THE NEOTIA UNIVERSITY
ज्ञानम् आत्म प्रदीपाय

Weed Management Practical Manual

Course Code: EC-AGP 410
Credits: 3(2+1)

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Experiment No. 1

Techniques of Weed Preservation

Instructional objectives`

The student will know the method of collection of weeds and the preparation of herbarium and preservation of weeds.

Weed herbarium

A herbarium is a museum and a database of dried, pressed plant specimens. Preservation of specimen includes drying, identification, mounting and labeling of specimens in the herbarium.

Specimen- The specimen represents a total plant free from damages due to pest and mechanical injury. Roots are kept in herbs but excluded in shrubs, trees and vines. The large, specimens are fragmented in to 2,3 or more parts and bent into a V, N or W shape.

Materials required

i. Vasculum or polythene bag	vi. Khurpi, Spade and Nirani
ii. Old newspapers	vi. Field press
iii. Knife	viii. Blotting paper/ Absorbent drying paper
iv. Secateur/cutter	ix. Cello tape
v. Pick axe	x. Weed album/ Herbarium sheet

Pressing

For pressing, lay a piece of corrugated cardboard over a wood. Put a blotting paper on it and place the specimen over the blotting paper followed by another blotting paper above the specimen. Repeat this sequence until all specimens are arranged and the pile is large enough to be pressed conveniently. Tie the pile and an identifying tag.

Preservatives

The specimen is preserved in order to prevent insect and fungal attack. Specimens are dipped in the one of the following chemicals,

i) 15 to 20% mercuric chloride solution.

ii) 10% formalin solution

Mounting

The mounting sheets are made from heavy, long lasting white card sheets in uniform size of 42 cm x 28 cm. The root portion of the specimen should be at bottom of the sheet. Some portion at right hand corner is left for label.

Fixing and stitching the specimen on the sheet

The glue is uniformly spread over the glass plate of 50 cm x 35 cm size. The specimen is placed on the glass and then immediately mounted on the mounting sheet.

Strapping

If specimen is not glued, it can be strapped by thread stitches. Paper tapes or adhesive tapes are also used for strapping.

Identification

The specimens are identified by botanical name and family referring to weed flora monographs or illustrated books or with help of competent plant taxonomist. After mounting of specimen, the herbarium sheet is labeled. With the following use trial information.

Storage

The herbarium sheets are stored in closed containers. To prevent further insect attack, a handful of 1:1 mixture of para dichlorobenzene and naphthalene should be placed in cloth bag in the container. The place of keeping herbarium cabinets need spray of mild insecticides regularly.

Suggested link:

1. https://www.youtube.com/watch?v=6MDfQjAOxcs
2. https://www.youtube.com/watch?v=3fDjdHO382Y

Interpretation

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Conclusion

Experiment No. 2

Identification of weeds in upland crops

Instructional objectives

To study, identify and acquaint with the common weeds of upland crops of the locality
To gain an idea regarding biological and ecological adaptations of weeds in upland

Materials required

i. Note book and pencil
ii. Polythene bags with rubber bands
iii. Magnifying glass

Procedure

Visit the at Instructional Farm of The Neotia university, West Bengal at scheduled practical class with the teacher and identify the weed species occurring in upland.

Observation

Table 2.1 Record the identified weeds in tabular manner to make the lists of weeds

SL.NO	COMMON NAME	BOTANICAL NAME	FAMILY	MORPHOLOGICAL FEATURE (Flower, color of flower, time of flowering, inflorescence)
Annual monocot weeds				
1	Goose grass	*Eleusine indica* (L.) Gaertn.	*Poaceae*	The leaf sheaths are flattened and the margins present bundles of long hairs. Inflorescence is formed by 4 to 5 spikes green – light, raised obliquely from the extremity of the culm. Spikelet consists of 3 to 9 flowers; they are arranged in the lower face of the spike axis.
2	Barnyard grass	*Echinochloa crusgalli* (L.) P. Beauv.		

3	Witch grass	*Panicum capillare* L.		
Perenial monoot weed				
1	Tropical spiderwort	*Commelina benghalensis* L.		
2	Baramuda grass	*Cynodon dactylon (L.) Pers.*		
3	Yellow nut sedge	*Cyperus esculentus L.*		
Annual broad leaves weed				
1	Chickweed	*Stellaria media* (L.) Vill.		
2	henbit dead-nettle	*Lamium amplexicaule* L.		

3	Hairy bittercress	*Cardamine hirsute*		

				clasp the stems,
Summer Perennial broad leaved weeds				
1	common yarrow	*Achillea millefolium* L.		
2	broadleaf plantain	*Plantago major* L.		
3	common blue violet	*Viola sororia* Willd.		

Parasite weeds				
1	Broomrapes	*Orobanche aegyptiaca* Pers.	Orobanchaceae	The broomrape plant is small, from 10–60 cm tall depending on species
2	Dodder plant	*Cuscuta* sps. L.		

Viola sororia

Commelina benghalensis

Cuscuta sps.

Suggested link:

1. https://www.youtube.com/watch?v=wBy3DLeEGl0&list=WL&index=34&t=218s
2. https://www.youtube.com/watch?v=gKPylyhZ53A&list=WL&index=32
3. https://www.youtube.com/watch?v=SFvcF6oNRME&list=WL&index=31
4. https://www.youtube.com/watch?v=WaClq6Xe8SY&list=WL&index=30

Conclusion

Experiment No. 3

Identification of weeds in upland direct seeded rice

Instructional objectives

To study, identify and acquaint with the common weeds of the upland direct seeded rice.
To gain an idea regarding biological and ecological adaptations of weeds.

Materials required

i. Note book and pencil
ii. Polythene bags with rubber bands
iii. Magnifying glass

Procedure

Visit to a farm in the scheduled practical class. Follow to the teacher. Record the weed species occurring in upland direct seeded rice field.

Observation

Recorded the lists of weeds present at Instructional Farm, The Neotia university, West Bengal in tabular manner.

Sl.no	Common name	Botanical name	Family	Morphological features (Flower, color of flower, time of flowering, inflorescence)
Grasses				
1	Goose grass	*Eleusine indica* (L.) Gaertn.	*Poaceae*	The leaf sheaths are flattened and the margins present bundles of long hairs. Inflorescence is formed by 4 to 5 spikes green – light, raised obliquely from the extremity of the culm. Spikelet consists of 3 to 9 flowers; they are arranged in the lower face of the spike axis.
2	Baramuda grass	*Cynodon dactylon* (L.) Pers.		
3	Crab grass	*Digiataria sanguinalis* (L.) Scop.		

4	Fox tail grass	*Setaria glauca* L.		
Sl.no	Common name	Botanical name	Family	Morphological features (Flower, color of flower, time of flowering, inflorescence)
Sedges				
1	Sedge grass	*Cyperus difformis* L.	*Cyperaceae*	There are usually a few long, wispy leaves around the base of the plant. The inflorescence is a rounded bundle one to three centimeters wide, containing up to 120 spikelets, each long and partially or entirely covered in up to 30 bracted flowers.
2	Nut sedge/ Coco-grass	*Cyperus rotundus* L.		
Broad-leaved weeds				
1	Button/pig weed	*Borreria hispida* L.	*Rubiaceae*	Stem bluish, hispid. Leaves 1-2 x 0.8-1.5 cm, oblong-elliptic to obovate, acute at apex, attenuate at base, hispid on both sides. Stipules sheathing. Flowers in axillary verticillate cymes.
2	Hairy spurge	*Euphorbia hirta* L.		
3	Tropical spiderwort	*Commelina benghalensis* L.		
4	Khatimithi	*Oxalis corniculata* L		

5	Amaranthus	*Amaranthus viridis* L.		
6	Goat weed	*Agertum conyzoides* L.		
Sl.no	Common name	Botanical name	Family	Morphological features (Flower, color of flower, time of flowering, inflorescence)
7	Gajar ghass/ Carrot grass	*Parthenium hysterophorus* L.		

Digitaria sanguinalis

Cyperus rotundus

Amaranthus viridis

Suggested link:

1. https://www.youtube.com/watch?v=wBy3DLeEGl0&list=WL&index=34&t=218s
2. https://www.youtube.com/watch?v=gKPylyhZ53A&list=WL&index=32
3. https://www.youtube.com/watch?v=SFvcF6oNRME&list=WL&index=31
4. https://www.youtube.com/watch?v=WaClq6Xe8SY&list=WL&index=30

Conclusion

Experiment No. 4

Identification of weeds in low land rice

Instructional objectives

To study, identify and acquaint with the common weeds of the low land rice
To gain an idea regarding biological and ecological adaptations of weeds

Materials required

Note book and pencil, Polythene bags with rubber bands, Magnifying glass

Procedure

Visit to a farm in the scheduled practical class. Follow to the teacher. Record the weed species occurring in low land rice and irrigated field.

Observation

Recorded the lists of weeds present at Instructional Farm, The Neotia university, West Bengal in tabular manner

Sl.no	Common name	Botanical name	Family	Morphological features (Flower, color of flower, time of flowering, inflorescence)
Annual monocot weeds				
1	Barn yard grass	*Echinocloa crusgalli*	Poaceae	Height - 30- 60 cm with thick, coarse, mostly erect smooth and

				branching at the base. Sessile leaf blades attached to a smooth sheath which encircles the stem in the absence of ligule. The leaf blade is 10-30 cm long and 5-20 mm wide. Midrib is prominent. Stem is stout. Culms branches at the base and produce tillers. Inflorescence is 10-20 cm long with slender spike like. Panicle green or purplish in colour. Spikelets are densely crowded in 2-4 rows on each side of the stem. Seeds are light orange yellow in colour. Adventitious root system.
2	**Jungle rice**	*Echinocloa colonum* **L**		
Annual broadleaf weeds				
1	Monochoria	*Monochoria vaginalis* (Burm.f.) C.Presl ex Kunth	*Pontederiaceae*	Leaves linear or narrowly ovate with cordate base 5 to 15 cm long Pedicel long; flowers in recemes, usually blue spotted with

				red;petaloid; perianth;1-6 stamens inserted at the base of perianth; ovary superior, tricarpellary 3 celled with many ovules in each cell; fruit a capsule.
2	Marsilea	*Marselia quadrifolia* L.		
3	*Ludwigia*	*Ludwigia parviflora* L.	*Onagraceae*	Leaves linear or lanceolate; simple, alternate Flowers small, axillary, solitary, yellow; calyx tube narrow with 4-6 lobes; corolla 5 lobed; stamens 8-10; ovary inferior,4-5 carpels, 4-5 celled, ovules many in, vertical rows; fruit a capsule smaller, 4 sided, about 2 cm long with persistent calyx at the tip; seeds small, pink
Sedges				
1	Small-flowered nut sedge	*Cyperus difformis* L	*Cyperaceae*	tem tufted, 12.5 to37.5 cm long Leaves flaccid, as long as the stem; bracts 2-3, 5 to 20 cm long

2	Umbrella sedge	*Cyperus iria* L		
3	hoorah grass	*Fimbristylis milacea* L		

Marselia quadrifolia

Ludwigia parviflora

Echinocloa crusgalli

3.5 Conclusion

Experiment No. 5

Identification of weeds in non cropped field and aquatic bodies

Instructional objectives

To study, identify and acquaint with the common weeds of the non cropped field and aquatic bodies
To gain an idea regarding biological and ecological adaptations of weeds

Materials required

i. Note book and pencil
ii. Polythene bags with rubber bands
iii. Magnifying glass

Procedure

Visit to campus of The Neotia university of West Bengal in scheduled practical class. Follow to the teacher and record the weed species occurring in the waste land, road side and pond.

Observation

Table 4.1Record the weeds in tabular manner while identifying in non-cropped field and aquatic bodies.

SL.NO	Common name	Scientific name	Family	Morphological feature (Flower, color of flower, time of flowering, inflorescence)
Non-crop weeds				
1	common burdock	*Arctium minus* (Hill) Bernh. 1800 not Schkuhr 1803	Asteraceae	It can grow up to 1.5 meters (1 to 5 feet) tall and form multiple branches. It is large and bushy. Flowers are prickly and pink to lavender in color. Flower heads are about 2 cm (0.79 in) wide
2	wild carrot	*Daucus carota* L.		
3	spotted	*Centaurea* L.		

	knapweed	*Maculate* L.		
Aquatic weeds				
1	common water hyacinth	*Eichhornia crassipes* Mart.	Pontederiaceae	water hyacinth may rise above the surface of the water as much as 1 meter (3 feet) in height. The leaves are 10–20 cm (4–8 inches) across on a stem which is floating by means of buoyant bulb like nodules at its base above the water surface.
2	*Hydrilla*	*Hydrilla verticillate* (L.f.) Royle		
3	Typha	*Typha latifolia* L.		

Eichhornia crassipes

Hydrilla verticillata

Centaurea maculata

Suggested link:

1. https://www.youtube.com/watch?v=wBy3DLeEGl0&list=WL&index=34&t=218s
2. https://www.youtube.com/watch?v=gKPylyhZ53A&list=WL&index=32
3. https://www.youtube.com/watch?v=SFvcF6oNRME&list=WL&index=31
4. https://www.youtube.com/watch?v=WaClq6Xe8SY&list=WL&index=30

Conclusion

Experiment No. 6
Studies on Biology of Nut Sedge, Bermuda Grass, *Parthenium* and Alligator weed

Instructional objectives

To study the biology of nut sedge, bermuda grass, carrot grass and *Alligator weed*

Procedure

Before study of weed biology, follow the teacher to identify the weeds correctly**.**

Identification of the weed purple nut sedge / plant characteristics

a. Growth habit - A highly variable perennial sedge: flowering stems erect, up to 60 cm tall; inflorescence a terminal, open umbel subtended by several leafy bracts.

b. Root – The root system of a young plant initially forms white, fleshy rhizomes, up to 25 mm (1.0 in) in dimension, in chains

c. Stem – Cyperus rotundus is a perennial plant, that may reach a height of up to 140 cm

d. Leaf- The leaves sprout in ranks of three from the base of the plant, around 5–20 cm (2–8 in) long

e. Inflorescence- Several unequal rays, 2-6 cm long, support 3-8 reddish-brown to purplish-brown, flattened spikelets, 1-2 cm long and 2 mm wide, each with up to 30 glumes.

Biology of purple nut sedge (*Cyperus rotundus*)

Purple nut sedge is a perennial plant. The formation of the lateral rhizomes from the basal bulb starts 4 to 6 weeks after the appearance of the first aboveground shoots. Tuber production in the field can be as large up to one thousand in tropical areas. The tubers act as dispersal units. The tubers remain dormant for some time at the end of the growing season. The leaves and flowering stalks generally die after maturity, but tubers and rhizomes survive in the soil and sprout again. The tubers are oval to spherical in shape and have 3 - 10 buds arranged spirally These tubers are produced on rhizomes (underground stems) that grow as deep as 20 to 30 cm below the soil surface. Generally 80% of tubers can be found in

the top 15 cm of soil. The majority can survive for 1 to 3 years. It has the ability to thrive under very adverse conditions and is very difficult to be eradicated due to prolific production of tubers.

Identification of the Bermuda grass / plant characteristics

a. Growth habitat- Bermuda grass tends to grow where water is available. The plant is not frost or shade tolerant and the rhizomes and stolons are susceptible to desiccation

b. Root – It has a deep root system

c. Stem – The erect stems can grow 1–30 cm (0.39–11.81 in) tall. The stems are slightly flattened, often tinged purple in colour.

d. Leaf- short leaves

e. Inflorescence- Inflorescence supported on a culm up to 25 cm high, consisting of a single whorl of 3-7 narrow racemes, each 3-8 cm long.

Biology of Bermuda grass (*Cynodon dactylon)*

Bermuda grasspropagates through seeds, runners and rhizomes.. The complete cycle from germination to seed production takes around four months. Bermuda grass often grows under the crop canopy and sends out runners. It's extensive underground root system makes it virtually impossible to eliminate it by either by hand pulling or by spraying of herbicides. Grows in either acid or alkaline conditions and survives floods and drought through regrowth from underground rhizomes. A single plant produces about 170 seeds.It's seeds are small, one kg containing around 45 lakh seeds.

a. Growth Habit- Erected aromatic, whitish, branched herb from 30 to 75cm in heigh

b. Stem –It is branched and with the stems meanly hairy

c. Leaf- The leaves are alternate and profoundly cut in narrow segments.
d . Inflorences- Inflorescences are grouped by 4 or 5, in small spherical heads

Biology of carrot grass (*Parthenium hysterophorus*)

Parthenium weed, with suitable conditions (rain, available moisture, mild temperatures), can germinate at any time of the year. Plants can flower 4 – 8 weeks after germination, and flowering may continue for 6 to 8 months. In summer, plants can flower and set seed within four weeks of germination, particularly if stressed.. A single plant can produce up to 25,000 seeds and may go up to 1 lakh. Seed has no dormancy. Germination temperatures for Parthenium occur across the 8 to 30° C range with the optimum germination temperature being 22 to 25° C. Parthenium seeds are light in weight and disseminated by wind, water, vehicles, machinery, stock, birds and animals.

Identification of alligator weed (*Alternanthera philoxeroides*)

a. Growth habit - Annual, branched herb.

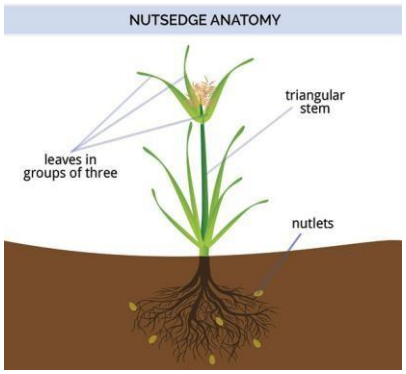
b. Stem – Cylindrical, soft, hollow, hairy; hairs simple, non-glandular, multicellular, green, with node and internode; internode 2-7 cm. long.

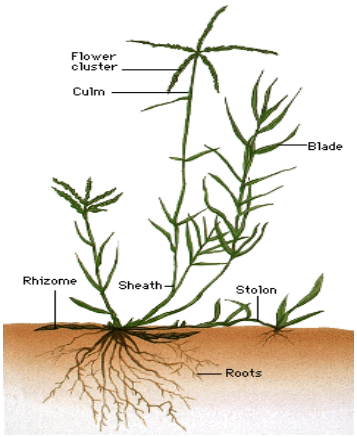
c. Leaf- Opposite decussate, simple, lanceolate, 8-9 cm. in length and 1-1.5 cm. in breath, acurninate, entire, cuneate base, herbaceous; venation reticulate, hairy; hairs simple multicellular, green, sessile, exstipulate.

d. **Inflorescence-** Spike dense and compact, axillary; peduncle cylindric, 0.5 cm, green, glabrous.

Biology of alligator weed (*Alternanthera philoxeroides*)

Alligator weed is able to spread and reproduce rapidly through stems or leaf cuttings making it difficult to eradicate in areas once established because it can grow from small portions of the plant left behind. Alligator weed propagates most commonly from stolons vegatatively with each individual node capable of propagating allowing for rapid spread and propagation of the plant.





Problem No. 1 Draw the diagram of bermuda grass and label different plant parts . State the mode of propagation.

Problem No. 2 Draw the diagram of brown nut sedge and label different plant parts. State the mode of propagation.

Suggested link:

1. https://www.youtube.com/watch?v=qoFv_1MNqh8&list=WL&index=33

Conclusion

Experiment No. 7
To study the methods of recording weed intensity

Instructional objectives

a) To learn about recording of weed population per unit area.

b) To learn about recording of weed dry matter per unit area.

Materials required

Quadrat, measuring tape, paper bags, sickle, balance, oven etc.

Procedure

For recording weed intensity, quadrat of different sizes that is 30cm x 30cm, 50cm x 50cm, 1m x 1m etc are in use which can be selected as per row to row spacing and nature of growing habits of the crop. Generally, quadrate of 30cm x 30cm is commonly used. Through the quadrat at random in a plot of different crops/ treatments and count the total number of weeds coming in the quadrat repeat this process 2-3 times per plot. Then convert the number of weeds counted from 30cm x 30cm quadrat into number of weeds per square meter. For recording dry matter, first of all take fresh weight of weeds (without roots) from quadrat of 30cm x 30cm. Dry the samples in the sun and put these samples in oven for complete dryness at a temperature of 55 to 60°C

Observation

Report weed count as number of weeds per square meter and weed dry matter as q/ha.

Sr. No.	Name of the crop per treatment	Weed count per 30cm x 30cm area	Weed count / sq.m	Dry matter weeds per 30cm x 30cm area	Dry matter of weeds (q/ha.)

Suggested link:

https://www.youtube.com/watch?v=fDEpsZMMWZI

Interpretation

Conclusion

Experiment No. 8

Studies on losses caused by weeds

Instructional objectives

To estimate the yield losses due to competition of weeds with crop for various growth factors like nutrient, moisture, light and space

- To study the losses caused by weeds in agriculture

Relevant information on weed competition and yield loss

Competition occurs between crop and weeds for a growth factor which becomes in short supply. Weeds compete with crop plants for water, light, nutrients, space, air and the ultimate effect is reduction in yield. In general weeds cause 5% loss in agricultural production in developed countries, 10% loss in less developed countries and 25% loss in least developed countries. .In India, yield losses due to weeds are more than those from insect and diseases. Generally, weeds deprive the crops by 47% N, 42% P, 50% K, 39% Ca and 24% Mg of their nutrient uptake.

Effect of weed competition on crop growth and yield

1. Crop growth and yield is affected
2. Leaf area is reduced
3. Reduce the water use by the crop
4. Lowers the input response
5. Crop suffers from nutritional deficiency
6. Yield attributes will be lowered
7. Causes yield reduction
8. More occurrence of pest attack

Weeds compete with crops for soil moisture, nutrients, sun light and space. They soon Losses due to weeds

5.3.1. Reduction in crop yield: outgrow the crops and consume large amounts of water and nutrients, Being hardy and vigorous in growth habit, ultimate effect they cause heavy losses in yield.

5.3.2 Computation of yield losses due to weeds

Yield losses in percentage due to weeds in a particular treatment from best treatment is calculated as follows .

Percentage (%) reduction in yield: It is a measure of the efficacy of particular treatment when compared with weed free treatment and is expressed as percentage reduction in yield. Higher in percentage yield reduction means greater loss due to weeds:

$$\textbf{\% yield reduction} = \frac{X - Y}{X} \times 100$$

Where, X is yield from weed free treatment = 40.50 q/ha And Y is yield of weed check treatment =15.34 q/ha
% Yield reduction in weedy check treatment= {(40.50-15.34)/ 40.50} x100 = 62.12 %

Conclusion -It is inferred that uninterrupted growth of weeds reduced the yield by 62.12 % in weed check treatment condition. The magnitude of loss was reduced with the adoption of weed management practices.

Problems:

1. **A weed free plot of Sorghum has given yield of 1500 kg ha^{-1} whereas atrazine has given yields of 1400 kg. Calculate the % yield reduction?**

2. **A weed free plot of maize has given yield of 2100 kg ha^{-1} whereas, simazine treated plot had given the yield of 1450 kg ha^{-1}. Calculate the % yield reduction?**

Suggested link:

1. https://www.youtube.com/watch?v=4R84sny-fgI

Interpretation

Conclusion

Experiment No. 9
Study of herbicide formulations and mixture of herbicide

Instructional objectives

To acquaint with different herbicide formulation available in the market and herbicide mixture

Materials required

Herbicide containers bearing labels, sample labels of various commercial herbicides.

Procedure

Read the information on the labels attached to the herbicide containers.

Types of formulations

A) Solid Formulations :

a) Solid formulation for Direct use :

Granules (GR / G) - A free-flowing solid formulation of a defined granule size range and ready to use. The active ingredient either coats the outside of the granules or is absorbed into small particles of clay, talc, or similar carrier. The amount of active ingredient is relatively low, usually ranging from less than 1% to 15%. The carriers in many granular formulations absorb moisture so humidity affects their flow rate during application. Ex. Butachlor 5% GR; Anilophos 2% GR; Oxyfluorfen 0.35% GR.

b) Solid formulation for Dispersion :

Wettable Powder (WP): Active ingredients are applied to finely ground talc or clay particles. Most WP formulations also include wetting and/or dispersing agents. Usually, they are mixed with water to form a suspension and applied as a spray. They will settle quickly without constant agitation. To prepare a spray suspension, prepare a slurry by mixing the WP with a small amount of water, then dilute this slurry mixture further with water. Ex. Atrazin 50% WP; Clodinafop propargyl 15% WP; Pyrazosulfuron ethyl 10% WP; Metribuzin 70% WP etc.

Water Dispersible Granules (WG) or Dry Flowables (DF) : These are basically WP formulations that have been compressed into dust-free, granule-sized particles. These formulations readily pour out of their containers and are easier to measure and cleaner to handle than WPs. It is mixed with water and applied as a spray suspension. Once in water and agitated, the granules break apart into fine powder. These formulations require constant agitation to keep them dispersed in water.

WG has one added benefit of reduced dermal exposure risk for user. Ex. Sulfosulfuron 75% WG; Flucetosulfuron 10% WG; Metsulfuron methyl 20% WG.

c) Solid formulation for Dissolution :

Soluble Powder (SP) : These formulations look like wettable powders. However, when mixed with water, soluble powders dissolve readily in water and form a true solution. After a thorough mixing, no additional agitation is necessary. Soluble powders have all the advantages of WPs but the major disadvantage is inhalation hazard during mixing due to fine powder. **Ex. No registered**

herbicides available in this formulation because very few active ingredients dissolve in water.

Soluble Granules (SG) : SG is a formulation consisting of **granules** to be applied as a true solution of the active ingredient after dissolution in **water**, but which may contain insoluble inert ingredients. Ex. Glyphosate 71% SG.

B) Liquid Formulations :

a) Simple solution :

Soluble Concentrate (SL) : Soluble Concentrate is a clear to opalescent solution of the active ingredient after dilution in water. The liquid may contain water-insoluble adjuvants. It is also known as Soluble Liquid. Ex. Glyphosate 41% SL; Imazethapyr 10% SL; Glufosinate Ammonium 13.5% SL .

b) Solution for Dispersion :

Emulsifiable Concentrate (EC) : It consists of the active ingredient dissolved in an organic solvent with sufficient emulsifier added to create on oil in water emulsion.

The emulsifier allows the active ingredient in the solvent to mix with water and form an emulsion. Emulsion is a mixture of liquid suspended in another liquid like fat globules in milk. The EC when added to water form a milky solution. Ex. Cyhalofop Butyl 10% EC; Clomazone 50% EC; Butachlor 50% EC; Oxyfluorfen 23.5% EC.

c) Emulsions :

Emulsion in Water (EW) : An emulsion in water formulation is the dispersion of a liquid active ingredient in water. EWs are less likely to damage tender plant foliage and reduced dermal toxicity because they do not contain solvents. Ex. Pretilachlor 37% EW;
Butachlor 50% EW.

d) Suspensions :

Suspension Concentrate (SC) or Flowable (F): Some active ingredients will not dissolve in either water or oil so they are impregnated in a dry carrier, such as clay, which is ground into a fine powder. The powder is suspended in a small amount of liquid to make the thick liquid formulation called SC or F. Ex. Penoxsulam 21.7% SC; Bispyribac Sodium 10% SC; Metamitron 70% SC

Herbicide mixture

Herbicide mixture is the mixing of two or more herbicides having different mode of action. Pre and post emergence herbicides are mixed to increases in the spectrum of weeds control over a longer period of time. It prevents herbicide resistance development in weeds and weed flora shift in crops and cropping system to selected herbicides.

Types of herbicide mixture

a) Ready mix or Premix: The mixture of desired herbicides are prepared in the factory with definite proportion. Ex. (Bensulfuron methyl 0.6%+Pretilachlor 6% GR) ; (Bispyribac Sodium 20% + Pyrazosulfuron Ethyl 15 WG); (Clodinafop Propargyl 15% + Metsulfuron Methyl 1% WP); (Imazethapyr 35% + Imazamox 35% WG) **.**

b) Tank mix- It is mechanical mixing of two or more registered herbicides with required quantities in the spray tank right before applying to the field. ***Tank Mixing of herbicides is not a regulated***

practice and purely a farmers practice.

Mixture herbicides in general widen the Spectrum of Weed control.

Interaction effects of mixture

a) **Synergistic effect-** The total effect is more prolonged than the sum of effects of the component herbicides taken independently.
Ex. (2, 4 –D Amine salt + Metribuzin) and (Paraquat dichloride + Diuron) are good tank mixture for Synergistic effect for controlling *Avena sp*. and *Agropyron repens* (Quackgrass), respectively.

b) **Additive effect -**It is the combine action of component herbicides mixture when the total effect of mixture is equal to sum of total effects of component herbicides applied independently.
Example- (Bensulfuron methyl 60% DF + Pretilachlor 50% EC); (Clodinafop propargyl 15% WP + Metsulfuron methyl 20% WP) result in additive effect in tank mix.

c) **Independent effect**- The total effect of mixture is equal to the effect of the most active component herbicide applied.

d) **Enhancement effect-** It is obtained when a non-phytotoxic chemicals / surfactants are added with the active ingredient and increase the efficacy of herbicide.
Example- (Chlorimuron Ethyl 25% WP + 0.2% Non-ionic Surfactant); (Imazethapyr 10% SL + 0.2% MSO adjuvant) [MSO = Methylated Seed Oil]

e) **Antagonistic effect**- Antagonism is when the effect of herbicides mixture is less than the predicted effect of each herbicide applied separately. Example- (2,4 D Amine salt + Glyphosate) (Fenoxaprop-P-ethyl + Bispyribac-sodium) mixtures are antagonistic to each other in field application.

Table : Trade name, formulation, a.i. and common use and source of herbicides

S.N.	Common name	Trade name	Formulation and a.i.	Common use	Source
Herbicides					
1.	2,4-D (amine)				
2.	2,4-D (ester)				
3.	2,4-D (Na salt)				
4.	Acetachlor				
5.	Anilofos				
6.	Alachlor				
7.	Atrazine				
8.	Benthiocarb				

9.	Butachlor				
10.	Chlorimuron				
11.	Chlorosulfuron				
12.	Dalapon				
13.	Diclofop-methyl				
14.	Diuron				
15.	Fluchloralin				
16.	Fluazifop				
17.	Glyphosate				
18.	Imazethapyr				
19.	Isoproturon				
20.	Mestsulfuron-methyl				
21.	Metolachlor				
22.	Metribuzin				

S.N.	**Common name**	**Trade name**	**Formulation and a.i.**	**Common use**	**Source**
Herbicides					
1.	2,4-D (amine)				
2.	2,4-D (ester)				
3.	2,4-D (Na salt)				
4.	Acetachlor				
5.	Anilofos				
6.	Alachlor				
7.	Atrazine				
8.	Benthiocarb				

9.	Butachlor				
10.	Chlorimuron				
11.	Chlorosulfuron				
12.	Dalapon				
13.	Diclofop-methyl				
14.	Diuron				
15.	Fluchloralin				
16.	Fluazifop				
17.	Glyphosate				
18.	Imazethapyr				
19.	Isoproturon				
20.	Mestsulfuron-methyl				
21.	Metolachlor				
22.	Metribuzin				

23.	Oxadiargyl				
24.	Oxadiazon				
25.	Oxyflourfen				
26.	Paraquat				
27.	Pendimethalin				
28.	Pretilachlor				
29.	Sulfosulfuron				
30.	Trifulralin				
Formulated combinations					

1.	Bensulfuron + pretilachlor				
2.	Clodinafop + metsulfuron				
3.	Imezethapyr + imazamox				
4.	Metsulfuron methyl + chlorimuron ethyl				
5.	Mesosulfuron + idosulfuron				
6.	Pendimethalin + imazethapyr				
7.	Sulfosulfuron + metsulfuron-methyl				

Suggested link:

1. https://www.youtube.com/watch?v=s3SeHDa7nTs
2. https://www.youtube.com/watch?v=q36VksF2xu8
3. https://www.youtube.com/watch?v=I8MASBHNYrM

Conclusion

Experiment No. 10
Identification of common herbicides

8.1 Instructional objectives

To study, identify and acquaint with common herbicide available in the market.

8.2.Material required

i. Herbicides container bearing labels
ii. Sample labels of various types of commercial herbicides

Procedure

Read the information on the labels attached to the herbicide containers. Record the information in systematic manner.

Observation

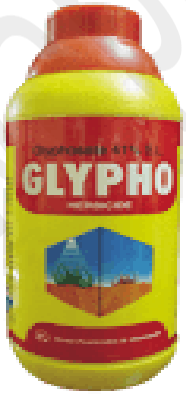
Record the following observations in tabular form indicating common name, trade name, formulation and manufacturing company of agrochemicals .

Table : Identification of herbicides

List of commonly available agrochemicals and their manufacturing companies

Common name	**Trade name**	**Formulation**	**Manufacturing Company**
Herbicide			
Imazethapyr	Pursuit	10% SL	BASF India Ltd., Mumbai
Clodinafop propargyl	Topik	15% WP	Syngenta India Ltd, Pune
Glyphosate	Glycel	41% SL	Sumitomo Chemical India Ltd., Mumbai
Pyrazosulfuron ethyl	Saathi	10% WP	UPL Ltd., Mumbai
Glufosinate Ammonium	Basta	13.5% SL	BASF India Ltd., Mumbai
Pretilachlor	Rifit	50% EC	Syngenta India Ltd, Pune
Flucetosulfuron	Zechor	10% WG	Indofil Industries Ltd., Mumbai

Revolt



Ken-Phosate

Sofit

Suggested link:

1. https://www.youtube.com/watch?v=e4gNOy9Chvs
2. https://www.youtube.com/watch?v=rHClmvqOnNk
3. https://www.youtube.com/watch?v=i7jwSZqnFgw
4. https://www.youtube.com/watch?v=jEUqnkOHBvs

Conclusion:

Experiment No. 11
Study on Methods of Herbicide Application

Instructional objectives

To know the effective use of herbicide to reduce the weeding cost, labour use and save time.

Method of herbicide application

The herbicide application is grouped into the following ways:

A Method of application of soil active herbicides

a) Surface application: The soil applied herbicides are applied on soil surface where they are left as such or incorporated in to the soil. Under the influence of soil moisture or rain herbicides move to 3 to 4 cm of soil depth under the influence of rain or irrigation water. The volatile herbicides like trifluralin and fluchloralin herbicides are incorporated to the soil by light ploughing or with light irrigation to the depth of 5 cm.

b) Sub surface layering

In this method the herbicides are applied in concentrated band about 7-10 cm below the soil surface. It is very effective in controlling perennial weeds (e.g. *Cyperus rotundus*) by inhibiting the growth of shoots. The subsurface application is done through the special flood nozzles introduced below the soil.

c) Broadcast and band application: Broadcast application of herbicide is made over an entire area. The band application of herbicides is done on restricted area along the crop rows. This application is cost saving as it reduces the quantity of herbicides required. In the band method of application the inter rows are cultivated later to remove weeds from the unsprayed areas.

a) Soil fumigant application

Depending upon the nature of the soil fumigant it can be applied either by-

(i) Soil injection (e.g chloropicrin)
(ii) Releasing under sealed plastic covers (e.g methyl bromide)
(iii) Soil surface application (e.g metham)

B) Method of application of foliage active herbicides-

a) Blanket application

The herbicides are applied uniformly to the standing crop irrespective of the location of the crop plants. The highly selective herbicides are preferred for blanket application.

b) Directed spraying

In this method the application of herbicides is directed to weeds growing in the inter rows of the crops avoiding the crop foliage as much as possible (e.g. paraquat in sugarcane). Directed spraying is also performed by setting the nozzles low with spray patterns to intersect the base of the crop plants just above the soil line. This saves the crop plants from herbicide injury and improves weed kill. Directed spraying can also be accomplished by fitting the nozzle in the hood. Usually the selective herbicides are used in crops. But in hardy crops with greater plant height over weeds, the non selective herbicides can be applied by using nozzle attached with the hood.

c) Protected spraying - In wide spaced vegetables and ornamental plants, the non selective herbicides are applied by covering the crop plants with plastic or metallic covers. This method is very laborious. But it is very effective in weeding the high value crops.

d) Spot treatment – The herbicides are applied to small patches of weeds leaving the weed free gaps untreated. Noxious perennial weeds are effectively controlled with application of potent herbicides in this method.

C) Method of treating brush and tree weeds

a) **Basal bark treatment** – The basal bark of the brush or tree to the length of 30 cm is peeled and herbicides are applied to the peeled portions only.

b) **Cut stump treatment** - The herbicide application is made on the cut surface after sawing the tree just above the ground level.

c) **Frill and notch method** - The frill and knotches are made with sharp tool into the tree weed at convenient height. The frill and notches are filled with herbicide. The herbicides are also injected in to the holes made in the tree trunk up to 2.5 cm thickness. These methods are adopted on thick stem trees of 8 cm or more in diameter.

D. Other methods of herbicides application

a) **Direct contact application (DCA):** It involves the techniques of wiping, rubbing and smearing of herbicides on the target plant surface. It is done by using herbicide wax bar, herbicide cloth mulch, roughing gloves or hand brush. The herbicide laden wax bars are dragged against weeds growing much taller to the crop plants. Herbicide cloth mulches are placed in the crop inter rows. The rouging gloves carry arrangement to smear herbicide on the weed gripped by the worker.

b) **Soil injection:** Herbicides like ethylene dibromide, carbon disulphides and vernolate are applied by soil injection at prescribed spacing before planting of crops.

Solution of problem no.1 Write down the precautionary measures to be followed while spraying a herbicide.

Precautions in Herbicide Application

- Read the herbicide label carefully and follow the direction on the label.
- Check the sprayer before starting spray. It should be working properly.
- Use only *Flat fan* or *Evan* spray nozzle.
- Clean the sprayer with clean water before and after spraying.
- Calculate the amount of commercial products required for area to be sprayed.
- Mix the herbicide in small quantity (1-2 litres) or water first and then make the required volume with water (600-750 L/ha).
- Divide the field to be sprayed into parts i.e. one bigha land may be divided into four parts of 200 sqm. Each and spray 12-15 litres of herbicide solution in each part. This will ensure uniform spray in whole area.
- Do not spray herbicide on windy and rainy days.
- Judge the stage of crop and weeds in case of post-emergence application.
- *Store the herbicide* in labelled containers and way from food material and children.

Suggested link:

1. https://www.youtube.com/watch?v=fdNgUsYpYzI&list=WL&index=39
2. https://www.youtube.com/watch?v=0c4frbuPSPc&list=WL&index=38

Conclusion

Experiment No. 12
Study of Herbicide Spraying Equipments

Instructional objectives

To acquaint with different types of sprayers, proper handling of sprayers and familiarize with various mechanism of sprayers to increase the spraying efficiency

Procedure

Write the various parts of the sprayer and nozzles along with nozzle types.

Study of sprayers

Sprayers are of two types depending upon the type of force required

Manually operated

i) Compressed air sprayer
ii) Hydraulic sprayer

11.3. 2. Power operated

i) Gaseous energy sprayers –motorized knapsack sprayers
ii) Centrifugal energy sprayers –Controlled droplet and micron herbisprayer
ii) Tractor mounted power driven sprayers
iii) Aerial sprayers

But generally hand operated sprayers are used by common farmer.

11.3.3 Hand operated sprayers

Compressed air or Pneumatic sprayer

i) **Knapsack sprayers -** The knapsack sprayers are loaded on the back of the applicator. Three types of knapsack sprayers are available (a) hydraulic (b) manual pneumatic and (c) motorized pneumatic.

a) **Hydraulic knapsack sprayers -** It works under hydraulic pressure. The tank capacity varies from 5 to 15 litres with the provision of mechanical agitation of the spray liquid. The operator operates the lever with his left hand and pumps the spray liquid in to the lance held by his right hand. While operation it is usually possible to deliver the spray at almost constant pressure. The hydraulic knapsack sprayer could spray at pressure of 3 to 5 kg/ cm^2. This sprayer is of low cost, easy to maintain and is a small holding farmer sprayer. It is more suitable for spot and band application of herbicides.

b) **Pneumatic or compressed knapsack sprayer** - This sprayer does not require pumping during spraying and is not pressurized before loading on the back of the worker. It is filled up as per the capacity of the sprayer. Then it is pumped either with a built in pump or from an external source like a charge pump or carbon dioxide cylinder. The main disadvantage of this sprayer is that uniform delivery pressure cannot be maintained due to decreasing spray pressure during the spraying operation. This may cause uneven spray.

c) **Motorized pneumatic sprayer -** It is a low volume sprayer suitable for spraying concentrated

spray liquids. A blast of air acts as a carrier of herbicide concentrates in these sprayers are called blowers. The air is forced through the spraying jet of the delivery hose of the blower and the nozzle tube ejects the spray liquid. In this type, the air blast atomizes the spray liquid into tiny drops. The atomization is more vigorous when the air is pumped at faster rate in to the spraying unit.

The herbicide is lost as spray drift as the blower produces the droplet size of 50-100 microns. The main advantages of knapsack blowers are low volume spray resulting in reduction in loss of time in refilling the tank and fast spraying. It has a swath of 7-8m .There is requirement of 60 litres of spray liquid for spraying one hectare.

d)**Foot sprayers -** Foot sprayers are used for application of herbicides in larger holdings. The pump lever of a foot sprayer has a pedal conveniently worked with a foot. The pedal pump sprayer has an external spray tank through an intake pipe fitted with a sieve at its sucking end. The working pressure may range between 17 to 21kg/cm^2. Foot sprayers have provision of long delivery hoses fitted with a lance. The suction spout is dipped in a container filled with herbicide spray solution which acts as an external tank.

ii) **Hand held sprayers** - The hand carried lighter weight low volume battery operated sprayers are suitable in smaller holding size in tropical and subtropical countries. Two types of such spray are available to the farmers.

a) Controlled droplet applicator (CDA) – In this type, the spray droplet size is 250 microns which is more effective and adequately drift tolerant. The controlled size droplets are known as ultra low volume sprayer. It has a rotary atomizer and a spinning disc with a serrated edge which revolves at a speed of 2000 revolutions per minute (rpm) to produce droplet size of 250 micron. The herbicide spray solution is gravity fed to the disc from a plastic container of 2.5 litres capacity. The atomizer is driven by a small electric motor which is attached to the tube carrying the batteries that provide power for the motor. The spray volume is 15-20 litres/ha. This sprayer is more handy for small holdings, treating rough topography land and wet paddy fields. The sprayer covers the swath of 1.2 m wide with a walking speed of 3 to 5 km/hr. This method is particularly useful in case of foliage applied systemic herbicides.

Parts of knapsack sprayer

a) **Flat or bean-shaped tank of 10-15 litres capacity**
b) **Pump fitted inside/outside the tank**
c) **A handle to operate the pump**
d) **Agitator**
e) **Filter**
f) **Delivery hose**
g) **Spray gun with nozzle and**
h) **Flow control lever.**

Types of nozzles

Adjustable nozzle
Double swirl spray
nozzle Selecting a
spray nozzle Selecting
a spray nozzle
Hollow cone nozzles-Disc and core
type Flat fan nozzles
Floodjet nozzles
Adjustable nozzles

Fig. 12. 1 : Mention the types of sprayer and label it's parts

Fig.12. 2: Mention the type of sprayer and label it's parts

Fig. 12. 3: Mention the type of sprayer and label it's parts

Fig. 12. 4. Mention the type of nozzle and label it's parts

Fig. 12. 5: Mention the type of nozzle and label it's parts

Fig. 12. 6: Mention the type of nozzle and label it's parts

Suggested link:

1. https://www.youtube.com/watch?v=94MmnMAXBoQ&list=WL&index=44
2. https://www.youtube.com/watch?v=JnT5X7ij06A&list=WL&index=43
3. https://www.youtube.com/watch?v=NyOU6RtXcX4&list=WL&index=42

Conclusion

Experiment No. 13

Calibration of herbicide spraying equipments

Instructional objectives

To calibrate the spray equipments for required spray volume.

Materials required

Sprayer (Knapsack), buckets, water, measuring tape, graduated cylinders, time clock.

Method of calibration

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

Step 1 : 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

Step 2 : 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 graduated cylinder
- Repeat the operation for three times.
- Determine the average reading. This is the nozzle discharge or flow rate expressed in litres / minute.

Step 3 : Determination of spray volume

Measure and mark an area of 50 sq.m 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.

Step 4 : 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.

Step 5 : 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.

Step 6 : Observation

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

a) Total distance travelled = d metre
b) Time taken for travelling distance 'd' metres = t min.
c) Swath width = x metres
d) Amount of water discharged at a given pressure = L litre.

Calculation

A. Spray volume

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

$$= \frac{L}{d \times x} 10000$$

Example : If 50 metres were covered while spraying a solution (water) of 4 litres with a swath width of 1 metre, the volume required for one hectare would be :

$$= \frac{4 \times 10000}{50 \times 1} = 800 \text{ litres } (1 \text{ ha} = 10{,}000 \ m^2)$$

B. Area covered per hour by sprayer

Area sprayed (m^2 / minute) = width of spray swath (m) x walking speed (m/min)

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

$$\text{Area (ha/hr)} = \frac{\text{WS (m /hr) x Swath (m)}}{10{,}000}$$

C. Pump capacity of a sprayer

The rate of discharge of a sprayer per unit time can be calculated by fo llowing formula : Spray

$$\text{Pump capacity (L /hr)} = \frac{\text{volume (L/ha) x Swath width (m) x Walking speed (m/hr)}}{10{,}000}$$

Example : If a person is walking at 2 km/hr covering a swath of 1 m width, with a spray discharge rate (pump capacity) 100 litre s/hr, then calculate the area covered (ha) per hour, time taken (hr) to cover an area of one hectare and spray volume required for an area of one hectare

(a) Area covered per hour $= \frac{2 \times 1000 \times 1}{10000} = 0.2$ ha /hr

(b) Time required to cover one hectare $= \frac{1}{0.2} = \frac{10}{2} = 5$ hrs

(b) Spray volume for one hectare = Discharge rate (L /ha) x Time required (ha) for spray (hr) x Area

= 100 x 5 x 1 = 500 litres /ha

Example : Find out the spray volume in litres /ha if the pump capacity is 50 litres / minute, swath width is 5 m and walking speed is 10 km/hr.

$$\text{Pump capacity (L /hr)} = \frac{\text{Spray volume (L /ha)} \times \text{Swath width (m)} \times \text{Walking speed (m /hr)}}{10{,}000}$$

$$\text{So, spray volume (L /ha)) } = \frac{\text{Pump capacity (litres /hr)}}{\text{Swath width (m) x Walking speed (m/hr)}} \times 10{,}000$$

$$= \frac{50 \times 60 \times 10{,}000}{5 \times 10{,}000} = 600 \text{ L /ha}$$

Problem -1

What minimum size of pump is required to apply a spray at 90 L/ha with sprayer travelling at 8 km /hr and equipped with a 8 m long boom.

Solution

Given spray volume = 90 l /ha

Walking speed = 8 km /hr

Spray swath = 8 m

Pump capacity (l /m) = ?

$$\text{Pump capacity (l /minute)} = \frac{\text{Spray volume (L /ha)} \times \text{Swath width (m)} \times \text{Walking speed (m /hr)}}{10{,}000 \times 60}$$

$$= \frac{90 \times 8 \times 8{,}000}{10{,}000 \times 60} = \frac{48}{5} = 9.6 \text{ L/m}$$

Problem -2

A tractor drawn sprayer is walking at 10 km /hr covering swath width of 2 m, with a spray discharge rate of 50 L/ha. Calculate the area covered per hour, time taken (hr) to cover an area of 5 hectares and spray volume required for the same area.

Solution

Suggested link:

1. https://www.youtube.com/watch?v=eeas2Vs0n4U
2. https://www.youtube.com/watch?v=Epf1rjJyGeM
3. https://www.youtube.com/watch?v=iF1ZiILoqN0

Conclusion

Experiment No. 14

Calculations of Herbicide Doses

Instructional objectives

To learn about calculations of herbicide doses
To determine quantities of herbicide required for weed control in crops

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 herbicides.
a.e. or a.e. for liquids.

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 active part and adjuvant part. Since all the recommendations are made on the basis of a.i., certain calculation becomes necessary to find out the quantity of commercial product to be required for a given area.

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.

General Formula for Conversion of Active Ingredient (a.i.) to Formulation dose:

$$\text{Herbicide Formulation Required (in g)} = \frac{\text{Recommended dose in g a.i./ha}}{\text{\% Conc.of Herbicide Formulation}} \times 100 \times \text{Area (in ha)}$$

Problem No.1 :
Pre-emergence tank mix application of Pretilachlor 50% EC @ 500 g a.i./ha + Bensulfuron methyl 60% DF @ 60 g a.i./ha is effective in controlling grassy weeds . Find out the required herbicides formulations for 1.25 ha.

Answer :
Quantities of Pretilachlor = 100/50 x 500 x 1.25 = 1250 g
Quantities of Bensulfuron methyl = 100/60 x 60 x 1.25 = 125 g

Problem No. 2 :
Post emergence Tank Mix application of Pyrazosulfuron ethyl 10% WP @15 g a.i./ha + Bispyribac sodium 10% SC @ 20 g a.i./ha effectively controls grasses, broad leaves and sedges. Calculate the required herbicide formulations for 0.75 ha.

Answer :
Pyrazosulfuron ethyl 10% WP = 100/10 x 15 x 0.75 = 112.5 g
and Bispyribac sodium = 100/10 x 20 x 0.75 = 150 g

Problem No. 3

Post emergence application of 2.4-D Na salt containing 80%WP (80% a.i.) @ 0.5 kg a.i./ ha is sprayed. Find out the quantity of 2.4-D Na salt is required for a hectare?

Answer:

Problem No. 4

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. Find out the quantity of Na salt will be required?

Answer:

Problem No. 5

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

Answer:

Problem No. 6

Calculate the amount of Eptam-6EC containing 0.6 kg of active ingredient (S-ethyl dipropylthiocarbomate) per litre, for an area of 5 ha. The application rate is 1.5 kg a.i./ha.

Problem No. 7

If in area of 0.5 ha is to be sprayed with Atrazine (50 % WP) @ 1 kg/ha, what would be the quantity of commercial herbicide required?

Suggested link:

1. https://www.youtube.com/watch?v=sLUohJ5ZhKQ&t=3s

Conclusion

Experiment No. 15

Calculate the crop weed competition using different indices

13.1 Instructional objectives

(i) To estimate the competitive effect of weeds on crop growth.

(ii) To demonstrate the effect of competition among weeds and crop plants.

(iii) To study the weed and crop response to weed control treatments.

(iv) To study efficacy of herbicides.

(v) To determine efficacy of intercropping on suppression of weed.

(vi) To calculate the crop-weed competition using different indices

13.2Quantitative method of evaluation methods

Record the data on dry matter production of weeds and count of weeds species in unweeded and treated plots or from intercropped plot and sole crop plots and crop yield from unweeded and treated plots of the experimental area.

Formula and Calculation:

1. Weed infestation: It refers to the percentage of weeds in the composite population of weed and crop plants.

$$\text{Weed infestation (\%)} = \frac{\text{Total number of weeds in unit area}}{\text{Total number of weeds and crop plants in the same area}} 100$$

2. Weed index / weed competition index: It refers to the reduction in crop yield due to the presence of weeds in comparison to weed-free crop:

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

This is used to assess the efficacy of herb icide. Lesser the weed index, better is the efficiency of herbicides and vice versa.

Example: Calculate the weed competition index for alachlor and pendimethalin applied in greengram from the following data.

1. Yield of greengram from weed free plot = 18 q ha^{-1}
2. Yield of greengram from alachlor treated plot = 16 q ha^{-1}

3. Yield of greengram from pendimethalin treated plot = 14 q ha^{-1}

Calculation

i. Weed index for alachlor = $\frac{18-16}{18} \times 100 = 11.11\%$

ii. Weed index for pendimethalin = $\frac{18-14}{18} \times 100 = 22.22\%$

Results :

The weed index is lesser for alachlor, so it is a better herbicide than pendimethalin.

Weed Control Index (WCI) and Weed Control Efficiency (WCE): It indicates the efficiency of the applied herbicide or other practices to control weeds. It is the percentage reduction in weed dry matter by any weed control treatment in comparison to weedy check plot. This index is used to compare the different weed control treatments. Higher the WCE of any treatment, better is the treatment, and vice versa.

$$WCI\ (\%) = \frac{\text{Dry matter of weeds in unweeded plot} - \text{Dry matter of weeds in treated plot}}{\text{Dry matter of weeds in unweeded plot}} \times 100$$

or

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

Example : In a weed control experiment in groundnut, dry weight of weeds in weedy check plot was 570 kg $ha^{-1,}$ whereas, for herbicides x and y, it was 355 and 240 kg ha^{-1}, respectively. Find out which herbicide is better.

$$WCI = \frac{X - Y}{X} \times 100$$

4. Weed control index for herbicide x = $\frac{570-355}{570} \times 100 = 37.72\%$

5. Weed control index for herbicide y = $\frac{570-240}{570} \times 100 = 57.90\%$

Results

Since WCI of herbicide y is higher than x, hence it is better than x.

3. Weed smoothering efficiency (WSE)

It is used to determine the effect of intercropping on suppression of weeds in comparison to pure stand crops.

$$\text{WSE (\%)} = \frac{\text{Dry matter of weeds crops from intercropped plots} - \text{Dry matter of weed from pure stand}}{\text{Dry matter of weeds from pure stand crop}} \times 100$$

Problems :

1. Calculate the weed competition indices in mustard with the help of following details.
   (i) Yield of weed free plot = 18.5 q ha^{-1}
   (ii) Yield of fluchloralin (1.0 kg ha^{-1}) treated plot = 15.0 q ha^{-1}
   (iii) Yield of pendimethalin (1.0 kg ha^{-1}) treated plot = 14.32 q ha^{-1}
   (iv) Yield of oxyfluorfen treated plot = 15.8 q ha^{-1}
   (v) Yield of weedy check plot = 8.5q ha^{-1}
   Which herbicide will you recommend to the farmers.

2. Application of 2,4-D at 1.0 kg ha^{-1} in wheat field gave a seed yield of 45.0 q ha^{-1}. If weed index is 10%, then calculate the yield of weed free plot.

3. A weed free cumin crop produced 4.45 q seed ha^{-1}. If weed indices for one hand weeding at 25 DAS, pendimenthalin at 1.0 kg ha^{-1} and trifluralin at 1.0 kg ha^{-1} are 18.5, 13.8 and 10.6%, respectively, then calculate the yield of cumin recorded under these treatments.

4. Calculate the weed control efficiency of alachlor and nitrofen in soybean with the help of following information :
   i. Weed dry matter in weedy check plots = 17.25 q ha^{-1}
   ii. Weed dry matter in alachlor (1.5 kg ha^{-1}) treated plots = 5.70 ha^{-1}
   iii. Weed dry matter in nitrofen (1.0 kg ha^{-1}) treated plots = 4.50 q ha^{-1}

   If metribuzin (0.7 kg ha^{-1}) controlled the weeds to the extent of 85%, compute the weed dry matter accumulated under this treatment. Which herbicides is recommendable to the farmers?

5. Calculate the weed infestation in a mustard field if the plant population of mustard is 650 in a plot of 5 m x 3m. The weed population in the same area is 280.

Suggested link:

1. https://www.youtube.com/watch?v=22L53L7kX5g&t=319s
2. https://www.youtube.com/watch?v=SgVAFm2JmR4

Conclusion

Experiment No. 16
Shift of Weed Flora Study in different crop fields

Instructional objectives

To study and gain knowledge in shift of weed flora in different crop fields.

Relevant information

A weed shift is the change in the composition or relative frequencies of weeds in a weed population or community in response to natural or human-made environmental changes in an agricultural system. Susceptible weeds are largely eliminated over time with continued use of the same cultural practice or herbicide. This allows inherently tolerant weed species to remain, which often thrive and proliferate with the reduced competition

Weed shift in crops and cropping system

With a foliar herbicide without residual activity like glyphosate, there could also be a shift within a weed species to a late emerging biotype that emerges after application.Growing rice under alternating flooding regimes and residual soil moisture conditions prevalent in the Cauvery Delta region of Tamil Nadu, red sprangletop*{Leptochloa chinensis*(L.) and European water clover *(Marsileaqua drifolia*L.) became predominant in rice fields by replacing barnyard grass *(Echinochloa*sp.).In the eastern Indo-Gangetic Plains, adoption of zero tillage has resulted in an increase in population of globally-significant perennial weeds such as purple nutsedge (*Cyperus rotundus*) and Bermuda grass *(Cynodon dactylon)*

Effect of continuous use of herbicides on weed shifts in rice-wheat system

In long-term experiment on rice-wheat cropping system, continue use of herbicides (butachlor + 2,4-
D) and rotational use of herbicides (butachlor/pretilachlor (cyhalofop-butyl) in later years) + 2,4-D) in rice and continue use of (isoproturon + 2,4-D) and rotational (clodinafop/isoproturon)use of herbicides in wheat were tested in rice – wheat cropping system.

During winter season, *Phalaris minor*, *Avena ludoviciana*, *Vicia sativa*, *Anagallis arvensis* and *Coronopus didymus* were dominant weeds in wheat. Population density of all these weeds decreased in later years. *Coronopus didymus* was not observed after use of above herbicides. Again after 3-4 years, *Poa*, *Lolium* and *Ranunculus* were appeared. *Poa* and *Lolium* had alarming proportion in the later years while *Ranunculus* disappeared after 2-3 years. Again , after five years of experimentation, *Polygonum* and *Alopecurus* were the new invaders. In the later years, *Trifolium*, *Stellaria*, *Lathyrus*, *Plantago* and *Daucus carota* had little infestation in the experimental field. In *kharif*, *Echinochloa crusgalli*, *Panicum dichotomiflorum* and *Cyperus iria* were the main weeds initially. The population of these weeds decreased over the years. Lately *Digitaria*,*Ischaemum*, *Aeschynomene*,*Commelina*, *Paspalum*, *Ammannia*), *Eriocolon* and *Monochoria* were appeared in the experimental field. The population of *Monochoria*and *Ammannia*was in the decreasing trend while that of *Ericolons*showed increasing trend.

Based on 14 years phytosociological analysis, *Phalaris minor,Avena ludoviciana and Poa* occurred frequently amongst grasses while *Vicia , Anagallis*, *Coronopus*, *Lolium* were common broad leaved weeds during winter. During *kharif*, *Echinochloa, Cyperus, Panicum a and Ageratum Ammannia* and *Erio colon* invaded the rice crop .

Weed shift studies in maize based cropping system at Himachal Pradesh

Eight cropping systems such as Maize – Wheat, Maize + French bean – Pea – Summer squash; Maize +Soybean – Garlic; Maize – Broccoli – Potato; Maize + Asparagus bean – Radish – Onion; Maize + Mash – Cauliflower – French bean; Maize + Rice bean – Cauliflower -Buckwheat and Maize + Asparagus bean – Broccoli – Radish] were tested with three situations (normal weed control, no weed control/weedy and supplement weed control).

All together 28 weed species occurred in experimental field. During kharif*, Commelina and Ageratum* were the predominant weeds. In rabi, *Coronopus, Phalaris and Spergula* were the main weeds. During kharif, *Ageratum. Conyzoides* had highest importance value index (IVI), irrespective of the cropping system and situation. *C. benghalensis, Cyperus sp, Bidenspilosa and Ageratum houstonianum* were the other important weeds having higher value of the indices.

When the weeds were controlled with additional hand weeding, *Ageratum conyzoides*, *Bidenspilosa*, *Ageratum houstonianum*, *Polygoenum* sp, *Echinochloa crusgalli*, *Cyperus* sp. were the robust robbers. Weed flora during *rabi* was richer than that during *kharif*. *Phalaris minor* had higher importance value index (IVI) in the maize – wheat cropping system. In the other cropping systems either *Coronopus didymus*, or *Spergula arvensis* had higher values of these indices. *Bidenspilosa*, *Galinso gaparviflora*, *Stellariamedia*, *Alopecurus myosuroides*, *Lolium temulentum*, *Ageratum* sp, *Polygonum* sp, *Avena ludoviciana*, and *Cynodon dactylon* which were present in normal weed control situation but were completely eliminated in supplimented weed control . In the supplimented weed control then, *Rumex*sp, *Poaannua*, *Polygonum plebegium*, *Trifolium repens*, *Polypogon monspelensis* were major invaders.

Suggested link:

1. https://www.youtube.com/watch?v=idp9MTKuzPo&list=WL&index=36&t=157s
2. https://www.youtube.com/watch?v=iQpv8cIwdII&list=WL&index=37

Interpretation

Conclusion

References

Sharma, O.P. 2008. Practical Manual on Weed Management – Agron 121. Department of Agronomy, SKN College of Agriculture, Rajesthan Agricultural University, Campus Jobner, Jaipur, Rajesthan.

Rana, S.S., Kumar, S. and Rana, M.C. 2018. Practical manual for Agron 247. Department of Agronomy, Forages and Grassland Management, College of Agriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur.

Annexure – I

HERBARIUM SHEET

Sr. No._____

Local Name : .....
Common Name: .....
Botanical Name: .....
Family : .....
Habitat : .....
Locality : .....
Collection Date : .....
Collected by : .....
Notes : .....
.....
.....
.....

Annexure – II

List of common weeds

Scientific name	Vernacular name	English name
A. Grasses		
Andropogan leniger	Boor grass	-
Aristida depressa	Lampra grass	Three own
Avena fatua L.	Jangli Jai	Wild oat
Cenchrus cilliaris	Anjan	-
C. purea	White anjan	-
C. setigerus	Dhaman black	-
Cenchrus biflorus	Bhoorat, baroot	Sand bur
Cynodon dactylon (L.) Pers.	Doob	Bermuda grass
Cyperus iria L.	Dachab	Umbrella sedge
Cyperus rotundus L.	Motha	Purple nut sedge
Dactyloctenium aegypticum (L.) *Beauv.*	Makra grass	Crow foot grass
Digitaria ciliaris	Jhernia	Crab grass
Echinochloa colonum (L.) Link	Jangli Dhan (sama grass)	Jungle rice
Echinochloa crusgalli (L.) Beauv.	Sawan /kodon	Barnyard grass (water grass)
Eleusine indica (L.) Gaertn.	Mandla/Balrara	Goose grass
Eragrostis poacides	Chidi grass	Lover grass/stink grass
Lasirus sindicus L.	Sewan grass	Desert grass
Oryza sativa var. fatua	Jangli rice	Wild rice
Paspalum distichum	-	Knot grass
Phalaris minor Retz.	Gullidanda / ghehu ka mama	Little canary grass
Poa annua L.	Sua grass	Annual blue grass
Saccharum munja L.	Moonj	-
Saccharum spontaneum L.	Kans	Thatch or tiger grass
Seteria glauca (L.) Beauv.	Bandra-bandri	Fox tail grass
Sorghum halepense (L.) pers.	Barru/sudan grass	Johnson grass
B. *Kharif* weeds		
Achyranthus aspera	Latjira/chirchitta Apamarg /Puthkkunda	Snake's tail
Amaranthus blitum var. oleracea	Sabjiwali chandlai	Amaranth / pig weed
Amaranthus spinosus	Kantewali chaulai	Prickly amaranth
Amaranthus viridis	Jangli chandlai	
Boerhavia diffusa (syn. B. repens)	Sati /Biskhapra	Hog weed /Horse purslane
Celosia argentia L.	Safed murga	Cock's comb
Citrulus colocynthis	Tumba	Bitter apple

Commelina benghalensis L.	Kankana /Morabati	Day flower
Cumumis callosus	Kachari	Small gourd
Corchorus acuntaglis	Kag roti /Jangli jute	Wild jute
Digitaria sanguinalis	Jhernia ghas	Crabgrass
Digera muricata (Syn. D. Arvensis)	Lesua /Gundra/ Lohru	Amaranthus
Eichhornia crassipes (Mart.) Solms.	Jalkumbhi	Water hyacinth
Euphorbia hirta L.	Bari dudhi /Lal duhi	Ashthma weed /garden spurge
Euphorbia macrophylla	Choti dudhi	Carpet weed
Euphorbia themaphlia L.	Medium dudhi	-
Heliotropium subulatum & H. strigosum	Kali bui	Helitrop
Indigofera deffusa	Bekaria	Wild indigo
Leucas inifolia	Guma	Leucas
Momordica diocoa Rotb	Jangali karela	Wild small bitter gourd
Mollugo cerviana	Parpat /chiria-ro-khet	Pill pod spurge
Pedarium murex	Bada gokharu	-
Physalis minima	Papotan/Tulatipati	Sunberry/ground cherry
Portulaca oleracea and P. asiatica	Kulfa /Nunia	Pursalane
Striga lutea & S. asiatica	Runkhadi	Witch weed
*Trianthema portulacastrum (*Syn. *T. Monogyna)*	Lasabuni Patherchatta/Satha	Horse purslane
Tribulus terrestris L. and *T. alatus* L.	Gokhru/Bhalri/Kantri	Punctursvine
Tridax procumbens	Pardeshi bhangra /	-
Vernonia cinerea & V. baldwine	Sahadevi /Phulni	Fleabane
Vigna trilobata	Jangli moth /Ark moth	
Xanthium strumarium	Adhasis / Banokra /Bichu	Wild moth cocklerbur / Bur weed
***C. Rabi* weeds**		
Launia asplenifolia	Jangli gobi	-
Bergia suffruticosa	Kharbuje	-
Solanum nigrum	Makoy	Back night shade
Orobanche aegyptiaca	Sarson –banela	Broomrape
Ranunculus acutus	Jangli palak	Buttercup
Medicago denticulata wild	Jangli rajaka	California bur clover
Cirsium arvense	Gokhru	Canada thistle
Cichorium intybus	Kasni	Chicory
Clitoria ternatea	Titli matar	Conch flower creeper
Convolvulus arvensis L.	Hirankhuri	Field bind weed
Fumaria parviflora	Pitpapra / Gajri	Fumitory

Chenopodium murale L.	Kharthua / Bhabra	Goosefoot
Chenopodium album L.	Bathua	Lamb's quarters

Melilotus indica	Senji (Pili)	Indian clover
Melilotus alba Desr.	Senji (safed)	White sweet clover
Phyllanthus niruri (Syn. P. fratemus)	Hazardana /Jangli amli / Jeramala	Nirure
Polygonum pumila	Jari	-
Parthenium hysterophorus	Congress ghass	Parthenium, wild carrot weed
Angallis arvensis L.	Krishna neel	Pimpernel, scarlet
Plantago medica / P. rugelii / P. lanceolata	Jiri	Plantains
Argemone mexicana L.	Satyanashi	Prick /Mexican poppy
Spergula arvensis L.	Satganthia	Sand weed or corn spurry
Daucus carota	Jangli Gajar	Wild carrot
Alium vineale	Jangli lahsun	Wild garlic
Brassica kaber	Jangli sarson	Wild mustard
Asphodelus tenuifolius Cav.	Pyaji	Wild onion
Allium calendulosa	Jangli Pyaj	Wild onion
Carthamus oxyacantha	Pohli	Wild safflower
***D. Perennial* weeds**		
Desmostachya bipinnata	Dab/Kusha	-
Psoralea corylifolia	Babchi	-
Blumea lacera	Kukranda	Spreading hog weed
Eclipta prostrata L.	Bhangra /Mochkand	Hassk
Lantana camara	Phullakri	Lantana
Artemisia scoparia	Barna	-
Tephrosisa purpurea L. pers	Dhamasa	Tephrosia
Pluchea lanceolata	Chhajas /Baisuri	Arrow weed
Alhagi camelorum	Jawasa	Camelthorn
Abutilon indicum & A. poersicum	Kanghi	Country mallow
Crotolaria burhia	Sinia	Crotolaria
Cuscuta reflexa	Amarbel	Doddeer
Gomphrena globossa	-	Globe amaranth
Heliotropium ellipticum	Kamera	Heliotrop
Cannabis sativa	Bang	Hemp
Datura stramonium	Datura	Jimson weed
Agropyron repens	-	Quack grass /couch grass
Calotropis gigantea /procera	Aak /Madar	Swallow word
Imperata cylindrica	Thatch grass	Thatch grass/ Congo grass
Zizyphus nummularia	Jharber	Wild ber
Aerva pseudotomentosa	Safed buie	Bui
Caparis aphylla	Ker	-
Caligonum polygonoides	Phog	-
Leptodenia pyrotechnica	Kheep	-

Important weeds of aquatic environment of India

Emergent	*Typha angustala*	Cattail narrow weed
	Paspalum distichum	Paspalum
	Scirpus maritimus	Bulrush
	Ipomea carnea	Besharam

	Polygonum glabrum	Smart weed
	Eclipta prostrata	Eclipta
Floating	*Eichhornia crassipes*	Water hyacinth
	Salisnia molesta	Water from /salvinica
	Ipomea aquatica	Swamp morning glory
	Azolla pinnata	Azolla
	Pistia stratiotes	Water lettuce
Submerged	*Hydrilla verticillata*	Hydrilla
	Vallisnaria spirallis	El weed
	Potamogeton spp.	Pond weed

Annexure – III

Trade name, formulation and a.i. of common herbicides and approved combinations

S.N.	Common name	Trade name	a.i. content and Formulation
Herbicides			
1.	2,4-D (amine)	Zura	58% SL
2.	2,4-D (ester)	Weedmar	Ethyl ester 38% EC
3.	2,4-D (Na salt)	Weedmar	80% WP; 38% EC
4.	Acetachlor		50% SC, 60% SC 50% EC, 90% EC 80% WP 90% WG(WDG)
5.	Anilofos	Aniloguard	30% EC
6.	Alachlor	Lasso	50% EC
7.	Atrazine	Atrataf	50% SC; 50% WP; 80% WP
8.	Butachlor	Dhanuchlor	50% EC; 50% EW
9.	Bispyribac Sodium	Nominee Gold	10% SC
10.	Carfentrazone	Affinity	50% WG
11.	Chlorimuron-ethyl	Kloben	25% WP
12.	Clodinafop-propargyl	Topik	15% WP
13.	Cyhalofop-butyl	Clincher	10%EC, 10%WP,10%EW
14.	Diclofop-methyl	Iloxan	3% EC
15.	Diuron	Diurex	80% SC; 80% WP
16.	Ethoxysulfuron	Sunrise	15% WDG
17.	Fenoxaprop-P-ethyl	Whipsuper	10% EC; 9.3% EC
18.	Fluchloralin	Basalin	45% EC
19.	Glyphosate	Round up	41% SL; Ammonium salt 71% SG
20.	Imazethapyr	Pursuit	10% SL
21.	Isoproturon	Chemlon	50% WP; 75% WP
22.	Mestsulfuron- methyl	Algrip	20% WP
23.	Metolachlor	Dual	50% EC
24.	Metribuzin	Sencor	70% WP
25.	Oxadiargyl	Topstar	80% WP
26.	Oxadiazon	Ronstar	50% EC
27.	Oxyflourfen	Oxygold	23.5% EC
28.	Paraquat	Gramaxone	24% SL
29.	Pendimethalin	Stomp xtra	30% EC; 38.7% CS
30.	Pinoxaden	Axial	5.1% EC
31.	Pretilachlor	Rifit	50% EC; 37% EW
32.	Propaquizafop	Society	10% EC
33.	Pyrazosulfuron –ethyl	Saathi	10% WP
34.	Pyrithiobac	Hitweed	10% EC
35.	Quizalofop-ethyl	Tergasuper	5% EC
36.	Sulfosulfuron	SF_10	75% WG
37.	Trifulralin	Trifogan	48% EC
Formulated combinations			
1.	Bensulfuron + pretilachlor	Londox power	0.6 + 6% GR
2.	Clodinafop + metsulfuron	Vesta	15 % + 1% WP
3.	Imezethapyr + imazamox	Odyssey	35% + 35% WG
4.	Metsulfuron methyl + chlorimuron ethyl	Almix	10+10% WP
5.	Mesosulfuron + idosulfuron	Atlantis	3+0.6 WG
6.	Pendimethalin + imazethapyr	Valor	30+2% EC
7.	Sulfosulfuron + metsulfuron-methyl	Total	75+5% WDG

Annexure – IV

Trade name, formulation and source of new herbicide molecules

Chemical name	Trade name	Formulation (%)	Source
Acetachlor	MON-8435, ICIA-5676	90 EC	Monsanto
Acifluorfen	Blazer	90 EC	BASF
Ametryn	Gesapax	50 WP	Rallis
Bentazon	Basagran	4.5 EC	BASF
Bentazone-Aciflourefen	Galaxy	-	BASF
Cnosulfuron	Setoff	20 WP	Syngenta
Ciefoxidim	Tetris	75 EC	BASF
Difenzoquat	Avenge	15 EC	Gharda
Dimethenamid	Frontier	72 WP	BASF
Dithiopyr	Dimension	12 EC	Rohm & Hass
Haloxyfop-methyl	Focus, Gallant, Verdict	10 EC	De-nocil
Imazaquin	Scepter	1.5 EC	Cynamid
Metribuzin+Flufenacet	Domain	60 DF	Bayer
Metsulfuron+Chlorimuron	Almix	20 WP	Dupont
Prometryn	Gesagard, Prometre	50 WP	Rallis /Syngenta
Propagizafop	Agil	10 EC	Syngenta
Pyrazosulfuron	Clincher	5 WP	Rallis
S-metolochlor	Dual Gold	98 EC	Syngenta
Triasulfuron	Logran	20 WP	Syngenta
Tribenuron –methyl	Express	10 WP	Dupont
Quinclorac	Facet	25 EC	BASF