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A PRACTICAL MANUAL ON WEED MANAGEMENT IN HORTICULTURAL CROPS

(As per recommendations of 4th dean's committee)

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A Practical Manual on Weed Management in Horticultural Crops

As per guideline of B.Sc (Horticulture) Course

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PREFACE

Weeds are the major deterrent to the development of more sustainable agricultural systems. They compete with the crop plants for nutrients, moisture , solar radiation and space when they are limited and reduce the crop yield and quality. Removing weeds at any time during growing season may not be beneficial . Weed management in different crops require and integrated approach that utilizes effective preventive, cultural, mechanical, biological, ecological and chemical methods in a mutually supported manner with due consideration of economic, environmental and sociological consequences.

Agriculture education in the country is being recognized by implementing the revised course as the recommendation of the 4th dean's committee with main emphasis on practical training. The practical portion can be strengthen by updated laboratories , instructional farm and literature i.e. manuals for better understanding about the pin points of weed management for horticulture crops. An endeavor has been made through this manual by covering all aspect of weed management based on bonafide syllabus.

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VINAMARTA JAIN

CONTENT

Basic weed identification tools

Exercise - 1
Identification of weeds

Identify weeds with the help of a good field guide, manual, or taxonomic key to the agricultural weeds in your region. Collect a representative specimen or several specimens (recommended), and examine them closely, including foliage, stem, flowers, roots, and other belowground parts. Familiarize yourself with some of the jargon used in your field guide or key (most references have a glossary of terms).

Objectives

1. Weeds identification through laminations
2. Weeds identification through images
3. Weeds identification in field

S. No.	Common name	Scientific Name	Family
1.	Carrot grass	*Parthenium hysterophorus*	Asteraceae
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
13.			
14.			
15.			

Exercise - 2

Survey of weeds in crop fields and other habitats

Objectives

1. Survey of weeds in different habitats
2. Survey of weeds in crops and cropping systems

S.No.	Common name	Scientific name	Propagation	Annual/Binnial/Perrinial

Exercise - 3
Collection of weed specimens and Preparation of Herbarium

Herbarium is a collection of plants that are dried, pressed and preserved on herbarium sheets and arranged in sequence in accordance of specific purpose for future reference, record and study. Or

Herbarium is the collection of weeds and it is essential so that one can know about the morphology and biology of weed, just for effective control of weeds under field condition.

Objectives

1. How to collect weed specimens.
2. Steps in preparation of herbarium.

Materials required

1) Sharp knife / scalpel - for cutting
2) Vasculum - It is a container made up of wood having a lid to keep the specimen in turgid condition.
3) Plant press
4) A weed note book

Herbarium collection

1) Collect the plant material at flowering stage
2) It is desirable to maintain all the plant parts intact (leaf, stem, flowers, fruits)
3) Collect fresh part of the plant but not diseased preferably apical part.

Herbarium pressing and drying

- The wooden press board consist of 2 wooden plates of 12"x13" each which are tighten with nuts on bolts for pressing.
- Placing each of the collected specimen in between the folds of the newspaper for blotting.
- Ensure that plant is maintained.
- The specimen in newspaper folds are to be arranged on the lower part of the pressing board.
- Place upper plate on the top and tighten upper and lower parts with nuts and bolts.
- Keep the specimen for 24 hrs for sweating of moisture. This is called as Sweating period.
- Ensure that the specimen is spread in the newspaper folds and if necessary the top portion should be bent during pressing.
- The large specimens are to be cut in 2 to 3 parts according to convenience the cut parts are to be arranged on separate sheets. If the specimen can't be directly dried they have to be preserved by preservatories.
- If the foliage is very thick, it has to be pruned assuring that the portion of the cut parts are identified.
- If the leaf is large, cut it vertically into 2 halves use one of the portion as specimen.
- The newspaper/bolting paper changed after 12 hrs in first incidence and these after 24 hrs, 48 hrs and 72 hrs is done till the specimen is dried completely. This is called Natural drying.
- In artificial drying, after sweating period specimens are direct in hot air oven by maintaining 62^{0}C.

Herbarium mountings

- Thick herbarium sheets of 11 ½" x 16 ½ " are used for mounting.
- Keep the specimen in centre and spread properly.
- Fix the specimen to the mounting sheet with glue / gum / tape.

Herbarium labeling

- Label the specimen in the space provided 4 ½ x 3 ½ on lower right side of the herbarium sheets.
- The label information should have details of botanical name, local name, family, habit, habitat and name of the student.
- Arrange the herbarium by group into terrestrial and aquatic weeds, sub group them into monocots and dicots and further into annuals, biennials and perennials.
- Number the herbarium sheets, serially on the top right corner of the sheet.
- Write the index for it.

Exercise - 4

Calculation of weed infestation, weed index, weed control efficiency and weed smothering efficiency

The common indices use for weed flora study are weed infestation, weed index, weed control efficiency and weed smothering efficiency.

Objectives :

- To study the weed and crop responses to weed control treatments.
- To study efficacy of herbicide.
- To determine the efficiency of intercropping systems in suppression

Weed Infestation :

It refers to the percentage of weed in the composite population of weed and plants.

$$\text{Weed infestation (\%)} = \frac{\text{Total number of weeds in an unit area}}{\text{Total no. of weed and crop plant in the same area}} \times 100$$

Weed index: It refer to the reduction in yield due to presence of weed in comparison of weed free plot.

$$\text{Weed Index} = \frac{\text{Yield from weed free plot - yield from treated plot}}{\text{Yield from weed free (hand weeded) plot}} \times 100$$

Example : Calculate the weed index for atrazine and simazine in the maize from the following data.

(1) Yield from maize in weed free plot = 20g
(2) Yield from maize in atrazine treated plot = 18g
(3) Yield from maize in simazine Treated plot = 19g

Calculation

$$\text{Weed Index for atrazine} - \frac{20-18}{20} \times 100 = 10\%$$

$$\text{Weed Index for Simazine} - \frac{20-19}{20} \times 100 = 5\%$$

Weed index is less for simazine, compared to atrazine, therefore, simazine to be applied in maize for effective control of weeds.

(3) Weed control efficiency: It indicates the percentage reduction in weed population or dry weight of weeds under treated plot (herbicide) in comparison to treated plot. This index is used to compare he different weed control treatments. It is also known as weed control index. Higher the WCE, better is the herbicidal /weed control treatments.

$$WCE\,(\%) = \frac{\text{Weed count in weedy plot - Weed Count in treated plot}}{\text{Weed count in weedy plot}} \times 100$$

Eg-In an weed control experiment in wheat crop , dry weight of weeds in unweeded plots was 500 kg/ha , whereas in isoproturon and metsulfuron treated plot was 210 and 145 Kg. find out the weed control efficiency.

$$\text{WCE for isoproturon} = \frac{450 - 210}{450} \times 100$$

$$= 53.3\%$$

$$\text{WCE for Metsulfuron} = \frac{450 - 145}{450} \times 100$$

$$= 67\%$$

Weed smothering efficiency : This index is used to determine the effect of intercropping on suppression of weeds in comparison to sole crop stand.

$$WSE\,(\%) = \frac{\text{Weed dry weight in sole crop stand - Weed dry weight in intercropped plots}}{\text{Dry matter of weeds in sole crop stand}} \times 100$$

Study of weed population

For accurate estimation of losses caused by weeds and selection of right method of weed control for a given environment ,it is essential to find out the weeds cover in the field.

Procedure

Quadrate sampling is the most common method for obtaining various types of data on weed cover. In general , a square quadrate measuring 1 x 1 m is sufficient to represent the composition of an agricultural field. Select a field or sample area for study of weed flora. Randomly put the quadrate in different plots and note down the observations

Plant species	No. of plant in given quadrate (number)					Total no. of plant	No. of quadrate of occurrence	Total no. of quadrate studied
	1	2	3	4	5			
Cynodon dactylon								
Madicago Spp								
Amarathus viridis								

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

$$\text{Density} = \frac{\text{Total number of weeds in all quadrates}}{\text{Total number of quadrate studied}} \times 100$$

$$\text{Relative density} = \frac{\text{Number of individual species of a given weed species}}{\text{Total number of individual of all the weed species}} \times 100$$

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

$$\text{Frequency} = \frac{\text{Total of quaderate of occurrence of a species}}{\text{Total number of quaderate studied}} \times 100$$

$$\text{Relative frequency} = \frac{\text{Frequency of a given weed species}}{\text{Sum of frequency of all weed species}} \times 100$$

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

Dominance = Average basal area of a given weed species x density

$$\text{Relative dominance} = \frac{\text{Dominance of a weed species}}{\text{Dominance of all weed species}} \times 100$$

Weed biomass = Ralative dry weight of weeds is

$$\text{Ralative dry weight} = \frac{\text{Dry weight of a given weed species}}{\text{Total dry weight of all weed species}} \times 100$$

Important value index: It is used to express the over all dominance and ecological success of a given weed species over others in a community with a single value.

$$\textbf{IVI} = \frac{\text{Relative weed density} + \text{Relative frequency} + \text{Relative weed dominance}}{3}$$

Exercise - 5
Herbicide label information

The information on a pesticide label is very important. It helps applicators make sound decisions on pesticide storage, handling, application, and disposal. Every pesticide container carries certain information on its label. It includes the trade name, technical name, composition, manufacturer's address, registered uses, date of packing, date of expiry, and toxicity label, and is mandatory under the Insecticide Act, 1968.

Material safety data sheets (MSDSs) are developed by product manufacturers. These are a major source of information on pesticides. MSDSs are not legal documents. The information on a MSDS is based on research data. This supports label information. MSDSs also have information to protect human health and the environment. MSDSs help applicators to make informed decisions on handling, applying, and storing pesticides.

Objectives

1. To acquaint with the information on pesticide product labels.
2. To use the information on Material Safety Data Sheets (MSDSs).

Components of a Label

1. The front or principal display panel 2. The back or secondary display pan

Principal Display Panel

The principal display panel is the front of a pesticide product label. There are nine items on the principal display panel

List of items on principal display panel

1. Trade name or product name
2. Class designation
3. Use or purpose
4. Registration number (P.C.P. Act number)
5. Guarantee statement
6. Directions to read the label
7. Precautionary shapes, symbols, and pictograms
8. Net contents
9. Name and address of the registrant

List of items on secondary display panel

10 Directions for use
11 Precaution statements
12 Disposal methods
13 First aid
14 Toxicological information
15 Notice to user
16 Notice to buyer

Material safety data sheets (MSDSs)

A Material Safety Data Sheet (MSDS) provides information on health hazards, personal safety, and environmental protection for hazardous products. They are divided into nine sections.

1. **Product information :** Product information gives the trade name, chemical name, and primary use of the Product.
2. **Hazardous ingredients :** The active ingredient is listed in this section
3. **Physical data :** Physical data includes information on a product's appearance, odour, specific gravity, pH, boiling point, etc.
4. **Occupational procedures and prevention measures :** Occupational procedures and prevention measures provide information on safe handling and storage.
5. **First aid and emergency procedures :** First aid and emergency procedures explain what to do if someone is exposed to the product.
6. Fire and explosion hazard
7. **Reactivity data :** Special chemical properties of the product are given in this section. Acceptable storage temperatures are listed for the product.
8. **Preparation date and group :** This section tells who prepared the MSDS and when it was done. MSDS s must be updated at least every three years, or within 3 months if a pesticide is changed.

Exercise - 6
Determination of commercial quantity of herbicides

Herbicides are not substitution for physical, biological or good crop husbandry methods. They are used to bridge the gaps in these methods and herbicides are act as added production tools in agriculture. Herbicides have ample scope to use on both crop lands and non-cropland. On croplands total quantity of chemical reaching the target area, where as in non-cropped area herbicide rates in terms of their spray concentration.

Over rates of herbicides may injure the leaf vascular tissues and there by reduce the translocation of the applied herbicide to the weed roots. Under rates reduce control of all types of weeds. Uneven application of a herbicide may result in "hot spots" of localized over rates causing injury to the crop plants and "cold spots" of localized under rates, where poor or no weed control is obtained.

Objectives

1) To calculate correct dose of herbicide
2) To study the different aspects (carrier, spray volume) related to herbicide dosage calculations.

Rate of application: It is the amount of active ingredient or acid equivalent of herbicide applied to a unit area of land or water body. It is usually given in terms of kg ai / a.e / ha.

Active ingredient (ai): A chemical in commercial product that is directly responsible for its herbicidal effect is called active ingredient. It is also given as percent by weight or volume. Eg. Herbicide concentrate 40% w/v contains 400g of active ingredient per litre of the liquid product.

$$\text{The amount of commercial product} = \frac{\text{Recommended dose}}{\text{active ingradient in product (a.i/a.e)}} \times 100$$

Acid equivalent (a.e): Refers to that part of a formulation that theoretically can be converted to the acid. Eg. Some herbicide structures are active organic acids. Eg. Phenoxyalkanoic, picloram, chloramben, cacodylic acid.

But they are prepared in the form of their salts and esters for the ease of their field application. Eg: For instance 2,4-D in acid form is water insoluble then we have to use its sodium and amine salts and esters. The acid equivalent (a.e) of sodium salt of 2,4-D is 92.5%. It indicates that 2,4-D dichloro phenoxy acetic acid is 92.5% in sodium salt of 2,4-D.

Liquid formulations may indicate both per cent active ingredient or acid equivalent on weight per litre. In such cases, the concentration in terms of acid equivalent may be considered. A commercial formulation of 2,4-D containing 700 g of deiethanolamine salt per litre would have a concentration of a.i 70 per cent, but the concentration in terms of acid equivalent will be a concentration of a.i 70 per cent, but the concentration in terms of acid equivalent will be

$$= 70 \times \frac{\text{Molecular wt. of 2,4 - D acid}}{\text{Molecular wt. of 2,4 deiethanolamine}} = 70 \times \frac{221}{326} = 47.44\%$$

The acid equivalent of a concentrate is always less than its content of a.i.

Career (Diluents) : It is solid or liquid material used to increase the volume of a chemical compound. So it can be applied uniformly over the target area. The universal career of herbicide is water because of its negligible cost and freedom from interactions. Sometimes career oils are also used for a quick knock down effect of weeds in non-cropped area. Hard water should not be used for spraying as it may precipitate the herbicides.

Volume

It refers to total quantity of liquid applied per unit area. The quantity of toxicant reaching the target weed or soil is more important than spray volume as much as. The toxicant is uniformly distributed over the target area. The spray volumes for herbicides have been classified into 5 classes from high volume to ultra low volume sprays. The high volume spray provides thorough coverage of target plants to the point of runoff or drip. Eg: contact herbicides. But translocated herbicides should be applied in low or medium volume sprays, because it is not necessary to wet the foliage completely. In dry weather, high spray volumes may prove superior to low volume sprays. High volume sprays are necessary to improve the solubility or suspend ability of a herbicides.

The quantity of herbicide formulation or commercial products depends upon the type of formulation, per cent active ingredient, area to be sprayed and volume of water to be used.

Material

Herbicide formulation, area to be treated, measuring tape, weighing balance etc.

Procedure

All the herbicide recommendations are based on active ingredient (a.i.) until and unless specified. If a.i. is known, herbicide requirement can be determined by using the following formula.

$$\text{Commercial quantity} = \frac{\text{Recommended dose (kg a.i./ha) X Area to be treated (ha)}}{\text{\% a.i. in the formulation}} \times 100$$

Example : Determine the commercial quantity of glyphosate (Glycel 41 % SL) required to treat 2.0 ha non cropped land, if the recommendation of glyphosate is 2.0 a.i. /ha.

$$\text{Quantity of herbicide required} = \frac{2.0 \times 2.0 \text{ (ha)}}{41} \times 100 = 9.75$$

Exercise - 7
Study of herbicide application equipment

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:

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:

The pumps force air into an air tight tank containing spray liquids thus moving 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 to carry. The tank is provided with a large opening fitted with a strainer and cap to fill in the liquid. Small openings have difficult to fill in liquid an clean the tank.

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 be used to apply pesticide emulsion and suspension.

5. Distribution System:

It includes

i) Nozzle
ii) Spray lance
iii) Spray boom
iv) House

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 band 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 fan like 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 and fitted to its free and 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 trip of the sprayer over the field. Total width of land wetted by a boom can be adjusted to 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) Knapsac Sprayers:

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 Knapsac 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.

ii) Pneumatic or compressed system Knapsac:

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

Knapsac blower are:

1. Low volume spray. Loss 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 Knapsac blowers.
   Liquid - 60 liters / ha swath 7 to 8 m.

B. Foot Sprayer / Pedal Pump Sprayers:

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, Luck now 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. Acrial sprayers:

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

Maintenance and Cleaning of Sprayers

Maintenance 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 each 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 small brush.
2. Mix one box of detergent with 30 gallons of water in tank. Circulate through by pass system or 30 minutes and the drain out.
3. Replace the screens and the boom extensions.
4. Fill the tank one half with 2% household ammonia Circulate this mixture through the pump and nozzles. Let the remaining solution stand over night 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.

Exercise - 8
Calibration of Sprayer

The main aim of caliberation is to adjust the application presser. Prorer application of herbicide depend upon the proper adjustment of all the basic component of sprayer. For uniform spraying of herbicide it is necessary to caliberated the amount at water to be applied, walking speed, pressure to be maintained.

Objective

1. To calibrate the sprayer for uniform application.
2. To learn about operational difficulties of a sprayer
3. To Calculate the requirement of spray volume and related factor.

Materials - Sprayer, buckets, water, measuring tape, graduated cylinder, stop watch etc.

Method of caliberation

Sprayer

(1) Remove and clean the nozzle.
(2) Rinse the sprayers and fill up with clean water.
(3) Build up pressure and cheek up for leak age.
(4) Flush pump, hose pipe and lance with clean water after removing nozzle and strainers.
(5) Readjust the nozzle and strainers.
(6) Refill tank.

Now sprayer is ready for spray operation.

Determination of nozzle discharge

1. Keep the sprayer on the ground fill up with water and built up the pressure.
2. Now take a bucket and dip the nozzle in it. Spray water for 5 minute into the bucket. Shut off the valve exactly at the end of five minute.
3. Measure volume of water collected in bucket with the help of graduated cylinder.
4. Repeat the Operation three times.
5. 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 50 sq. metre with the help of a measuring tape . Spray the water in this measured area of 50 sq. m. Determine the Volume of spray delivered from the tank .

Determination of Wallking Speed

1. Make a Starting point on bare soil Surface with a Stake.
2. Adjust the Prepared Sprayer on the back and operate pumping, directing lance and nozzle within Spray swath.

3. Wake at a normal and Constant Speed for Five Minutes.
4. Measure the distance Covered in five minutes.
5. Repeat the operation for three times .
6. Express the average walking speed in metre/minute.
7. Do the same operation in the cropped land 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 at a fixed height). The Spray lance could be hold firmly While Walking forward but could be swing form left to right.

Observation -

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

(1) Total distance travelled = d (in meter)
(2) Time taken for travelling distance "d" metre = t (in minute) .
(3) Swath Width = X metre
(4) Amount of water discharged at a given pressure = 1 (litre).

Calculate the application rate

Calculate the amount of water required for 1 ha from the following relationship.

$$\textbf{Volume of water required (L/ha)} = \frac{\text{Volume sprayed (l)}}{\text{Area sprayed (ha)}}$$

$$\textbf{Area sprayed (ha)} = \frac{\text{spray swath (m) x distance travelled (m)}}{10{,}000}$$

Eg: - The following details have been generated from a sprayer calibration attempt. Spray swath – 1.2 m; distance traveled – 60 ,; and volume sprayed – 3L. Calculate the volume of water required for spraying 1 ha.

$$\text{Amount of water required for 1 ha} = \frac{3 \times 10{,}000}{1.2 \times 60} = 417 \text{ litres.}$$

As a next step calculate the number of sprayer loads required for 1 ha.

$$\text{Number of sprayer loads/ha} = \frac{\text{Volume of spray solution required (l)}}{\text{Sprayer capacity (l)}}$$

In the above example, if the sprayer capacity is 13 litres, then

$$\text{Number of spray loads/ha} = \frac{417}{13} = 32$$

Exercise - 9
METHODS OF APPLICATION OF HERBICIDES

Methods of application of herbicides are decided largely by their modes of action and selectivity. environmental factors, convenience and cost are other important factors in deciding the method of application of a herbicide. An improper method of application of a herbicide can result in poor weed control and/ or severe crop injury. Important methods of application of herbicides to crop and non-crop lands are given below.

Soil Application of Herbicides

Surface Application: Soil-active herbicides are commonly applied to the surface of the soil where they may be either left undisturbed or incorporated into the soil, physically. Even when left on the soil surface, the applied herbicide should be able to move into upper 3.5 to 4 cm of soil under the influence of rain (or irrigation) to kill the germinating weeds Many substituted triazine, urea and anilide herbicides form our common surface applied herbicides in crop production.

Sub-Surface Layering: It is the application of a herbicide in a concentrated band, about 7-10 cm below the soil surface. The technique has proved effective in controlling certain perennial weeds with conventionally, soil-incorporated herbicides which are usually employed to control only annual weeds.

Broadcast and Band Application: Broadcast application of herbicides is their application over the full surface area, without leaving any intentional gaps. In variance with it, the band application of a herbicide constitutes its application to a restricted band along the crop rows, leaving an untreated band in the inter-rows. The band application of herbicides is primarily a cost saving device since it reduces the quantity of herbicide in the ratio of the treated band width to the crop row width.

In the band method of application of herbicides the inter-rows must be cultivated later to remove weeds from the unsprayed areas. This will also help in the control of perennial, and some other weeds, which may be resistant to the herbicide.

Soil Fumigation: Depending upon the nature of the soil fumigant, it can be applied either (1) by soil injection (Ex. Chloropicrin); (2) by releasing it under sealed, plastic covers (Ex. Methyl bromide); or (3) by direct soil surface application (Ex. Metham).

Foliage of Application of Herbicides

1. **Blanket Application:** Blanket (or over-the-top) application of herbicides is their uniform application to standing crops with disregard to the location of the crop plants. Only highly selective herbicides are applied by this method eg 2,4-D in wheat, MCPB in pea, 2,4-DB in Lucerne,
2. **Directed Spraying:** It is the application of herbicides to chiefly weeds growing in the inter-rows of crops, avoiding the crop foliage as much as possible. Directed spraying is accomplished by setting nozzles low with spray patterns fashioned to intersect at the base of crop plants, just above the soil line. This saves the crop plants from herbicide injury and improves weed kill. In potato and soybean, vine-lifters are used to improve the accuracy of directed spraying

Protected Spraying: Non-selective herbicides can be employed to obtain selective weed control in distantly planted vegetables and ornamentals by covering the non-target plants before application of the herbicide with plastic or metallic covers. This can be done in 3-4 rows at a time and shifting the covers to the untreated rows each time. This method is called protected spraying.

Spot treatment: Spot treatment is the application of herbicides to small patches of weeds, leaving the weed free gaps untreated. The method is used for treating patches of noxious, perennial weeds in certain crop fields with potent herbicides.

TYPES OF HERBICIDE TREATMENTS

Pre-plant treatment: herbicide treatment made any time before the crop is planted is called a preplant treatment. There are two types of pre-plant treatments, namely (a) pre plant desiccation and (b) preplant incorporation treatrnent.

Pre emergence treatment: Application of a herbicide soon after planting of the crop, when neither the weeds nor the crop have germinated, is called pre emergence treatment.

Post emergence treatment: Post emergence treatment is the application of herbicide after the emergence of both the crops and the weeds. But when the weeds grow before the crop plants have emerged through the soil, and these are knocked with a herbicide, the treatment is called early post emergence treatment

Lay-by application: It is the application of herbicides after the last cultivation in cops, such as, after ridging in sugarcane and cotton.

PRECAUTIONS IN STORAGE AND HANDLING OF HERBICIDES

- Store herbicides away from fertilizers, seeds, food, feed, and children, in cool and well ventilated places.
- The left-over herbicides must be retained in original, well labeled containers.
- The container must be closed airtight to avoid herbicide caking, oxidation and fuming.
- The herbicide stores must be checked periodically for possible leaks.
- While preparing to use a herbicide, read the label carefully. Do not transport herbicides from store to the field on body; better use a hand trolley
- Prepare herbicide dilutions in open spaces, away from source of irrigation water.
- Wear rubber gloves, a pair of eye glasses, and cover your nose with a cloth.
- Always use a stick to stir herbicide solutions, and never your hand.
- Bury the empty containers deep in any wasteland.
- Keep lots of fresh water and soap handy to meet any emergency.
- In the tropics, a pair of shoes, gloves, sunglasses, a light head dress, and a cloth put around the mouth and nose, can be considered adequate precautions;
- Each worker must wear a long sleeve shirt and full trousers.
- Do not smoke or eat during and in-between the spray intervals.
- Also, never use mouth to blow the clogged nozzles.
- Bathe and wash the clothes thoroughly as soon the spray work is over for the day.
- If there is an accident, provide first aid to the patient and contact the nearest doctor at the same time.
- Lie down the patient in shade and remove his all tight clothings and masks.
- Wash the affected body parts immediately with plenty of fresh water and soap (do not use soap in the affected eyes).
- In the case of oral intake of a herbicide, induce quick vomiting by any locally available method.
- When a toxic herbicide has been inhaled, wash the nose and ask the patient to gargle with fresh water.
- Do not surround the patient, give him artificial breathing, if needed.
- When the doctor arrives, he must be shown all available literature of the herbicide in question to enable him to choose a proper antidote.
- Usually antidotes are available
- Avoid herbicide drifts from reaching the non-target crops, wild life and man.

An octagon on the label indicates an extreme hazard. The signal word "danger" is associated with it.

A diamond indicates a moderate hazard. This has the signal word "warning" associated with it.

An upside-down triangle indicates a slight hazard. This has the signal word "caution" associated with it.

Precautionary Shapes

A skull and crossbones on a label indicates that a product is a poison.

A flame indicates that a product is flammable.

A bony hand indicates that a product is corrosive.

An explosion symbol indicates that a product is explosive.

Exercise - 10

Study of trade name, formulation and source of herbicides

Objective

1. To acquaint about common herbicides
2. To demonstrate the herbicide to the students
3. To relate the use of herbicide to an economic base

List of commonly available herbicides

Common name	Trade name	Formulation and a.i.	Source
Alachlor	Lasso	50 EC	Monsanto
Anilophos	Aniloguard, Arozin	30 EC	Bayer
Atrazine	Atrataf	50 WP	Bayer
Butachlor	Machete	0 EC	Coromandal
Chlorimuron - ethyl	Kloben	25 WP	Dupont
Chlorimuron ethyl+ metsulfuron methyl	Almix	20 WP	Dupont
Clodinafop propergyl	Topic	15 WP	Syngenta
Chlorsulfuron	Glean	75 WP	Dupont
Clomazone	Command	50 EC	Rallis
Diuron	Karmex	80 WP	Dupont
Fluchloralin	Basalin	45 EC	BASF
Fenoxaprop-ethyl	Puma super	10 EC	Aventis
Fluazifop butyl	Fusilade	9 EC	Syngenta
Glyphosate	Round up, Glycel	41 EC	Monsanto
Glyphosinate-Ammonium	Basta, Liberty	15 SL	Aventis
Isoproturon	Arelon	50 and 75 WP	Dupont/Gharda
Imazethapyr	Pursuit	10 EC	Cynamide
Lactofen	Cobra	24 EC	Aventis
Linuron	Afalon	50 WP	Aventis
Metolachlor	Dual	70 WP	Syngenta
Metribuzin	Sencor	70 WP	Bayer
Metoxuron	Dosanex	20 WP	Searl Ind. Ltd.
Metsulfuron-methyl	Algrip	25 EC	Dupont
Oxadiozone	Ronstar	23.5 EC	Rhon-Poulenc
Oxyfluorfen	Goal	24 EC	Rohm & Hass
Paraquat	Gramoxone	30 EC	Syngenta
Pendimethalin	Stomp	30 EC	Cynamid

Pretilachlor	Rifit	50 EC	Syngenta
Pretilachlor + Safener	Sofit	50 EC	Syngenta
Sulfosulfuron	Leader	10 EC	Monsanto
Thiobencarb	Saturn	50 EC	Pesticide Ind. Ltd
Trifluralin	Treflan	48 EC	De-nocil
Acetochlor	MON-8435, IC IA- 5676	90 EC	Monsanto
Acifluorfen	Blazer	90 EC	BASF
Ametryn	Amertres, Gesapax	50 WP	Rallis
Bentazone	Basagran	40.5 EC	BASF
Bentazone + Aciflourfen	Galaxy	DF	BASF
Carfentrazome ethyl	Affinity	50 WG	Rallis
Cinosulfuron	Setoff	20 EC	Syngenta
Difenzoquat	Avenge	15 EC	Gharda
Dimethanamid	Frontier	72 WP	BASF
Dithiopyr	Dimension	12 EC	Rohm &Hass
Haloxyfop-methyl Focus,	Gallant, Verdict	10 EC	Cynamid
Imazapic	Cadre	24 AS	Cynamid
Imazaquin	Scepter	15 EC	Cynamid
Metribuzin +	Domain	60 DF	Bayer
Flufenacet			
Metsulfuron + Chlorimuron	Almix	20 WP	Dupont
Oxadiagryl	Raft, Topstar	6 EC, 80 WP	BASF
Prometryn	Gesaguard	50 WP	Ralis/ Syngenta
Propaqixafop	Agil	10 EC	Syngenta
Pyrazosulfuron	Clincher	5 WP	Rallis
S-metolochlor	Dual Gold	98 EC	Syngenta
Traisulfuron	Logran	20 WG	Syngenta
Quinclorac	Facet	25 SC	BASF

Exercise - 11

Study of phytotoxic symptoms of herbicides in different crops

Objectives

1. To study the toxic effects of herbicides on weeds and crop plants.
2. To know the differential ratings of herbicide phytotoxicity.

The herbicides are generally applied either on foliage (post emergence) or soil (pre emergence) upon the application of herbicides the herbicide effects are generally studied both on weeds and on the crop in which it is used for weed control. The observations are generally made on crop starting from 3-4 days of sowing on the germination of crop later on the stand of the crop.

These effects on crops could be grouped as quantitative and qualitative.

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 and weeds and is given below.

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)

Table :- 0 to 10 point visual scoring scale for grading treatment effects for weed and crop

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 sever injury
	6	Moderate control	No recovery is possible
Severe	7	Satisfactory control	Severe in dry and Stand least
	8	Good control	Almost destroyed, Very few plants left
	9	Good excellent control	Plant may be removed or ploughed
	10	Complete control	Complete crop destruction

Exercise - 12
Field study and control of problematic weeds

Scientific name: *Cynodon dactylon*
Common name: Doob grass , bermuda grass, star grass
Family : Poaceae
Biology and habitat

It is one of the world worst weed. It occurs throughout tropics and subtropics and semiarid regions of world. A fine to robust stoloniferous perennial, mostly with rhizomes. Rhizomes can penetrate 40-50 cm in clay soil and 70-80 cm in sand. Foliage dense, 10-40 cm tall (rarely to 90 cm). Leaves vary greatly in length from 3-20 cm. smooth or hairy on upper surface Inflorescence consist of 4-5 slender purple spikes of 10 cm long. Some varieties used as lawn grass/ it propagates vegetative more than by seeds. It is susceptible to competition and shading. Bermuda grass reproduces by seed production and through runners and rhizomes. A single shoot from a rhizome may cover 2.5 square m of soil surface in 150 days after its emergence

Management:

1. Deep tillage during summer (desiccates by 7-14 days).
2. Bermuda grass growth can be reduced by increasing shade from trees and tall shrubs
3. Small patches can be dug out but all rhizomes and stolons must be removed. Solarization by plastic sheet is used in sunny locations
4. Bermuda grass can be controlled by grass-selective herbicides like sethoxydim (Grass Getter), fluazifop (Fusilade, Ornamec, and Grass-B-Gon), or clethodim (Envoy).
5. Deep tillage can be improved by application of dalapon, glyphosate (1.0 - 2.0 kg / ha) and amitrole T.
6. Glyphosate and amitrole-T are having less residual effect
7. Paraquat and diquat are more suitable under more intensive cropping as they are non residual type.
8. These chemicals could be applied one week before deep tillage.

Scientific name: *Cyperus rotundus* (Purple nut sedge) ,*Cyperus esculentus* (Yellow nut sedge)
Family: Cyperaceae
Biology and habitat

It is very persistent perennial sedge. It is considered as world's worst weed as it occurs in 52 crops in 92 countries. It is native of India and widely distributed throughout tropics and subtropics. The slender underground runners grow out from the base of stem and form series of black irregular shaped or nearly round tubers which may growth up to 2 cm length. The tubers often sprout to produce new plants while still attached to the parent plant. Yellow nut sedge propagate through seeds whereas purple nut sedge propagates through tubers. In mixed stands, purple nut sedge is distinguished by its red, reddish-brown, or purplish brown loosely arranged inflorescence, dark green leaves which grow low to the ground with boat-shaped leaf tips. Yellow nut sedge has a yellowish-brown or straw-coloured inflorescence which is arranged along an elongated axis in the shape of a bottle brush. It has pale green leaves which grow upright with long needle shaped leaf tips.

Each spike let is made up of 10-30 small closely crowded florets which ripen to form black triangular

nuts, roots are fibrous and extensively branched. The rhizomes give rise to under ground tubers which proliferate intensively. Rhizomes do not give rise to new growth except through tubers. Most of the tubers grow in top 10 cm to 30 cm of soil Tubers store food for other parts of plants and they are effective means of propagation. New tubers are produced within 3 weeks after spouting of an individual tuber. It also propagates through seed. It is sensitive to shade and grows well in wet and dry soil and warm climates. It is a serious weed in many dry land irrigated crops.

Management

1. Mechanical methods kill only top growth with little effect on tubers. Herbicides which translocates rapidly into tubers to prevent regeneration are most effective in controlling this grass.
2. Summer deep tillage
3. Solarization with 1000 guage black film
4. 2,4 -D & MCPA at 2-5 kg/ha could control this grass.
5. Application of these in addition to trifluralin and exposing tubers or desiccation was more effective than herbicide alone.
6. In arid areas it was found that deep cultivation in summer supplemented by 2,4 - D Sodium salt at 2-4 kg/ha before onset of monsoon completely controls this grass as it checks the regeneration.
7. In humid areas fallow tillage should be shallow and it should be repeated at 18-20 days interval as it is at pre-flowering stage when the food reserve are at low.
8. Glyphosphate 1 kg/ha is more effective than many foliage applied herbicides.
9. Paraquat kills the top but repeated application would deplete the tubers of food reserves and gives better control.
10. Atrazine is particularly good for the control of seedling nutsedge.
11. Soil fumigation with metham or MB for treating nurseries and pot weeds

Field study and control of problematic weeds Parthenium and Celosia

Scientific name: *Parthernium hysterophorus*

Common name: Carrot grass, congress grass

Family: Asteraceae

Biology and habitat: It is a noxious exotic weed which has spread to many parts for country covering 5 million ha. It is annual plant (thermo and photo insensitive). reaching 2m tall in good soils, usually 50 to 150cm, germinating after rain at any season, flowering in 6 to 8 weeks, and senescing with drought or frost. the stem is branched and covered with trichomes. Leaves are pale green, lobed, hairy, initially forming a basal rosette of strongly dissected leave that are up to 30 cm in length. Young roselles with their radial leaves closely press to the ground, allow no other species to come up in their vicinity. The number of leaves per plant ranges from 6 to 55. Flower heads are creamy white, about 4 mm across, arising from the leaf forks. Reproduces by small seeds lasting up to 20 years in soil, induced dormancy on burial The plant is capable of flowering when one month old and remains in flower for 6 to 8 months It produces 5000-10000 seeds/plant. The toxin parthenin is responsible for allergic dermatitis and mental depressions in human being. Plant prefer moist shady and organic rich habitat they have remarkable adaptation to environment extremes which exerts allelopathic influence on the neighboring plant species, the seed leachates inhibit germination of

other weed seeds cause allergies and skin diseases. Seeds are light in weight and armed with pappus and disseminated by wind, water, birds and animals. It is not only an agricultural weed but also a municipal weed.

Management

1. Mechanical and cultural: Manual uprooting of Parthenium before flowering and seed setting is the most effective method. A plant in flower will aid in the dispersal of pollen grains, resulting in allergic reactions.
2. Ploughing the weed in before the plants reach the flowering stage and establishing pastures or other plants may be effective
3. Competitive replacement of Parthenium can be achieved by planting species like *Cassia sericea*, *C. sparsiflorus*, *Amaranthus spinosus*, *Sida acuta*, *Tephrosia purpurea*, *Stylosanthes scabra* and *Cassia auriculata*, which will compete with the weed and reduce its population.
4. Similarly, planting *Cassia tora* will help to cover and suppress the growth of Parthenium. In certain parts of India, crop rotation using marigold during rainy season, instead of the usual crop, is found effective in reducing parthenium infestation in cultivated areas.
5. 2,4-D, paraquat provide effective control of weed.
6. Pre-em application of atrazine, alachlor, butachlor prevent seedling emergence up to 2-5 months.
7. Chlorimuron @0.2-0.4kg/ha and metasulfuron @0.003-0.0045 kg/ha as pre-em.
8. Already established vegetation: in non cropped areas 2,4-D esters @2-5kg/ha or common salt @ 15 20% at actively growing stage.
9. Biological. The leaf-feeding beetle *Zygogramma bicolorata* and the stem-galling moth *Epiblema strenuana* are widely used in several countries to manage Parthenium. *Z. bicolorata* is now widely used in India to control Parthenium. The moth significantly reduces flower and seed production of the weed, especially at a young age.

White cock's comb

Scientific name: *Celosia argentia*

Common name: White cock's comb.

Family: Amaranthaceous

Biology and Habitat:- It is a plant of tropical origin and it is very bright colour and grow well in full sunlight. It is a tender annual i.e often grown in gardens. It is propagated by seeds. The seeds are very small upto 4300 seeds per ounce. The flower head can last up to 8 weeks and further growth can be promoted by removing dead flowers. The stem is some what glaborous some what angled and striate. Leaves are simple alternate. Ex:- Stipulate linear lanceolate up to 5" long either sessile or base tappers into short petioles.

Management

- Cut of the flowering tops with gram cutting sward whenever they appear.
- Hand pulling is certainly effective but it is not always practicable.
- Methods for weeds destruction should have to be used before spike matures and no plant should be spared to prevent seedling.

Exercise - 13

Calculation on economics of weed control practices

Any new technology proposed to be introduced in agriculture, or other places, should be cost effective, and yield a Benefit-cost ratio (B:C) that is sufficiently high to attract the client towards its adoption. Introduction of herbicides in cropping plants is no exception to it. Research work conducted so far with different crops has clearly shown that application of herbicides for controlling weeds is a very rewarding proposition from its economic point of view, some data on B:C ratios of this technique are summarized in Table. It may be noted from these data that, despite the fact that hand-weeding resulted in grater crop yields than herbicides, yet because of high, and ever increasing wages and comparatively lower herbicide cost, the use of herbicides resulted in higher B-C ratios. In different crops it varied from 9.0 to as high as 33.5; The B-C ratios of hand-weeding varied in different crops from 3.5-10.1.It may be pointed out here that B:C ratios of the most popular input in agriculture viz., the fertilizers, is only between 2.0 and 3.0 Obviously, in comparison to it the B-C ratios of herbicide use are 5 to 15-folds.

Example

Calculation of B : C in a weed management experiment

Treatments	Total cost of weed control treatment (Rs//ha)including herbicide, labour etc	Value of produce grain, straw etc. (Rs/ha)	Additional weeding cost	Additional value of produce over control (Rs/ha)	B/C	Net B/C
Unweeded check	0					
Hand weeded	540		540	2071	3.48	2.84
Herbicide 3581	233			502	2.15	1.15
Herbicide 2	358			1627	4.55	3.55
Herbicide 3	419			802	1.91	0.91

B:C Shows the benefit (Rs/ha) derived by spending additional 1 Rs/ha on the new technology.

Exercise - 14
Weed management in vegetable crops

Most vegetable are initially slow growing crops, incapable of offering any competition to the aggressive weeds. Dense growth of weeds in vegetable hides fruits which are variously discovered in the absence of natural light , become over ripe and finally rot. For harvesting of vegetables at their intended development stage , the visibility of vegetables should not be hindered by weeds . Root vegetable are malformed in the presence of weeds. Insanitation due to weeds also increases burden of insect pest and diseases in vegetables.

Hand weeding is the most common practice of weed control in vegetables in the country. Despite its high cost, it is sometimes favored because of high cash return from these crops. Chemical weed control of weeds in vegetable crops is relatively new . Few herbicide are made available for control of weeds in vegetable.

System that combines herbicides with cultivation and other good crop husbandry practices like proper field selection , crop rotation , stale seed bed , land preparation, sanitation and other cultural practices should be adopted.

Reduction in economic yield of vegetable has been reported to be 6-82 % in potato, 25-35 % in pea, 70-80 % in carrot , 67 % in onion 42-71 % in tomato and 61 % in caulifilower.

Critical period of crop weed competition (Adapted from Singh *et al* 1993 and Mercado, 1979)

Crop	Critical stage (Days)	Development stage
Onion, Garlic	30-75	Bulb formation
Cabbage/ Cauliflower	30-45	Head initiation
Okra	15-30	10-15 cm tall
Tomato/ Chilli	30-45	20-30 cm tall
Brinjal	20-60	
Carrot	15-20	7-10 cm tall
Potato/radish	25-30	

SEED BEDS

Many vegetables are grown in seed beds to develop suitable seedlings for transplanting in the field. Soils dedicated to seed beds are usually light, with good tilth, and fertilized to obtain a good plant emergence. Seed beds are usually flood-irrigated and plastic-protected. Many weed control techniques are already described in the work of Labrada, (1996). Here we add some possibilities for weed management.

Stale seed beds

Stale ('false') seed beds are sometimes used for vegetables when other selective weed-control practices are limited or unavailable. Success depends on controlling the first flush of emerged weeds before crop emergence, and on minimal disturbance, which reduces subsequent weed flushes. Basically, this technique consists of the following:

1. Preparation of a seedbed 2-3 weeks before planting to achieve maximum weed-seed germination near the soil surface.
2. Planting the crop with minimum soil disturbance to avoid exposing new weed seed to favourable germination conditions.
3. Treating the field with a non-residual herbicide to kill all germinated weeds (William et al. 2000) just before or after planting, but before crop emergence.

Recommended herbicides are bypiridyliums, glyphosate, sulfosate and glufosinate-ammonium, among others. In light-textured soils, such as sand or in artificial planting media, herbicide treatments are risky for crops (especially in tomato). With glyphosate or sulfosate it is recommended that either of these be applied ten days before planting. It is also possible to treat the soil with metham sodium, but planting must be delayed until the oil is free of metham, usually after 20 days. The use of this fumigant is very effective against *Solanum nigrum* in tomatoes.

Solarization

It is an effective method for the control of soil-borne diseases and pests that can control also many weeds. The method has been previously described by Labrada (1996). The soil must be clean, surface levelled and wet or moist, previously to being covered with a thin (0,1-0,2 mm) transparent plastic and very well sealed. The soil must be kept covered during the warmer and sunnier months (30-45 days). Soil temperatures must reach above 40° C to exert a good effect on various soil-borne pests, including weed seeds. Soil solarization is a broad-spectrum control method, simple, economically feasible and environmentally friendly. It does not affect soil properties and usually produces higher yields. After solarization the plastic must be recovered, and the use of deep or mould board tillage must be avoided. This system is more suitable for small areas of vegetables, but it has been mechanized for extensive areas of tomatoes.

Chemical control in seed beds

There are even less registered herbicides for seed beds than for planting crops. Some of the recommended herbicides are described by Labrada (1996). Table 1 shows some new additions.

There are several post-emergence grass-killers (usually known as 'fop' and 'dim' families) that could be used well in vegetable seedbeds, as for example, cycloxydim (for onion, cruciferous crops), cletodim (onion, tomatoes), fluazifop-butyl (tomato, pepper, lettuce, leek, onion). Rates must be low to avoid any problem of phytotoxicity (De Liñán, 2002).

Herbicide treatments under plastic cover are always hazardous and careful application should be carried out. Under plastic, high levels of moisture and elevated temperature are common and plants grow very gently. Selectivity could be easily lost and phytotoxicity symptoms may occur, while sometimes they

are just temporary. The effects are often erratic. The best way to deal with it is to be prudent and make some trials before a general treatment.

Table 1. Selective pre-emergence and early post-emergence herbicides for vegetable seedbeds.

a) Pre-emergence		
Herbicide	**Dose (kg a.i./ ha)**	Crop
Clomazone	0.18 - 0.27	Pepper, cucumber
DCPA	6.0 - 7.5	Onion, cole crops, lettuce
Metribuzin	0.15 - 0.5	Tomato
Napropamide	1.0 - 2.0	Tomato, pepper, eggplant
Pendimethalin Proanide	1.0 - 1.6 1.0 - 2.5	Onion, garlic Lettuce
Propachlor 5.2 - 6.5	Onion, cole crops	
b) Post-emergence (crops with at least 3 leaves)		
Clomazone	0.27 -0.36	Pepper
Ioxinil	0.36	Onion, garlic, leek
Linuron	0.5 - 1.0	Asparagus, carrots
Metribuzin	0.075 - 0.150	Tomato
Oxifluorfen	0.18 - 0.24	Onion, garlic
Rimsulfuron	0.0075 -0.015	Tomato

DIRECT-SEEDED AND TRANSPLANTED CROPS

Preventive measures

The following measures can be suggested to prevent the introduction of weeds in to non - inhabitate field .

1. Use clean seed
2. Use organic manures only after thorough decomposition to kill weeds
3. Clean tillage implements before moving to non-weed infested area.
4. Avoid transportation or use of soil from weed infested area
5. Inspect nursery stock movement in to non weed infested area.
6. Remove weeds that are near irrigation ditches and other non crop land.
7. Prevent reproduction of weeds.
8. Restrict live stock movement in to non weed infested area

Crop rotation

Crop rotation is the programmed succession of crops during a period of time in the same plot or field. It is a key control method to reduce weed infestation in vegetables. Crop rotation was considered for a long time to be a basic practice for obtaining healthy crops and good yields. This concept was mistakenly eliminated with the use of more agrochemicals. At present, however, crop rotation is gaining interest and is of value in the context of integrated crop management. Classically, crop rotations are applied as follows:

1. Alternating crops with a different type of vegetation: leaf crops (lettuce, spinach, cole), root crops

(carrots, potatoes, radish), bulb crops (onion, garlic), fruit crops (squash, pepper, melon).

2. Alternating grass and dicots, such as maize and vegetables.
3. Alternating different crop cycles: winter cereals and summer vegetables.
4. Avoiding succeeding crops of the same family: Solanaceae (potato, tomato).
5. Alternating poor- (carrot, onion) and high-weed competitors (maize, potato).
6. Avoiding problematic weeds in specific crops (e.g. Malvaceae in carrots, parasitic and perennials in general).

Examples of crop rotations

Tomato - okra - green bean

Sweet potato - maize - mung bean

Introducing a fallow in the rotation is essential for the control difficult weeds (e.g. perennials), cleaning the field with appropriate tillage or using a broad-spectrum herbicide. It is also important to avoid the emission of weed seeds or other propagules.

Mixed cropping

Growing two or more crops at the same time and adjacent to one another is called mixed cropping, or intercropping. Crop cycles must coincide totally or partially (relay-cropping). The advantages are a better use of space, light and other resources, a physical protection, a favourable thermal balance, better plant defence against some pests and fewer weed problems because the soil is better covered. Sometimes the results are less productive than cultivating just one crop alone. Usually the 'companion' crops are fast and low-growing plants, creeping and erect plants, or symbiotic species. Some examples are:

In tropical regions: this technique is very well adapted to the traditional agricultural system:

- maize + beans + squash
- tomato + pigeon pea
- sugar cane + onion, tomato.

Land preparation and tillage

As Labrada (1996) stated, suitable land preparation depends on a good knowledge of the weed species prevalent in the field. When annual weeds are predominant (Crucifers, Solanum, grass weeds), this must be achieved through shallow cultivation. If weeds have no dormant seeds, deep ploughing to bury the seeds will be advisable. If the seeds produced are dormant, this is not a good practice, because they will be viable again when they return to the soil surface after further cultivation.

When perennial weeds are present, adequate tools will depend on the types of rooting. Pivot roots (*Rumex spp.*) or bourgeon roots (*Cirsium spp.*) require fragmentation and this can be achieved by using a rotovator or cultivator. Fragile rhizomes (*Sorghum halepense*) require dragging and exposure at the soil surface for their depletion, but flexible rhizomes (*Cynodon dactylon*) require dragging and removal from the field. This can be done with a cultivator or harrow. Tubers (*Cyperus rotundus*) or bulbs (*Oxalis spp.*) require cutting when rhizomes are present and need to be dug up for exposure to adverse conditions (frost or

drought). This can done with mould board or disk ploughing. Chisel ploughing is useful for draining wet fields and reducing the infestation of deep-rooted hygrophilous perennials (Phragmites, Equisetum, Juncus). This is why reliable weed information is always necessary.

The success of many weed-control operations depends upon the timing of its implementation (Forcella, 2000). The opportunity for mechanical operation is indeed essential. Action must be taken against annual weeds before seed dispersion takes place. Tillage efficacy against perennials is higher when the plant reserves move up (e.g. *Convolvulus arvensis* in springtime. In autumn there are more fragment rootings).

Good practices in mechanical operations must look at optimal conditions, including the following:

- planting density must be in function of the weeding-tool working width;
- choice of adequate tools necessary for the work;
- paying attention to the weed and crop stage and avoiding delays in interventions;
- regulating the work depth, advance speed, attack angle;
- moisture content is important; look for the right tilth;
- do not increase the soil erosion: avoid parallel tillage to the slope direction line;
- foresee climatic conditions after completion of work. Avoid tillage if rainfall is expected.

Another typical operation that requires mechanical tillage is herbicide soil incorporation. Some very volatile herbicides commonly used in vegetables (e.g. trifluraline) must be thoroughly incorporated in the soil at an adequate depth (5-7 cm). The implement used for herbicide incorporation must be in good condition. For example, rotavator blades must be sharpened. L-shaped blades are the best choice for chemical incorporation. For correct incorporation the soil must be neither too wet nor too dry. In the first case it is convenient to change the rotavator by a flexible or rigid tine harrow. Unbroken pieces of manure or soil clods can reduce the treatment efficacy (Kempen, 1989).

Mulching material

Several types of mulched e.g plastic film, dry straw and crop residues are successfully used for weed control besides for retention of soil moisture . The plant material used for mulch are chopped into small pieces and then spread within the crop row before weed emergence . Some weeds i.e. *Cyperus rotundus* can place the plastic film as it emerges from the soil , therefore some complementary hand weeding will be necessary to avoid this problem.

Chemical weed control

The best approach to minimize inputs and to avoid any environmental problems is to apply herbicides in the crop row to a width of 10-30 cm (Labrada, 1996). Band application reduces herbicide use by up to 75 percent compared to an overall application. Weeds along the cropping row are then controlled and the interrow ones can be removed through cultivation.

Halosulfuron is a new compound selective on cucurbits and other vegetables with action against *Cyperus spp.* (Webster, 2002).

Sometimes a combination of two herbicides having a different weed-control spectrum may be used. Mixtures of different herbicide are possible (e.g. isoxaben + trifluralin, DCPA + propachlor, bensulide + naptalam) to achieve better efficacy, but previous trials are necessary. Some herbicides can be tested against the parasitic *Cuscuta spp.*, such as DCPA, pendimethalin, pronamide and imazethapyr.

For the selective control of grass weeds in vegetable crops the use some foliar active herbicides is recommended, such as cicloxidim (against annuals: 0.1-0.25 kg a.i./ha, perennials: 0.3-0.4), cletodym (0.1-0.2), fluazifop-butyl (annuals: 0.15-0.25, perennials: 0.5+0.25), haloxyfop-methyl (0.05-0.2), propaquizafop (0.1-0.2), quizalofop (annuals: 0.05- 0.125, perennials: 0.1-0.2). It should be noted that one application will not be sufficient against perennials. Their foliar activity is enhanced by adding a non-ionic surfactant or adjuvant (De Liñán, 2002).

The use of any herbicide in vegetables requires previous tests to verify its effectiveness in local conditions and selectivity to available crop cultivars.

Selective herbicide for weed control in vegetable crops

Herbicide	Dose (kg/ha.)	Treatment	Crops
Pendimethalin	0.65-1.0	Pre -em.	Transplanted peeper, Onion, Garlic, Brassica crops, umbelliferous crops
Fluchloralin	1.0-1.5	PPI	Tomatoes, Pepper, Brinjal, okra, cucurbits
Napropamide	1.0-2.0	Pre -em.	Umbelliferous crops, onion , garlic
Prometryn	1.0-1.5	Pre. Em. Or early post	Tomatos and Potato
Metribuzine	0.2-0.35	Pre. Em. Or early post	Direct seeded and transplanted onions
Oxyfluorfen	0.24-0.36	Early post	Melon and cucumber crops
Naptalam	2.25-4.5	Pre - emergence	Transplanted pepper and brinjal
Clomazone	1.7	Pre - emergence	

Chemical Weed management practices for different vegetable crops

Cabbage and Cauliflower		
Preplant	Nitralin (0.75-1.0 kg/ha) Fluchloralin (0.75-1.5 kg/ha)	Incorporation , treat only direct seeded crop
Pre emergence	Alachlor (2-3 kg/ha), Propachlor (2-3 kg/ha), Oxyfluorfen (0.05-0.25 kg/ha)	
Post emergence	Alachlor (1-2 kg/ha), CDAA (4-5 kg/ha) Nitrofen (1-3 kg/ha)	Apply as directed spray a week after transplanting . Do not use any wetting agent
Carrot		
Preplant	Fluchloralin or Trifluralin (0.75-1.5 kg/ha)	Incorporate rapidly
Pre emergence	Propham (4.5-9 kg/ha), Linuron (0.5-1.0 kg/ha), Metoxuron (1.0 kg/ha), Prometryn (0.57 kg/ha), Chloroxuron (3-4 kg/ha) Pendinethalin (1.0 kg/ha)	Choose from amongst these herbicides depending mainly upon soil type
Post emergence	Chlorbromuron (2-2.2 kg/ha)	Apply at 1-leaf stage
	Prometryn (0.5-1.0 kg/ha) Chloroxuron (3-4 kg/ha) Linuron (0.5-1 kg/ha)	Suited to 3-4 leaf stage
	Prometryn	Suited to 4-6 leaf stage of the crop
Colocasia		
Pre emergence	Propanil	
Post emergence	Ametryn, prometryn, triazine, prometone, diuron and trifluralin	

Cucumber		
Pre plant	Bensulide (5-1 kg/ha), Fluchloralin (0.75-1.5 kg/ha)	Incorporate quickly
Pre emergence	CDEC or Naptalan (2-6 kg/ha), Dinoseb (6-10 kg/ha), nitralin (0.75-1.5 kg/ha)	Nitralin may be mixed with soil.
Brinjal		
Directed post emergence	DCPA	
Post transplant	Alachlor, Fluchlorailn, Oxyfluorfen, Pendimethalin and metochlor	Apply after the transplants are established but before weed emergence
Gourds		
Pre emergence	Fluchloralin (0.5-1.0 kg/ha), Butachlor(1.0-1.25kg/ha)	
Ginger		
Pre emergence	Simazine, Diuron	
Okra		
Pre-plant	Trifluralin or fluchloralin (0.5-1.0 kg/ha), EPTC (1-2 kg/ha)	Incorporate quickly
Post emergence	Diphenamid (4-6 kg/ha), Alachlor (1-2 kg/ha), prometryn (0.5-1 kg/ha) Trifluralin (0.5 kg/ha)	
Onion and garlic		
Pre transplant	Nitralin (0.75-1.5 kg/ha), Fluchloralin (1-1.5 kg/ha)	Apply 2-3 days before transplanting, , trifluralin should be limited to garlic, . Do not incorporate oxyfluorfen and alachlor

Pre sowing	Oxyfluorfen	Apply 2-3 days ahead of sowing seeds at 0.2 kg/ha and repeat 30 days latter at 0.15 kg/ha
Pre emergence	Chloroxuron (1-2 kg/ha), pendimehtalin (0.5-1 kg/ha), Butachlor (1 kg/ha)	
Post emergence	Oxyflurfen, Chloroxuron (1-2 kg/ha), nitrofen (1-2 kg/ha) Propachlor (1-2 kg/ha)	Apply 2-3 days after transplanting Apply about 25 days after transplanting
Pea		
Pre emergence	Pendimethalin (1.0 kg/ha), Alachlor (1-1.5 kg/ha)	Limit the row spacing to 30 cm.
Chilli		
Pre plant	Nitralin or trifluralin or fluchloralin (0.5-1 kg/ha)	Incorporate 4-6 weeks before transplanting
Pre emergence	Bensulide (4-5 kg/ha), Diphenamide (4-6 kg/ha)	
Post emergence	Diphenamid (4-6 kg/ha)	
Post emergence	Chloramben, bensulide, DCPA, Diphenamid, oxyflurfen, pendimethalin, metalachlor	Apply as directed spray
Potato		
Pre plant	EPTC (1-2 kg/ha), Fluchloralin (1.0 kg/ha)	Incorporate rapidly, EPTC, inducs greater proportion of large tuber in the harvest.

Pre emergence	Metobromuron, Alachlor, Linuron, diphenamide, MCPA, Pendimethalin, Isoproturon, metribuzine, oxyflurfen, clomazone, Chlorimuron-ethyl, CDAA, CDEC	More selective on ridge planted crops and on medium to heavy texture soils. Adjust the dose suitably, depending upon the soil types.
Pre emergence in seed potato	Atrazine, isoproturon, pendimethalin	
Early post emergence	Paraquat or diquat (0.36-1 kg/ha)	Specific against annual grasses. Apply well before 10 % emergence of the Haulms, but after weed
Pumpkin		
Pre emergence	Chloramben, Butachlor	
Pre plant	Trifluralin	Incorporate quickly
Tomato		
Preplant	Diphenamide (4-6 kg/ha) Trifluralin or Nitralin (0.75-1 kg/ha), Napropamide (1.0 kg/ha)	Napropamide has long persistence. Do not incorporate oxyfluorfen
Pre emergence	Diphenamide, bensulide, fluchloralin, metribuzin, alachlor	
Post emergence	Diphenamide, trifluralin, nitralin	Apply as directed spray, after thinning the crop, but before the weed emergence. Diphenamide can be applied as over the top treatment.

Pre transplant	Diphenamide, nitralin, trifluralin	Apply 4-6 weeks before transplanting and incorporate
At transplant	bensulide, oxufluorfen	
Post transplant	Chloramben, diphenamide, linuron, Metribuzin (0.35-0.5 kg/ha), pendimethalin	Apply as directed spray about 3 to 30 days after transplanting
Radish		
Pre plant	EPTC	
Pre emergence	Alachlor (1.2-1.5 kg/ha), Metolachlor (1-1.5 kg/ha), TCA, trifluralin, linuron	
Post emergence	Nitrafen, prometryne (at 3 leaf stage), chloroxuron /(at 15 days crop growth stage)	

Good practices in the use of herbicides

- Periodically inspect the fields and assess the weed importance. Identify correctly the main weeds.
- The weed and crop stage of growth must be taken into account.
- Careful selection of the product and dosage, bearing in mind points one and two.
- Read the product label and follow the recommendations.
- Avoid adverse conditions at the time off application: wind, temperatures, rainfall. Do not delay treatment.
- Quality of the spraying is obtained by the correct calculation of dosage (surface to be treated must be well measured) and by the spraying equipment, which must be calibrated and in good condition (especially nozzles and manometer).
- Band or patch application to save herbicide and reduce residues.
- Keep to the environmental norms: avoid spills, drift, respect the edges, water ways, sensitive areas. Triple-rinse all empty cans or containers and do not re-use them.
- To avoid propagation of resistant species, the same herbicide or herbicides with the same mode of action must not be used repeatedly.
- It is essential to integrate the chemical weed control with opportune, surface tillage. Take preventive measures, especially early problem identification.

Annexure - 1

List of common weeds

Abutilon indicum (L) Sweet	Pilibuti	Malvaceae
Acacia farnesiaiana (L.) Wild	Huisache	Leguminoceae
Ageratum conyzoids L.	Billgoat weed, Makua	Compositae
Ageratum Houstonianum L.	Neela Makua	Compositae
Agropyron repens (L.) Beauv.	Quakgrass	Gramineae
Alopecurus myosuroides	Blackgrass	Gramineae
Amaranthus viridis L.	Pigweed, Choulai	Amaranthaceae
Amaranthus Spinosus L.	Sping Amaranthus	Amaranthaceae
Ammannia beccifera	Jangli mehndi	Lythraceae
Anagallis arvesis L.	Blue pimpernel	Promulaceae
Argenomon maxicana L.	Maxican poppy	Papaveraceae
Asphodelus tenuifolius Cavan	Wild onion	Liliaceae
Avena fatua L.	Wild oats	Gramineae
Avena ludoviciana Dur	Wild oats	Gramineae
Boerharia diffusa L.	Roadsided itsit	Nyctaginaceae
Caesullia axillaris Roxb.	Ghrilla	Compositae
Calotropis gigantean R. Br.	Swallowwort	Asclepiadaceae
Canabis sativa L.	Hemp, bhang	Cannabinaceae
Carthamus oxyacantha Biel.	Wild safflower, pohli	Compositae
Cassia tora L.	Sicklepod	Leguminoceae
Celosia argentea L.	Cock's comb, Salara	Amaranthaceae
Cenchrus catharticus Del.	Sandbur	Gramineae
Chenopodium album L.	Lambsquarter	Chenopodiaceae
Cleome viscose L.	Hulhul	Capparidaceae
Cichorium intybus L.	Chicory, Kasni	Compositae
Cirsium arvense L.	Canadathistle, Leh	Compositae
Commelina benghalensis L.	Dayflower	Commelinaceae
Convolvulus arvensis L.	Field bind weed	Convolvulaceae
Corchorus aestuans Linn.	Wild jute	Tilliaceae
Cuscuta reflexa Roxb.	Dodder , amarbel	Convolvulaceae
Cynadon dactylon (L.)	Bermudagrass	Poaceae
Cyperus difformis L.		Cyperaceae
Cyperus esculantus L.	Yellow nut sedge	Cyperaceae
Cyperus rotundus L.	Purple nutsedge	Cyperaceae
Cyperus irri L.		Cyperaceae

Dactyloctenium aegyptium	Crowfoot grass	Poaceae
Digitaria sangunalis (L.)	Crab grass	Poaceae
Dinebra retraflexa		Poaceae
Echinocloa colonum L.	Jungle rice	Poaceae
Eclipta alba L.	Bhangra	Asteraceae
Eichhornia crassipes	Waterhycinth	Pontederiaceae
Eragrastis minor	Stinkgrass	Poaceae
Euphorbia hirta	Bari dudhi	Euphorbiaceae
Euphorbia microphylla	Chhoti dudhi	Euphorbiaceae
Fimbristylis barbata		Cyperaceae
Fumaria parviflora	Fumitory	Fumariaceae
Leucas aspera		Labiatae
Madicago hispida		Leguminoceae
Melilotus alba Safed sengi		Leguminoceae
Melilotus indica	Sengi methi	Leguminoceae
Mimosa pudica L.	Sensitive plant	Leguminoceae
Panicum rapens L.	torpedograss	Poaceae
Parthenium hysterophorus L.	Carrot grass	Asteraceae
Paspalum conjugatum		Poaceae
Phalaris minor Retz.	Canary grass	Poaceae
Phyllanthus niruri	Hazardana	Euphorbiaceae
Physalis minima	Ground cherry	Solanaceae
Portulaca oleracea L.		Poaceae
Rumex dentatus	Jangali palak	Polypogonaceae
Saccharum spontaneum L.	Kans	Poaceae
Setaria glauca	Foxtail	Poaceae
Solanum nigrum		Solanaceae
Sonchus arvensis		Asteraceae
Sorghum helepence	Johnsongrass	Poaceae
Striga lutea	witchweed	Scorphullariaceae
Trianthema portulacastrum L.	Carpet weed	Aizoaceae
Tribulus terrestris L.	Puncture vine, desi gokhru	Zygophyllaceae
Tridex procumbence		Asteraceae
Vernonia spp.		Asteraceae
Vicia hirsute L.		Leguminoceae
Xanthium strumarium L.	Cocklebur	Asteraceae
Ziziphus nummularia (Burm.f.) W&A	Jharberi	Rhamnaceae

Annexure - 2

Eighteen most serious weeds in the world

Common name	Scientific name	Growth habitat and kind of plant
Smooth pig weed	*Amaranthus hybrids*	A-B
Spiny amaranth	*Amaranthus spinosus*	A-B
Wild oat	*Avena fatua*	A-G
Common lamb'squarters	*Chenopodium album*	A-B
Field bind weed	*Convolvulus arvensis*	P-B
Bermuda grass	*Cynodon dactylon*	P-G
Yellow nut sedge	*Cyperus esculentus*	P-S
Purple nut sedge	*Cyperus rotundus*	P-S
Crab grass	*Digitaria sanguinalis*	A-G
Jungle rice	*Echinochloa colonum*	A-G
Barnyard grass	*Echinochloa crusgalli*	A-G
Water hyacinth	*Echinochloa crassipes*	P-G
Goose grass	*Elusine indica*	A-G
Cogon grass	*Imperata cylindrica*	P-G
Sour paspalum	*Paspalam conjugation*	P-G
Common purslane	*Portulaca oleracea*	A-B
Itch grass	*Rottboellia exaltata*	A-G
Johnson grass	*Sorghum halepense*	P-G

A = Annual

B = Broadleaf

G = Grass

S = Sedges

P = Perennial

Annexure - 3

Conversion factors of measurements commonly needed in herbicide use work and weed control research work

To Convert from	To convert to	Multiply (1) by
1	2	3
ac	ha	0.405
	Sq m	4046.8
Cu ft (water)	Cu m	0.028
	l	28.4
ft	cm	30.48
	m	0.305
Gal	l	4.546
Gal ac^{-1}	l ha^{-1}	9.35
g l^{-1}	ppm	1000
g m^{-2}	Kg ha^{-1}	10
ha	ac	2.471
inch	cm	2.540
Kg	g	1000
Kg ha^{-1}	G $10m^{-2}$	1.0
Kg 1000 l^{-1}	% solution	0.1
Kg $10m^{-2}$	q ha^{-1}	10
ppm	g l^{-1}	0.001
	mg l^{-1}	1.00
	%	0.0001
% solution	ml (or g) $^{-1}$ water	10
	l (or kg)/1000 l water	10
lb	Kg	0.453
Lb ac^{-1}	Kg ha^{-1}	1.121
q	kg	100
Sq ft	Sq mt	0.093
Tonne (t)	Kg	1000
Table spoon	G	15

Note: ac = acre, ha = Hectare, Sq= square,m=meter, ft= feet, Gal=gallon, l= liter, g= gram, in=inch, ppm= parts per millon, lb= pound, mg=milligram, q= quintal

TERMINOLOGY

Absorption: The process by which herbicides are taken into plants, by roots or foliage.
Adsorption: The binding of substances on the surface of solids.
Alein weed : An alien weed species is one that occure outside its normal distribution , usually a counry.
Allelopathy: Detrimental effect of a plant on the germination , growth or development of its neighbouring plant through its toxic exudates; usually the root exudated release in the soil.
Annual: A plant that completes its life cycle in one year and then dies. Common sub classifications are summer annuals and winter annuals.
Antagonism: negative action of chemical used in combination so that the total action is inferior to their independent effects.
Aromatics: Compounds derived from the hydrocarbon benzene (C6H6).
Band applications: An application of spray or dust to a continuous restricted area, such as in or along a crop row, rather than over the entire field area.
Basal treatment: An application of herbicides to the stems of plants at and just above the ground line.
Biennial: A plant that completes its growth in 2 years. In the first year, it produces leaves and stores food; in the second year, it produces fruits and seeds.
Broadcast (blanket) application: An application of spray or dust over an entire area rather than only on rows, beds, or middles.
Carrier: The liquid or solid material added to a chemical compound to facilitate its storage, shipment, or use in the field.
Compatibility: Quality of two compounds that permits them to be mixed without effect on the properties of either.
Concentration: The amount of active material in a given volume of diluent. Recommendations and specifications for concentration of herbicides should be on the basis of pounds-per-unit volume of diluent.
Contact herbicide: A herbicide that kills primarily by contact with plant tissue rather than as a result of translocation.
Cotyledon leaves: The first leaf or pair of leaves of the embryo of seed plants.
Critical period : The shortest time span in the ontogeny of plant growth when a treatment will result in maximum effect.
Crop associated weed: Non parasitic weed associated with specific crop.
Crown: The point where stem and root join in a seed plant.
Directed spray: An application made to minimize the amount of herbicide applied to the crop. This is usually accomplished by setting nozzles low with spray patterns intersecting at the base of the plants just above the soil line.
Emergence: Appearance of the first part of the crop plant through the ground.
Emulsifying agent: A material which facilitates the suspending of one liquid in another.
Emulsion: A mixture in which one liquid is suspended in minute globules in another liquid; oil in water, for example.

Growth Stages:

1. **Tillering stage:** when a plant produces additional shoots from a single crown, as in corn.
2. **Jointing stage:** when the internodes of the stem are elongating.
3. **Boot stage:** when the seed head of a plant begins to emerge from the sheath--usually applied to corn and grain crops.

Herbicide: A chemical used for killing plants.

LD_{50} : Dose of a pesticide that would prove lethal when ingested by a specified test animal, usually the rat or rabit by 50 %. Its unit is mg of pesticide /1000 g body weight.

Non selective herbicide: A herbicide that can be used to kill plants generally with disregard to species.

Perennial: A plant that lives from year to year. In cold climates, the stem dies, but the root persists.

Post-emergence treatment: Treatment made after the crop plants emerge.

Preemergence treatment: Treatment made after a crop is planted but before it emerges.

Preplant treatment: Treatment made before the crop is planted.

Rate and dosage: These terms are synonymous, but "rate" is preferred. Usually refers to the amount of active ingredient material (such as 2,4-D acid equivalent) applied to a unit area (such as 1 acre) regardless of percentage of chemical in the carrier.

Rhizome: Underground stem capable of sending out roots and leafy shoots.

Selective Herbicide: A compound more toxic to weeds than to the crop in the field. Helps control weeds without damaging the crop.

Soil sterilant: A material which makes the soil incapable of supporting plant growth. Sterilization may be temporary or practically permanent.

Spray drift: The movement of airborne spray particles from the spray nozzle to beyond the intended contact area.

Stolen: Runners or stems that develop roots and shoots at the tip or nodes, as do strawberry plants.

Stool: To produce crown shoots; to tiller.

Surfactant: A material in pesticide formulation which imparts emulsifiability, spreading, wetting, dispersability, or other surface-modifying properties.

Suspension: A liquid or gas in which minute solid particles are dispersed but not dissolved.

Systemic herbicide: A compound which is translocated within the plant and has an effect throughout the entire plant system.

Translocation: Transfer of food or other materials such as herbicides from one plant part to another.

Volatile: Quality which makes a compound evaporate or vaporize (change from a liquid to a gas) at ordinary temperature when exposed to air.

Weed control : The process of limiting weed infestation so that the crops could be grown profitably or other operation could be conducted efficiently.

Weed Eradication : the complete removal of all live plant , plant parts, and seeds of a weed infestation from an area.

Weed prevention : Any measure to deny the entry pr establishment of new weed in an area.

Wetting agent: A compound which, when added to a spray solution, causes it to spread over wet plant surfaces more thoroughly.

REFERENCES

Crafts, A.S. and Robbins, W.W. 1973. Weed Control. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

De Liñán, C. 2002. Vademecum de Productos Fitosanitarios y Nutricionales. 18ª Ed. Agrotecnicas S.L. Madrid. pp. 196-275.

Forcella, F. 2000. Rotary hoeing substitutes for two-thirds rate of soil-applied herbicide. Weed Tech. 14: 298-303

Gupta, O.P. 2004. Modern Weed Management. Agro Bios (India), Jodhpur.

Kewat, M.L. and Sharma, R.S. A practical manual for weed control.

Kempen, H.M. 1989. Weed management in vegetable crops. Growers Weed Management Guide. Thomson Publication. Fresno, Ca., USA, pp. 82-158.

Labrada, R. 1996. Manejo de malezas en hortalizas. In Labrada, R., Caseley, J.C., Parker, C. Manejo de malezas para países en desarrollo. Estudio FAO Production Protection Vegetal 120. FAO, Roma. pp. 298 308.

Rao, V.S. 2000. Principles of Weed Science. Oxford & IBH Publishing Co., New Delhi.
Subramanian, S., Mohammed Ali, A. and Jayakumar, R. 1991. All About Weed Control. Kalyani Publishers, Ludhiana.

Webster, T. M. 2002. Nutsedge (Cyperus spp.) Management in Cucurbits. (available at http://www.epa.gov/ozone/mbr/almet00/64webster).

William, R.D., Ball, D., Miller, T.L., Parker, R., Yenish, J.P., Miller, T.W., Morishita, D.W. & Zaragoza, C. 2001. Uso de herbicidas en cultivos hortícolas. En Uso de Herbicidas en la Agricultura del Siglo XXI, editado por De Prado, R. & Jarrín, J., Cap.15. Servicio de Publicaciones. Universidad de Córdoba, Spain. pp.169-182.

Weeds found in horticultural crops

Amaranthus viridis

Amaranthus Spinosus

Ageratum conyzoids

Anagallis arvensis

Argenomon maxicana

Agropyron repens

Cassia tora

Celosia argentea

Chenopodium album

Chichorium intybus

Convolvulus arvensis

Cuscuta reflexa

Cynodon dactylon

Cyperus rotundus

Cyperus difformis

Ceasulia auxillaris

Commelina benghalensis

Digitaria sanguinalis

Dinebra retroflexa

Dacayloctenium aegyptium

Euphorbia geniculata

Eclipta alba

Euphorbia hirta

Echinocloa colona

Fimbystylis barbata

Medicago hispida

Melilotus alba

Leucas aspera

Melilotus indica

Portulaca oleracea

Panicum repens

Phyllanthus niruri

Physalis minima

Parthenium hysterophorus

Paspalum conjugatam

Panicum repens

Rumex dentatus

Sonchus arvensis

Saccharum spontaneum

Solanum nigrum

Trianthema portulacastrum

Tribulus terrestris

Tridex procumbence

Vicia sativa

Vernonia spp

Categorisation of pesticides

Depicition				
Colour of lower triangle	Bright red	Bright yellow	Bright blue	Bright green
Toxicity class	Extremely toxic	Highly toxic	Moderately toxic	Slightly toxic
Oral LD_{50} value (mg/kg)	< 50	51 - 500	501 - 5000	> 5000
Signal words (Upper half)	Posion (In red)	Posion (In red)	DANGER	CAUTION
Waming words (Outside the diamond)	Keep out of reach of children. If swallowed or symptoms of poisoning occur, call doctor.	Keep out of the reach of children.	Keep out of the reach of children.	-----

Different types of sprayer

Knapsack-sprayer

Battery-sprayer

MIST BLOWER SPARY

Foot-sprayer

Hand-compression sprayer

Pneumatic-sprayer

Trigger Spray

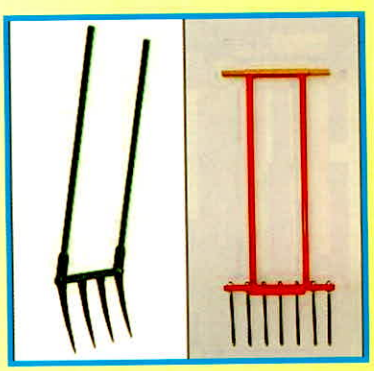
Tractor Mounted Sprayer

Different types of weeding tools

Hand weeding fork

Hacia

Spade



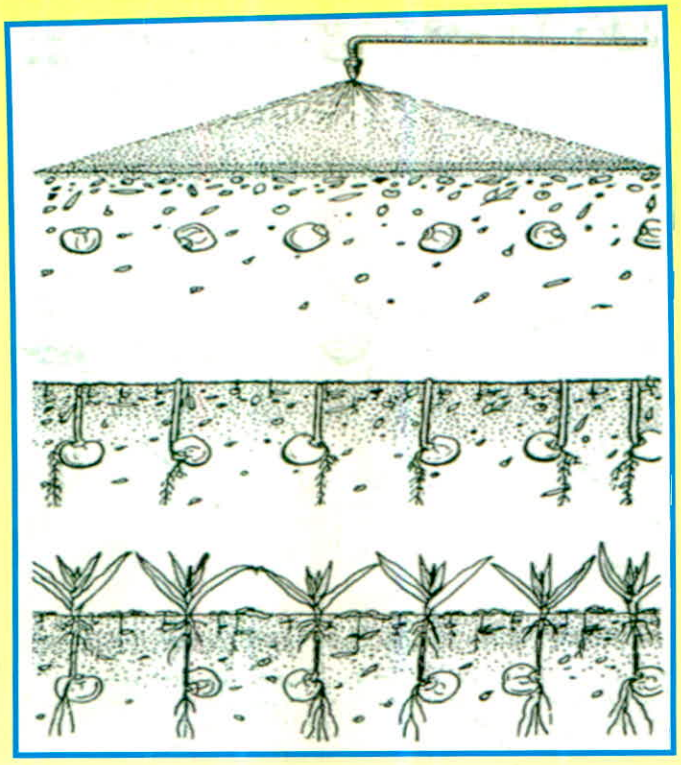
Broadforks

Wheel hoe weed slayer

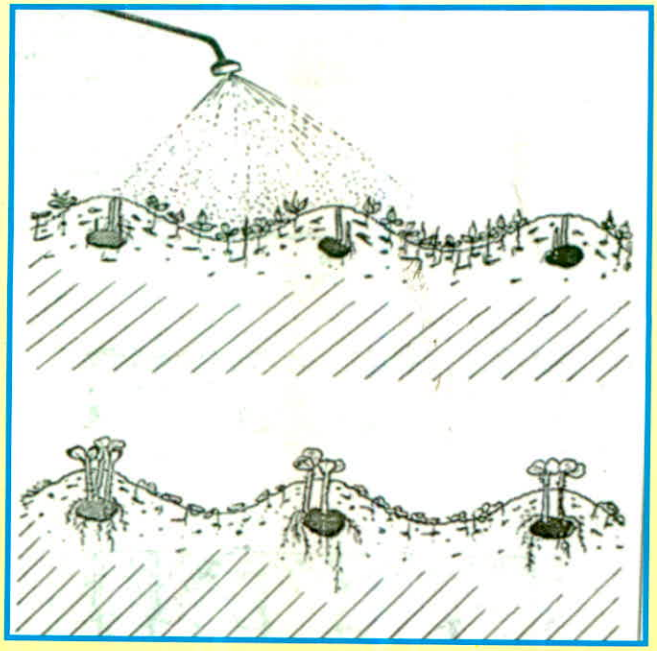
Pick-axe

Garden-weeding-fork

Weeding-trowel



[A] = Pre emergence application of herbicide. Note: neither the weed seed nor the crop seeds have yet germinated from their respective zone in the soil. [B] Both weed and crop seedling are ready to penetrate the even film of herbicide applied on the soil surface. [C]. While the susceptible weed seedling wither away, the tolerant crop seedlings emerge through the soil and grow in a weed free environment.



Early post emergence application of herbicide. Top = A non residual herbicide being applied after the weeds have emerged but before the crop potato) has done so (diagrammatic). Bottom= The emerged weeds killed with the herbicide while the potato shoots emerge through the soil after 1-3 days, safely.