | |
| d) Miscellanous<br>i) Irrigation<br>ii) Labour (mandays)<br>iii) Tractor operation (hours) | | | |
| **Cost of variable inputs:** | | | **A** |
| e) Weed management practice 1<br>i) Herbicide (Pendimethalin @ 0.45 kg/ha)<br>ii) Handweeding at 30 DAS (mandays) | | | |
| **Cost of weed management practice :** | | | **B** |
| **Total cost of variable inputs = A + B** | | | |

**Gross returns**

For calculating gross returns, the grain yield was multiplied by minimum support price (MSP) and the stover yield was multiplied with prevalent market price.

**Net returns**

Net returns were calculated by subtracting total variable costs from the gross returns. It was expressed as Rs/ha.

Net returns = Gross returns – Total variable costs (A + B)

**Benefit cost ratio**

The benefit cost ratio was calculated by dividing the net returns with the variable costs.

Benefit cost ratio= Net returns ÷ Total variable costs (A + B)

Exercise: Comparative economic analysis of two weed management practices in mungbean

| **Variable inputs** | **Quantity /ha** | **Price (Rs) /unit** | **Total** |
|---|---|---|---|
| a) Seed & seed treatment | | | |
| i) Seed | 20 kg | 100/kg | 2000 |
| ii) Fungicide/Insecticide | 60 g | 600/kg | 36 |
| iii) Biofertilizer | 2.5 pkts | 100/pkt | 250 |
| b) Fertilizer | | | |
| i) Urea | 27 kg | 544/q | 150 |
| ii) SSP | 250 kg | 660/q | 1650 |
| c) Plant Protection | | | |
| i) Indocarb | 500 ml | 2200/l | 1100 |
| ii) Triazophos | 1.5 l | 420/l | 630 |
| d) Miscellanous | | | |
| i) Irrigation | 2 | 200 | 400 |
| ii) Labour (mandays) | 50 | 300/ manday | 15000 |
| iii) Tractor operation (hours) | 7.5 hrs | 360/hrs | 2700 |
| **Cost of variable inputs:** | | | **23916** |
| e) Weed management practice 1 | | | |
| i) Herbicide (Pendimethalin @ 0.45 kg/ha) | 1.5 l | 600/l | 900 |
| ii) Handweeding at 30 DAS (mandays) | 15 | 300/ manday | 4500 |
| **Cost of weed management practice 1:** | | | **5400** |
| **Total cost of cultivation = 23916 + 5400 = 29316** | | | |

a) Grain yield = 1200 kg Market price of mungbean grain = Rs 50/kg
b) Stover yield = 3000 kg Market price of mungbean grain = Rs 1/kg
c) Gross return (Rs/ha) = (1200 x 50) + (3000 x 1) = 60000 + 3000 = 63000
d) Net return (Rs/ha) = 63000 – 29316 = 33684
e) Benefit-Cost ratio = 33684/29316 = 1.15

| **Variable inputs** | **Quantity /ha** | **Price (Rs) /unit** | **Total** |
|---|---|---|---|
| a) Seed & seed treatment | | | |
| i) Seed | 20 kg | 100/kg | 2000 |
| ii) Fungicide/Insecticide | 60 g | 600/kg | 36 |
| iii) Biofertilizer | 2.5 pkts | 100/pkt | 250 |
| b) Fertilizer | | | |
| i) Urea | 27 kg | 544/q | 150 |
| ii) SSP | 250 kg | 660/q | 1650 |
| c) Plant Protection | | | |

| | | | |
|---|---|---|---|
| i) Indocarb<br>ii) Triazophos | 500 ml<br>1.5 l | 2200/l<br>420/l | 1100<br>630 |
| d) Miscellanous<br>i) Irrigation<br>ii) Labour (mandays)<br>iii) Tractor operation (hours) | <br>2<br>50<br>7.5 hrs | <br>200<br>300/ manday<br>360/hrs | <br>400<br>15000<br>2700 |
| **Cost of variable inputs:** | | | **23916** |
| f) Weed management practice 2<br>i) Handweeding at 30 & 45 DAS (mandays) | <br>30 | <br>300/ manday | <br>9000 |
| **Cost of weed management practice 2:** | | | **9000** |
| **Total cost of cultivation = 23916 + 9000 = 32916** | | | |

a) Grain yield = 1300 kg Market price of mungbean grain = Rs 50/kg
b) Stover yield = 3200 kg Market price of mungbean grain = Rs 1/kg
c) Gross return (Rs/ha) = (1300 x 50) + (3200 x 1) = 65000 + 3200 = 68200
d) Net return (Rs/ha) = 68200 – 32916 = 35284
e) Benefit-Cost ratio = 35284/32916 = 1.07

**Practical No. 17 Visit of problem areas**

**Objective :** To visit areas infested by weeds and their identification
**Materials required :** Notebook, pen, pencil, etc.

A field trip provides an opportunity to students to acquaint themselves with the important crops and weeds of the farm. They are able to know the kind, diversity and severe of weeds to an area. Similarly, they can also observe other activities going on at the farm.

Materials: Note book, pencil, pen etc.

**Procedure**

- Carry all the necessary things.
- After arrival at the site, contact the farm manager.
- Introduce yourself with the farm manager and discuss about the purpose of visit.
- Note down the crop being grown in the problem areas. Also note down the weeds of the locality.

**Observations**:

Name of the field : .....
Characteristics of the soil: .....
Texture: .....
pH: .....
Season (*kharif* / *rabi /zaid* ) : .....
Rainfed / irrigated : .....
Source of irrigation (if irrigated): .....
Name of the crops cultivated: .....
Weed flora present in the locality: .....

| **Annual** | **Biennial** | **Perennial** |
|---|---|---|
| | | |
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