NATIONAL OPEN UNIVERSITY OF NIGERIA

SCHOOL OF AGRICULTURAL SCIENCE

COURSE CODE: CRP 503

COURSE TITLE: WEED SCIENCE AND CONTROL

COURSE GUIDE

CRP 503
WEED SCIENCE AND CONTROL (3 UNITS)

Course Team Alfred J. Augustine (Course Developer/Writer) – NOUN
Prof. N. E. Mundi (Programme Leader) – NOUN
Dr. Petu Ibikunle (Course Coordinator) – NOUN
Dr. Peter Tunku (Course Editor) – Dept of Agronomy, Faculty of Agric. A.B.U. ZARIA

NATIONAL OPEN UNIVERSITY OF NIGERIA

National Open University of Nigeria
Headquarters
14/16 Ahmadu Bello Way
Victoria Island, Lagos

Abuja Office
5 Dar es Salaam Street
Off Aminu Kano Crescent
Wuse II, Abuja

e-mail: centralinfo@nou.edu.ng
URL: www.nou.edu.ng

Published by
National Open University of Nigeria

Printed 2016

ISBN: 978-058-123-5

Printed by

CONTENTS **PAGE**

INTRODUCTION

Weed science and control: This is a three credit course for 500L students of B Sc. (Crop production programme). The course consists of 16 units in four modules which deal with introduction to weed science, weed control, herbicides application and weed control in crop and non crop situations. This course guide tells you briefly what the course is all about, and how you can work through these units. It suggests some general guidelines for the amount of time you are likely to spend studying each unit in order to complete it successfully. It also gives you some guidance on your tutor marked assignments.

WHAT YOU WILL LEARN IN THIS COURSE

The main aim of this course "Principles of Horticultural Crop Production" is to introduce the fundamental principles upon which horticultural crop production practices are based upon. By studying the principles of horticultural crop production you would be able to understand the interaction between the plant, the environment and how and why plants grow and develop. So that you would be able to manipulate the plants and their external conditions for better growth and development and crop yield.

COURSE AIMS

The aim of the cause is to acquaint you with the basic science of weed and their control in crop and non crop situations.

COURSE OBJECTIVES

In order to achieve the course aims, certain overall objectives have been set. In each unit specific objectives are set. These are usually stated at the beginning of the unit. You should pay attention to the objectives of each unit before starting to go through them. You can always refer back to the unit's objectives to check your progress. You should also look at them after completing a unit. By so doing you can be sure that you have achieved what the unit expects you to acquire. By meeting these objectives, the aims of the course as a whole would have been achieved. These objectives include:

- Define weed and state the characteristics of weed
- Explain the economic importance of weed
- Know some weed that are beneficial to man and some that are harmful to crops, animal and man

- Explain the classification of weed based on life cycle, habitat, morphology and growth habit stating examples in each classification
- Explain weed sexual and asexual reproduction
- Explain the different forms of asexual reproduction
- Differentiate between sexual and asexual method of reproduction
- Explain the methods of weed dispersal
- Explain weed management which include control, prevention, eradication and integrated weed management
- Explain cultural, chemical, biological and preventive methods of weed control
- Explain the different classification of herbicides and state examples of herbicide in each classification
- Differentiate the different classification of herbicide
- Know What is herbicide formulation
- Explain the different form of herbicide formulation
- State the importance of sprayer calibration
- State the procedures used in herbicide sprayer calibration
- Calculate herbicide dosage for small area and large area
- List and explain the methods used in herbicide application and the equipment used
- Know methods suitable for the different herbicide formulation
- Know safety measures to take when mixing and applying herbicide
- List the major information that should be on herbicide label
- Explain herbicide selectivity on the basis of plant characteristic, relationship to herbicide properly and time of herbicide application
- Explain assessment of herbicide performance
- List factors affecting herbicide performance
- Method of application of herbicide in crop and non crop situation
- Know how to apply herbicide in rice field and the herbicide to use

WORKING THROUGH THIS COURSE

To complete this course you are required to read the study units, read other recommended materials. You will be required to answer some questions based on what you have read in the text to reaffirm the key points. At the end of each unit there are some tutor marked assignments (TMA) which you are expected to submit for marking. The TMA forms part of continuous assessments. At the end of the course is a final examination. The course should take you 12 to 13 weeks to complete. You will find listed the component of the course, what you have to do and how you should allocate your time to each unit in order to complete the course successfully on time.

COURSE MATERIALS

The main components of the course are:

1. Course guide
2. Study units
3. Tutor marked assignments
4. References/further reading

STUDY UNITS

Module 1 - Introduction to weed science

Units 1 - Definition of weed and its economic importance
Units 2 - Classification of weed
Units 3 - Reproduction in weed
Units 4 - Mechanism of weed seeds dissemination

Module 2 - Weed control

Unit 1 - Weed management
Unit 2 - Weed control methods

Module 3 - Herbicides

Unit 1 - Definition and classification of herbicide
Unit 2 - Herbicide formulation
Unit 3 - Herbicide calibration and Dosage calculation
Unit 4 - Methods of herbicide application and equipments
Unit 5 - Herbicide resistance in plants
Unit 6 - Herbicide handling, storage, disporsal and safety
Unit 7 - Herbicide selectivity
Unit 8 - Herbicide performance assessment

Module 4 - Weed control in crop and non crop situation

Unit 1 - Weed control in crop situation
Unit 2 - Weed control in non crop situation

TUTOR-MARKED ASSIGNMENTS (TMA)

There are tutor marked assignments and self assessment in each unit. You would have to do the TMA as a revision of each unit. And there four tutor mark assessment you are required to do and submit as your assessment for the course. This would help you to have broad view and better understanding of the subject. Your tutorial facilitator would inform you about the particular TMA you are to submit to him for marking and recording. Make sure your assignment reaches your tutor before the deadline given in the presentation schedule and assignment file. If, for any reason, you cannot complete your work on schedule, contact your tutor before the assignment is due to discuss the possibility of an extension. Extensions will not be granted after the due date unless there are exceptional circumstances. You will be able to complete your assignment questions from the texts contained in this course material and References/further reading; however, it is desirable to search other References/further reading, which will give you a broader view point and a deeper understanding of the subject.

FINAL EXAMINATION AND GRADING

The final examination for the course will be 2hrs duration and consist of six theoretical questions and you are expected to answer four questions. The total marks for the final examination is 70 marks. The examination will consist of questions, which reflect the tutor marked assignments that you might have previously encountered and other questions within the course covered areas. All areas of the course will be covered by the assessment. You are to use the time between finishing the last unit and sitting the examination to revise the entire course. You might find it useful to review your Tutor Marked Assignments before the examination. The final examination covers information from all parts of the course.

CRP 503 WEED SCIENCE AND CONTROL

Module 1 - Introduction to Weed Science

Units 1 - Definition of weed and its economic importance
Units 2 - Classification of weed
Units 3 - Reproduction in weed
Units 4 - Mechanism of weed seeds dissemination

Module 2 - Weed Control

Unit 1 - Weed management
Unit 2 - Weed control methods

Module 3 - Herbicides

Unit	1	-	Definition and classification of herbicide
Unit	2	-	Herbicide formulation
Unit	3	-	Herbicide calibration and Dosage calculation
Unit	4	-	Methods of herbicide application and equipments
Unit	5	-	Herbicide resistance in plants
Unit	6	-	Herbicide handling, storage, disporsal and safety
Unit	7	-	Herbicide selectivity
Unit	8	-	Herbicide performance assessment

Module 4 - Weed Control in Crop and Non Crop Situation

Unit	1	-	Weed control in crop situation
Unit	2	-	Weed control in non crop situation

MAIN COURSE

CONTENTS **PAGE**

MODULE 1 INTRODUCTION TO WEED SCIENCE

UNIT 1 DEFINITION OF WEED, CHARACTERISTICS AND ITS ECONOMIC IMPORTANCE

CONTENTS

1.0 INTRODUCTION

The knowledge of weed is very paramount in crop and animal production. Weeds are unwanted plants growing where they are not wanted and as such can be nuisance in crop and animal production. This unit would give you a basic knowledge of weed, their characteristics and economic importance.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- define weeds
- state the characteristics of weed
- explain the economic importance of weed
- know some weed that are beneficial to man and some that are harmful to crops, animal and man.

3.0 MAIN CONTENT

3.1 Definition of weed and weed Science

Weed is defined as plants which grow where they are not wanted. Weeds can also be referred to as unwanted or undesirable plants that complete with crops for water, nutrients, light, space and carbondioxide6 and thus reduce yield. It can also be defined as an undesired plant growing out of place.

Weed Science is the study of vegetation (plant) management in agriculture, aquatics,, horticulture and all the fools available for this purpose such as cropping system, herbicides management techniques and seed genetics. Weed Science is concerned with weed.

3.2 Characteristics of weeds

Weeds have some distinct characteristic features that make them unique. This characteristics includes.

1. **Prolific seed production: -** Weeds have high reproductive capacity especially the annual weed e.g.

Amaranthus Spp - 96 – 235, 000 Seed / Plant
Eleusine indica - 41 – 135, 000 Seed / Plant
Striga hermontheca - 42,000 Seeds / Plant

2. **Wild and range growth: -** Weeds grow rapidly and branch and tiller profusely e.g *Digitaris spp* branch profusely while *Andropogons gayanus, Rattboelia Cochien chinensis grow faster.*
3. **Seed dormancy:-** This is a state in which a viable seed fails to germinate even under favourable environmental conditions. It is also r to the resting stage of seed. This ranges from seasonal to long period of dormancy. e.g.
4. **Spontenous growth:-** weeds appear without been sown especially weeds with tiny seed e.g. *Striga spp, Talium triangulare*
5. **High dispersibility:-** Weed seed are dispersed because of the nature of the seed. Most seeds are tiny or have spike and are easily dispersed to colonised and invade an area. E.g. *Tridax Procumbens.*
6. **Adaptability:-** Weeds adapt to environmental extremes and can tolerate moisture, nutrient stresses and unexpected evens such as drought.
7. **Bimodal reproduction:-** Some weed have more than one way to reproduce e.g. *Imperata cyclindrica* and *Commelina braziliensis*

can reproduce through rhizomes and succulent stem respectively apart from their seeds.

SELF ASSESSMENT EXERCISE

i. List 5 weed you know in your community
ii. Define weed.

3.3 Economic importance of weed

The benefits that we can derive from weeds are:

- Weeds protect soil against erosion because they cover the soil and reduce flow of water.
- Weeds especially grasses serves as food for animals e.g. *Cynodon dactylon*.
- *Amaranthus viridis and Portulaca sp* are used as leafy vegetable by man.
- Weeds add organic matter in the soil as such improve soil fertility.
- Some weeds are used as source of medicinal herb for man e.g. *Canabilis jacoba* used in the treatment of glaucoma.
- Some weeds are used as source of pesticide e.g. *Pyrethrum sp* extract used as insecticide *Chrysanthemum sp* used as pesticide.
- Some weeds are used in plant breeding as source of genetic material for improvement of crops especially in areas of crop resistance.
- Some weeds serve as host to beneficial insect such as honey bees.
- Some weeds are used in landscape and beautification purposes e.g. *Cynodon dactylon, Bryophyllum sp.*
- Aquatic weeds are useful in paper, pulp and fibre industry.

3.4 Losses cause by weeds

Apart from the positive benefit mentioned above, there are negative benefits or losses caused by weed to crops, animal and man. These losses are grouped in to direct and indirect losses.

3.4.1 Direct losses caused by weeds

- Weed reduces crop growth and yield. Uncontrolled weed may cause 30-90% yield loss in cereal and 40-70% yield loss in legumes.
- Weed reduces the quantity of crop produce or adds cost to harvesting and processing of crop produce.

- Weed imped water flow in irrigation canals
- Weed causes loss of water in the soil through evapotranspiration.
- Some weeds are poisonous to animal and man and can lead to death of animals e.g. *Mucuna pruriens.*

3.4 Indirect losses caused by weeds

- Weeds serves as alternative lost to certain pest and diseases e.g. *Pennisetum purpureum* is a host to stem borer.
- Weed limit farm size due to drudgery
- Weed affect fishing activities
- Weed reduce land value

4.0 CONCLUSION

The knowledge of weed usually help farmer to plan well in managing his crops against their attack so that he can obtain high yield and economic return.

5.0 SUMMARY

Weeds are unwanted plant growing where it is not tended and they have special characteristic features that makes them unique and difficult to control. These characteristics include high proliferation, wild and range growth, seed dormancy, bimodal reproduction among others. Weeds have positive and negative effect on crops animals and man which can either be direct or indirect effect.

6.0 TUTOR MARKED ASSESSMENT

1. Define Weed
2. State five characteristics of wee
3. List four weed that you know
4. State 3 positive benefit of weed and three negative effects of weeds.

7.0 REFERENCES/FURTHER READING

Akobundu, I. O (1987). *Weed Science in the Tropics*. John Wiley and Sons Inc.

UNIT 2 CLASSIFICATION OF WEED

CONTENTS

1.0 INTRODUCTION

In the previous unit you have learned about the definition of weed characteristics in weed and the positive and negative economic importance of weed. This unit will broaden your knowledge of weed classifications.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- classify weed based on life cycle
- classify weeds based on life habitat
- classification based on growth habit
- classification based on morphology.

3.0 MAIN CONTENT

3.1 Classification of weeds

There are many ways weeds can be classified into groups for convenience of planning, interpreting and recording control measures against them. For the purpose of this study we will limit ourselves to five classifications of weed.

3.1.1 Classification based on life cycle

Weeds are classified based on life cycle into three groups.

i. **Animal weeds: -** These are weeds that Complete their life cycle within a year of have two growing season in a year e.g. *Agerantum conyzoides, Tridax procumbens, Digistaria spp* etc. they produce large quantity of seeds have efficient mechanism of seed dispersal and good seed dormancy.
ii. **Biennial weeds: -** These are weeds that complete their life cycle in two years in the first year they remain vegetative in the second year they produce flower and set seeds e.g. *Daucus carota* (wild carrot) and *Lunea sp.*
iii. **Perennial weeds: -** these are weeds that persist for greater than one year and stay for many years. they have organs that can survive for many years e.g. *Cynodon dactylon, Cyperus spp, Oxalis latifolia and Bryophyllum spp*.

3.1.2 Classification based on habitat

This is weed classification based on where the weeds are found and they are grouped into:

i. **Terrestrial weeds: -** These are weeds that are found on Land where crop are cultivated or not. Terrestrial weed re further classified into:

(a) Crop land weeds: – weeds found in crop land
(b) Non crop land weed: - weeds found in uncultivated land
(c) Grassland weeds: - found in cultivated ground
(d) Orchard weeds: - weed found in orchards

E.g. terrestrial weed are most annual weed *Echinochoa spp, Agerantum conyzoides* etc.

ii. **Aquatic weeds**: - these are weeds found in water logged areas e.g *Cyperus difformis, Oryza logistaminata, Paspalum orbiculare and Ipomea spp.*
iii. **Plantation weeds** – these are found in plantation mostly in the south rain forest but these weds are less due to dominance of trees canopy which suppress weed growth e.g. *Chromdaerra odorata, Paspalum conjugatum.*

3.1.3 Classification based on growth habit

i. **Free living weeds: –** these are weed that grow on their on but complete with crops in the field for nutrient, moisture, carbondioxide and space for their growth.
ii. **Parasitic weed:** – These are weeds that depend on the other plants for nutrient and moisture for their survival. That is they cannot stand on their own. Parasitic weeds are grouped into

a. **Root parasite: –** they attached to the root of crops for their survival e.g. S*triga spp, Orabanche crenata*
b. **Stem parasite: –** they attached to the stem crops for their survival e.g. C*uscuta australis* and Dodder (mistle toes).

3.1.4 Classification based on morphology

This is classification based on the nature or physical features of the weed. Ii. **Narrow leaf weeds** – these are weeds that have narrow leaf with parallel *veination*. Most grasses weeds belong to this group. e.g *Cynodon dactylon*. Ii. **Broad leaf weeds** – these are weeds that their leaves are broad and the vein are characterized by net veination. Most legumes weeds belong to this group. E.g *Mucuna spp*.

3.1.5 Classification based on climate

i. **Temperate weeds** – these are weeds that grow well in temperate climate.
ii. **Tropical weeds** – these are weeds that grow well in tropical climates.

4.0 CONCLUSION

Classifying weeds helps the farmer to know the kind of control measures to use on different class of weed without harming crops.

4.0 SUMMARY

Weeds are classified in different ways but our studies limit this classification to classification based on life cycle, habitant growth habit, morphology and climate.

6.0 TUTOR MARKED ASSESSMENT

1. Classify weed based on life cycle
2. Classify weed based on morphology

3. Differentiate between terrestial weed and acquatic weed with example

7.0 REFERENCES/FURTHER READING

Akobundu, I. O (1987). *Weed Science in the Tropics*. John Wiley and Sons Inc.

UNIT 3 REPRODUCTION IN WEEDS

CONTENTS

1.0 INTRODUCTION

One of the characteristics of a living thing is reproduction which is the ability to produce young once. Weed as living things have reproduction mech anism which enable them to persist or continue to exist in a given environment. This unit will explain the different methods used by weeds in reproduction process.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- explain weed sexual and asexual reproduction
- explain the different forms of asexual reproduction
- differentiate between sexual and asexual method of reproduction.

3.0 MAIN CONTENT

3.1 Reproduction in weeds

Reproduction is the process of producing young ones. Weed as living thing reproduce through the following methods.

- Sexual reproduction (seed)
- Asexual reproduction (vegetative propagation)

3.1.1 Sexual reproduction

This refers to fusion of two reproductive gametes by fertilization. Majority of our weeds reproduce by distinct seed formation through

fertilization and they are largely **monocious** (plant having both the male and female flowers together). **Diocious** are plants which have male and female flower on different plant. Seed production in weeds is prolitic, partially in annuals and biennial but in perennial weeds seed production facility is limited like in example *Cyperus spp* and *Cynodon spp* which produce only 40 – 70 seeds / plant. In addition to prolific seed production, weed seeds are capable in retaining the viability (seed dormancy) for 2-25 years or even more depending on weed species within the soil.

3.1.2 Asexual reproduction

This is reproduction through other means apart from the seeds. It is also called vegetative propagation or reproduction. In vegetative reproduction a portion of the mother plant either stems or roots or leaves get detached and grow into a separate plant capable of colonizing a new area of land. Many perennial weeds reproduce vegetatively because they produce little or no seed e.g. *Oxalis latifolia, Pennisetum clandestinum*. These depend on their well developed vegetative organs for propagation. others propagate or reproduce both sexually and vegetatively e.g. *Imperata cylindrical,* C*ynodon dactylon.*

3.1.3 Methods of vegetative propagation

The methods of vegetative propagation (asexual reproduction) includes:

a. **Stolons and Runners: -** These are aerial shoots coming from axils of lower leaves running on the surface of the ground .e.g. of *stolon is Cynodon dactylon and e.g. of runner is Ipomea acquatica.*

b. **Rhizomes: -** these are underground stem which grow horizontally below the soil surface and difficult to control. When a cut part of the stem is exposed it spout. e.g *Imperata cylindrica, Pennisetum clandistinum*

c. **Tubers: -** These are modified swollen stem with compressed internodes which serves as storage organ, pereneting organ and reproductive organ. e.g *Cyperus rotundus*

d. **Bulbs: -** These are short small underground stem surrounded by the fleshy swollen leaves bases and they serves as food reserves and propagating organ e.g. *Oxalis latifolia* and wild onion (*Allium canadense*).

e. **Bulbils: -** These are auxiliary buds often found on leaves margin. Bulbils separate from parent plant and form new plant e.g. *Bryophyllum Pinnatum*.

f. **Stem: -** These are succulent stems which serve as propagating organs. Fragmentation of such stem will increase their population e.g. *Commelina benghalensis, Commelina Senegalensis.*

SELF STUDENT ASSESSMENT

i. How do crop plants reproduce?
ii. Give 3 examples of crops that reproduce sexually.

4.0 CONCLUSION

Weeds and crops are propagated in the same ways and they can have one or more way be propagated.

5.0 SUMMARY

The propagation of weed could either be sexually (seeds) or asexually through stolons, runners, stems rhizones bulb or bulbils. This makes the weed very difficult to control in cultivated land.

6.0 TUTOR MARKED ASSESSMENT

1. What is asexual propagation?
2. State five ways to achieve vegetative propagation
3. State 3 weed that can be propagated vegetatively.

7.0 REFERENCES/FURTHER READING

Akobundu, I. O (1987). *Weed Science in the Tropics*. John Wiley and Sons Inc.

UNIT 4 MECHANISM OF WEED SEED DISPERSAL (DISSEMINATION)

CONTENTS

1.0 INTRODUCTION

In the previous units, you have studied weed classification characteristics and their reproduction methods. However, there is need for you to know how weed are moved from one place to another which increase their population in an environment of crop or non crop land.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- list the various methods of weed dispersal
- explain the methods of weed dispersal.

3.0 MAIN CONTENT

3.1 Mechanism of seed dispersal.

Weed seed dispersal or dissemination is the physical movement of weed seeds or vegetative parts from their parent plant to another area. This is achieved through win, water, animals, and man which are known as agent of dispersal or mechanism of weed dispersal of the agents, dispersal of weed seed is quit uneven.

3.2 Methods of weed seed dispersal.

Weed sees are dispersed in two ways namely space and time.

3.2.1 Seed dispersal in space

Seed dispersal in space involves the physical movement of seeds from one place to another through the agent of dispersal which include wind, water, glacier, animals, man birds etc. Different weed seeds have one or more different dispersal agent. Below are some selected weeds and their mode of dispersal.

Selected weeds and their mode of dispersal

SN^{o}	Species of weed	Propagules	Mode of dispersal
1	*Agerantum conyzoides*	Seed/spikelet	Wind, animals
2	*Acanthosperm hispidium*	Seed	animal
3	*Imperata cylindrical*	Seed/spilet/rhizomes	Wind, human, water
4	*Imperata acquatica*	Seed	water
5	*Rotboelia spp*	Spikelet	Animal/shedding
6	*Cassia occidentalis*	Seed	shattering
7	*Oryza bathii*	Seed	Water, animal

3.2.2 Seed dispersal in time

Seed dispersal in time refers to the capacity of the seed to remain in dormant state for a period of time. Dormancy is the inability of a viable seed to germinate even when the necessary conditions for germination are provide. A dormant seed is a seed that fail to germinate eventhough it has absorbed water, exposed to temperature and oxygen. If a seed germinate immediately upon absorption of water without a barrier to germination, the embryo is a quiescent or non dormant. Sometimes non proximity to host plant may leave the portion of the seed bank dormant. Dormancy can be inert, induced or enforced.

Weed seeds dispersed off from the plant in three ways whether they are dispersed in space or time:

i. A part of it may fall near mother plant
ii. A part of it may move out of the fields with crop harvest

iii. The remaining dispersed with agent of dispersal to a short or long distance and this forms the basis of weed seed dispersal. An effective dispersal of weed seeds requires two essentials namely; a successful agent and an effective adaptation.

3.3 Agent of Seed Dispersal

The agents or sometimes called methods of weed seeds dispersal are:

3.3.1 Wind

Some weed seeds possess special organs that keep them afloat e.g include *Agerantum conyziodes* which have a parachute like structure and are easily blown by wind. Weed seeds dispersal through wind is called **anemochory.**

3.3.2 Animals

Many weed fruits and seeds are eaten by birds and animals, and after digestion most of the seeds are passed out with animal excreta which are dropped wherever they move. This mechanism of weed dispersal is called **endozoochory.** Ants carry a large number of certain weeds seeds possessing secretions from one place to another. This is called **myrmecochory**. Generally, weed seeds dispersal through animal is called **zoochory** and dispersal by birds is called **ornithochory.**

3.3.3 Man

Careless activities of man are greatly responsible for the dispersal of weeds. Movement of farm implements and automobiles sometimes have weed seeds attached to them and are deposited in other areas. Weeds mostly mature at the same time with crops and are usually harvested with them and transported to other areas e.g. *Oryzea bathii* with rice. Weed seeds dispersal by humans is called **anthropochory**.

3.3.4 Water

Aquatic weeds disperse primarily through water. Moving water during the rainy season or during irrigation disperse weed seeds to new fields. Weed seeds dispersal by water is called **hydrochory**.

4.0 CONCLUSION

Weed seeds dispersal take place naturally and un intentionally as no farmer would want to disperse weeds to his farm or home even though himself serve as one of the dispersal agent. What you have learn here

would make you to become careful in handling your crops so that you avoid being a dispersal agent of weed seeds.

5.0 SUMMARY

Weed seeds are dispersed in two ways (dispersal in space and in time):

- Dispersal in space which is movement of weed seed from one place to another.
- Dispersal in time is the dormancy period of weed seeds even when environmental conditions are favourable for germination.
- The agent of weed seeds dispersal includes wind, water, animal and man.

6.0 TUTOR-MARK ASSESSMENTS

1. Define seed dispersal, Dormancy
2. Differentiate between weed seeds dispersal in space and time.
3. List and explain the agents of weed seeds dispersal.

7.0 REFERENCES/FURTHER READING

Akobundu, I. O (1987). *Weed Science in the Tropics*. Principles and Practices John Wiley and Sons Inc.

MODULE 2 WEEDS MANAGEMENT AND CONTROL

Unit 1 Definition of weed management concept (prevention, eradication, control)
Unit 2 Weed control methods

UNIT 1 DEFINITION OF WEED MANAGEMENT

CONTENTS

1.0 INTRODUCTION

In previous studies you acquired knowledge on weeds, their characteristics and mode of dispersal which make their existence detrimental to our crops / animals and even human. Are weed of benefit to human more than crops of course the answer is No. if it is so, what do we do with them? This unit will would guide you on how to take care of your farm to avoid or reduce weed infestation.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- Explain various ways of weed management
- Define weed management terms (weed prevention, control and eradication)
- Weed prevention
- Weed control
- Weed eradication

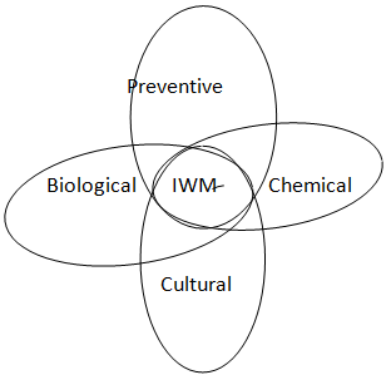
3.0 MAIN CONTENT

3.1 Weed Management

Weed exist only in those natural environment that have been disturbed by human such as agricultural lands, recreational facilities, irrigation aims etc. Weeds management is basic to the use of these environments for food, fiber, shelter and recreation purposes. Human efforts to deal with weeds have been documented historically. There are 6 stages in the evolution of weed management.

Weed management is the ability to manipulate weeds so that they do not seriously interfere with mankind's efficient use of their environment. In relation to agricultural activities, weed management refers to how weeds are manipulated so that they do not interfere with the growth, development and economic yield of crops and animals. Weed management encompasses all aspect of weed control including prevention and spread, together with those land-use practices and modifications in the crop habitat that interfere with the weeds ability to adapt to its environment. Efficient weeds management is therefore a primary objective of all meaningful agricultural activities. The practical implementation of weed management practices is to minimize weed introduction, spread, competition with crops and adaptation to given habitats is the primary objectives of weed management. The major components of weed management are preventive weed control, cultural control, biological and chemical weed control.

Integrated weed management refers to weed management strategies which combine all weed management components at the same time for effective weed control. The figure below shows the concept of weed management and integrated weed management.



Weed management system and strategies for integration

3.2 Weed Prevention

Prevention encompasses all measures taken to stop the introduction multiplication and spread of weeds. No weed control programmes is successful if adequate preventive measures are not taken to reduce weed infestation. Prevention is a long term planning so that the weed could be controlled or managed more effectively and economically. Weed prevention start when crops to be introduced to the country are quarantine to make sure the seed are weed free to seed certification purity, agronomic practices carried out on crops from the land preparation to harvesting and storage of farm produce. Prevention is more economical than control.

3.3 Weed Eradication

Weed eradication refers to the complete removal of all weeds and their progagules from a habitat. Weed eradication in food crop production is difficult to achieve and un economical in most situations. However, there are situations when problems posed by a noxious weed becomes so overwhelming that eradication should be considered if:

(a) Other weed control methods are ineffective.
(b) Weeds have many buried seeds that cannot be controlled by conventional practices.
(c) The infestation field is small and
(d) Benefits from eradication outweigh those of the alternative methods for coping with the weed.

3.4 Weed Control

Weed control refers to those actions that seek to restrict the spread of weeds, and destroy or reduce their population in a given location. Weed control is a required input in most crop production venture. It is part of the routine management of most environments that have been disturbed by humans. In food production, the effectiveness of weed control is affected by the type of crop grown, timing of the weeding operation, the nature of the weed problem, methods of weed control available to the farmer, type of weed to be controlled, cost of the operation, available labour or cash resources and environmental conditions before, during and after the time.

4.0 CONCLUSION

General understanding of weed management and control help the farmer to know what he should do before the rainy season and during crop

production so as to prevent, control and managed weeds in his field with low cost and maximize yield of his crops.

5.0 SUMMARY

- The major components of weed management are preventive cultural control, biological and chemical control.
- Weed prevention can be achieved through due quarantine of seeds before introduction, proper agronomic practices.
- Integrated weed management involves the application of all components of weed management to achieve weed control.
- Weed eradication means total elimination of weed in a field and this is usually difficult and uneconomical.

6.0 TUTOR- MARK ASSESSMENT

1. Brief define weed management, weed control, weed prevention and weed eradication.
2. Define integrated weed management.

7.0 REFERENCES/FURTHER READING

Akobundu, I. O (1987). *Weed Science in the Tropics*. Principles and practices. John Wiley and Sons Inc.

UNIT 2 WEED CONTROL METHODS

CONTENTS

1.0 INTRODUCTION

Weeds are unwanted plant growing on our fields and since they are unwanted they need to be removed from the field to allow wanted or cultivated crops to grow for man and his animals. In your previous studies, you learned about the general weed management aspect which gave you a broad idea on how to prevent the spread of weed. This unit would deal with the different weed control methods for your in-depth understating on how to control weeds.

2.0 OBJECTIVES

At the end of the study unit, you should be able to

- Explain cultural methods of weed control
- Explain chemical methods of weed control
- Explain preventive methods of weed control
- Explain integrated weed management.

3.0 MAIN CONTENT

3.1 Cultural Weed Control

Cultural weed control includes all aspects of good crop husbandry used to minimize weed interference with crops. These consist of the following:

i. Hand weeding
ii. Mechanical weeding
iii. Tillage
iv. Mulching
v. Burning
vi. Flooding
vii. Crop rotation

i. Hand weeding

Hand weeding is one of the oldest methods of weed control and consists of hand pulling, hand slashing, hoeing and mowing of weeds. Most of the drudgery associated with subsistence farming in the tropics centers around the peasant farmer and his manual weeding effort.

Problems associated with hand weeding

- A lot of drudgery and time consuming.
- Limited agricultural productivity because there is a limit to the size of land area that can be weeded manually.
- Organizational and other logistics and supervisory problems associated with human labour make its use cumbersome.

Hand pulling

Hand pulling is a major weed control method used in crop production in many parts of the tropics. It is particularly used in controlling weeds in cereal crops such as rice that are traditionally broadcast seeded.

Advantages of hand pulling

- It requires no additional tool.
- It is best for controlling weeds in broadcast-seeded crop where chemical weeding is not practiced.
- It is useful in removing weeds that have escaped other weed control measures.

Disadvantages

- It is laborious and full of drudgery.
- It is expensive when cheap labor is in short supply.
- Not suitable for controlling perennial weeds.
- Weeds cannot always be completely pulled out of the soil.

ii. Hand hoeing

This is by far the most widely used method of weed control in the tropics. It is a faster method of weed control than hand pulling and can be used in range of cropping systems. This method of weed control is used after the weeds have emerged but before they get too tall to interfere with hoeing operations. Hoe weeding is applicable to both annual and perennial weeds. Weeding hoes can be broadly grouped into light and heavy hoes. Generally the short handled hoes are used in the humid part of the tropics while the long-handled heavy hoes are used mainly in the tropical savanna for seed bed preparations.

Advantages of hand hoeing

- Both annuals and perennial weeds are controlled.
- It is an effective weed control measure for crops in rows.
- It provide a clean seed bed and loosens the soil.
- It is suitable for small farm size.

Disadvantages

- Weeds are usually well established in crops before farmers start weeding.
- Is labor intensive and could be expensive where cheap labor is in short supply.
- It is unsuitable for larger farms.
- Predisposes the soil to erosion as a result of clean weeding and loosening up of the soil.
- The propagule of perennial weeds may be buried at depth beyond the reach of hand hoes, thus making the control of such weeds difficult.
- Hand hoeing has a high risk of crop damage in many root and tuber crops.

iii. Hand-slashing

This is another manual method of weed control used mainly in right of way, non crop areas, bush clearing and in plantation crops. Hand-slashing is used in food crops for control of over grown annual weeds. The most widely used tool for manual slashing is the cutlass, machete and sickle.

Advantages of slashing

- It minimizes erosion.

- It is more labor efficient than hand hoeing.

Disadvantages of slashing

- Rapid regeneration of weeds is a major setback of slashing.
- Crop reduction as a result of accidental damage during slashing.
- High labor requirement.
- Drudgery.
- Is not suitable method of weed control in field crops that are under water stress because the basal portions of the weeds continue to deprive the crop of the limited water.

iv. Mechanical weeding

In mechanical weeding, a farmer channels energy produced by machines or animals into weeding operations. He gets more work done with the use of this type of energy than in hand weeding, when he not only produces the energy but also directs its use. The plough and harrows are most often used to control weeds before the crop is planted and between the rows of growing crop. During ploughing, weed seeds that have remained buried in the soil are brought to the surface. They then begin to germinate and if shallow tillage is done shortly afterwards the weed seedlings are destroyed. This is a particularly good method for controlling annual weeds. For perennials, repeated tillage at relatively short intervals may be necessary. Each tillage operation destroys the top growth, and forces the weed plant to produce new growth at the expense of underground reserves. Eventually these reserves are exhausted and the plant dies.

Tillage should be aim at destroying the weed plant before they reach the stage of setting seeds. For this reason, even fallow or uncropped fields should be subjected to occasional tillage as a method of controlling weeds. The point here is that if the weeds are permitted to produce seeds on fallow fields such seeds can easily be dispersed to the cropped fields. Those that are not dispersed may remain viable for several years and pose a problem when that particular field is eventually cropped.

Advantages of mechanical weeding

- Increase productivity.
- Increase economic returns, consequently improving the farmer's welfare.
- Reduces drudgery.
- Increases timeliness and precision in operations.
- More areas of land could be cultivated.

- Managing animals or machines is less problematic than managing human labor.

Disadvantages of mechanical weeding

- The initial cost of machines is high beyond the reach of most peasant farmers in tropical Africa.
- It requires highly trained experts to maintain the machines.
- Availability and cost of fuel may affect the cost of running the machines.

v. Animal drawn weeders

The use of animal-drawn weeders in the tropics is limited due to presence of tsetse fly which transmits the parasite *trypanosome spp.* to cattle in many humid and sub humid tropics. They are widely used throughout the arid and semi-arid savanna tropics.

Advantages of using Animal drawn weeders

- Low capital investment on source of power.
- Low cost of maintenance as draft animals are fed on forages available to other animals.
- Droppings from the animal serve as rich source of soil organic matter.
- No specialized training is required to operate the tool and guide the animal.
- Weeding implements is within the technological competence of most tropical farmers.
- Animal-drawn cultivators and weeders fit into the cropping patterns and farming systems of most farmers in many grassland regions of the tropics.
- These implements can be used in both small and large farms.

Disadvantages of Animal-drawn weeders

- Productivity of the system and work output of the animals depends on the state of their health and expertise of the handler.
- Precise cultivation and planting cannot always be obtained because of difficulty in controlling the animals.
- The presence of tsetse fly and animal diseases makes it impossible to use animals in some parts of the tropics.
- Religious beliefs and local customs of some parts of the tropics may make farming with animal difficult to practice.

vi. Machine-powered weeders

Machine-powered weeding refers to all weeding operations where the power used for removing weeds is derived from machines which in turn are using fossil fuel as source of energy.

Advantages of machine-powered weeders

- Weeding can be done more timely, reliably and cheaply than in manual or animal-drawn implements.
- Weeding can be done in less time and large farm land can be weeded.
- The same engine power can be used for other farm related activities such as tillage, planting, harvesting and transportation of farm produce.
- The use of machines eliminates drudgery and reduces risk of labor uncertainties.

Disadvantages of machine-powered weeders

- It is unsuitable where crops are not grown in rows.
- Heavy capital investment is required to buy and maintain the machines and equipment.
- Service maintenance and availability of spare parts are serious problems facing machine-powered agricultural operations throughout the tropics.

vii. Tillage

Cropland has for centuries been cultivated primarily to provide a good seed bed for seed germination and seedling growth. Other reasons for tillage include weed control. In addition to routine tillage, farmers usually carry out two distinct types of tillage for weed control purposes.

Types of tillage for weed control

These are delayed tillage and blind tillage:

- **Delayed tillage** involves preparing the seed bed and waiting until the weeds emerge before lightly cultivating the soil again and planting the crop. The purpose of delayed tillage is therefore to destroy the first flush of weeds so that the subsequently planted crop can grow at a reduced weed pressure.
- **Blind tillage** is when crop seeds are planted after the usual land preparation and lightly cultivated after weeds have emerged but

before crop emergence. This type of tillage works well if weeds germinate ahead of the crop.

Pre-planting land cultivation

This has the objectives of burying weed seeds and incorporation of organic matter in to the soil and cut off weeds as close to soil surface as possible. Use of tillage as a weed control method involving animal-drawn implements is often handicapped by the inability of animal-drawn cultivators to accomplish deep tillage satisfactorily even on light soil. Mounds are more desirable in controlling weeds because in giant mounds the weed seeds are buried deep in the mounds, there by reducing weed pressure.

viii. Burning

Fire is used as a weed control device in practically all parts of the world, it is used mostly to prevent weed growth and plant material prior to cropping and also destroy weed seeds lying close to the surface. Most of burning is done before crops are planted. There are three types of pre-plant field burning that are carried out in agricultural land worldwide:

- The uncontrolled
- Controlled burning
- The direct burner-assisted burning.

Uncontrolled burning refers to both the accidental forest (bush) fires and the type of burning deliberately started in the dry season of the savanna for hunting purposes. Uncontrolled burning damages the landscape, destroys wild life, homes and property, vegetation and exposes soil to erosion and may destroy economic trees.

a. Controlled burning

This refers to agricultural fires set by farmers for the purpose of creating a favorable environment for crop production and getting rid of unwanted vegetation. Controlled burning is used extensively in forestry to reduce the accumulation of litter and reduce the risk of wild fires that could destroy forests and property. This type of burning is done when environmental conditions are favorable and winds optimum. Hard-to kill weeds such as *Imperata cylindrical*, *Andropogon spp*. and *Hyparrhenia spp*. are often burned by peasant farmers during the dry season to stimulate new growth, which can then be fed to livestock before the cropping season begins.

Advantages of controlled burning

- It is a cheap way of getting rid of excess vegetation.
- It adds nutrients such as P and K to the soil.
- It reduces soil acidity.
- It destroys animal pests and pathogens that use the fallow vegetation as alternative hosts.
- Destroys weed seeds and soil borne pathogens.
- It stimulates re-growth in perennial grasses and may be used to rejuvenate grass pastures.
- It is a cheap and effective way to kill woody perennials.

Disadvantage of controlled burning

- It results in rapid loss of soil organic matter.
- Loss of non-metal elements e.g. sulphur and nitrogen as gases.
- Soil temperature, generated during burning is often not high enough and of long enough duration to ensure complete destruction of partially buried weed seeds and nematodes.

b. Direct burning

This is a type of controlled burning where special burners (mobile field incinerators, propane flamers) equipped with propane gas are used for burning plant residues.

Advantages of direct burning

- A good chance for complete and environmentally friendlier burning because there is practically no smoke.
- The speed of the operation can be controlled.

Disadvantages of direct burning

- It is expensive to buy special burners.
- Is slower than controlled burning.

ix. Flooding

This is also an effective method of weed control, although its use is mostly limited to paddy rice. Flooding kills the weeds by depriving them of oxygen. Since many weeds can survive flooding if they are not completely submerged, it is important the water level is maintained high enough so that no parts of the weeds are exposed. Generally several

weeks of waterlogging are necessary to destroy the unwanted vegetation.

Advantages of flooding

- Helps to kill some soil-borne fungi and nematodes.
- Anaerobic condition in flooded fields suffocates roots of dry-land plants and kills weed seeds.

Disadvantages of flooding as method of weed control

- It is not effective on well established aquatic weeds that cannot be submerged.
- It requires a terrain that is level or can be leveled.
- Could only be used in areas where water is available and can be impounded.

x. Mulching

Mulch is a layer of non-living material placed over the surface of the soil to smother the weeds and cut them off from direct sunlight. Mulching, in addition to this favorable effect on soil organic matter, is useful in managing the fragile tropical soil.

- mulching can help to conserve soil moisture.
- protect the soil from erosion
- reduce soil surface temperature
- increase water infiltration
- maintain soil structure
- provide favorable environment for biological activities in the soil.

Limitation of mulching

- It is a labor-intensive activity particularly if the mulch has to be transported.
- Most crops do not generate enough crop residues to provide effective ground cover.
- To be effective, the mulching materials must cover the soil surface and smother weeds.
- Covering the soil completely by the mulching material may interfere with other farming operations.
- Mulching materials placed before seedling emergence may interfere with seed germination or the growth of seedlings.
- Mulching material may serve as a trap for animal pest of crop, including promoting termite activity.

xi. Crop rotation

Crop rotation is a valuable tool in weed control because many weeds are associated with certain crops (host specific)

- Rotation play a long term role in weed control by preventing particular weed species from adapting to the growth cycle of specific crops.
- Rotating cereals with legumes and other trap crops is recommended for reducing *Striga* infestations in small holder farms.
- Crop rotation also helps the farmer to rotate his herbicides, thus ensuring that weeds resistant to a particular herbicide do not take over in a field.

3.4 Biological Methods of Weed Control

Biological method of weed control refers to the control or suppression of weeds by the action of one or more organisms, through natural means or by manipulation of the weed, organism, or the environment. The most dramatic instances are those in which natural enemies of the weed species have been identified and are either introduced or encouraged. With this approach, the Klamath weed is being controlled in the U.S.A with parasitic beetles; the prickly pear cactus has been controlled in Australia by the Argentine moth borer. This approach is, however, most efficacious where single troublesome weed species is predominant.

Major developments in this area include biological control of weeds with vertebrate animals (microbial control), use of microorganism such as plant pathogens for weed control (microbial control) and live mulch. Other areas with potential for biocontrol of weeds are exploitation of crop canopy, density and the allelopathic effects of both weeds and crops on weeds.

i. Live mulch

Live mulch is defined as a crop production system in which a food crop is planted directly in the living cover of an established cover crop without destruction of the fallow (cover crop) vegetation. Perennial legume cover crops have been evaluated and found to be suitable for use as live mulch.

Live mulch crop production aims at the following

- Suppresses weeds.
- Reduces weed seeds population in the soil.
- Reduces loss of soil organic matter.
- Provide favorable condition for earth worm activity.
- Protect the soil from erosion.
- Reduces soil compaction.
- As additional fodder for livestock.

Advantages of using live mulch

- Reduces the need to control weeds after harvest.
- It prevents the establishment of those weeds that colonize fallow land.

ii. Biological control with invertebrate animals

This involves the use of insects to control weeds. Example, the Klamath weed is being controlled in the U.S.A with parasitic beetles; the prickly pear cactus has been controlled in Australia by the Argentine moth borer. This approach is, however, most efficacious where single troublesome weed species is predominant.

Advantages of biological control of weeds by insects

- The effect is permanent.
- It can be used in places that are not easily accessible to man.
- It is cheaper in the long run.
- It does not pose any risk of polluting the environment.

Disadvantages of biological control of weeds by insects

- It is not suitable for food crop.
- Unfavorable weather condition or presence of predators may prevent the insects from adapting to the new environment.
- Inability of the appropriate growth stage of the insect to synchronize with the susceptible stage of growth of the target weed.

iii. Biological control of weeds with vertebrate animals

Animals have been used for suppressing vegetation for centuries. Pasturing land with sheep sometimes is an effective method for controlling certain weeds. Sheep are able to suppress field bindweed on land seeded to sudan grass for pasture. They eat the bindweed in

preference to the sudan grass, but they make good gain on the latter after eating down the weeds. Fish consumed algae in flooded fields.

iv. Microbial weed control

Microbial weed control involves the use of microorganism such as fungi, bacteria, nematodes and virus. Microbial control of weeds involved the multiplication of pathogens in a controlled environment and spraying them on the target weed as mycoherbicides.

v. Allelopathy

Allelopathy is a term used to describe the detrimental effects of chemicals or exudates produced by one living plant species on the germination, growth or development of another plant species or microorganisms sharing the same habitat.

vi. Plant canopy

The main effect of plant canopy is to shade the weeds and limit their ability to carry out photosynthesis. Example, melon (*Colocynthis citrullis*) and sweet potato can provide early ground cover and shade out weeds when intercropped with other crops.

3.5 Chemical Methods of Weed Control

Chemicals that are used for killing or adversely affecting plant growth are known as **herbicides.** The practice by which weeds are killed with herbicides is called **chemical weed control.**

Criteria used to classify herbicides

- The time when they are normally applied.
- Whether they are selective or not.
- Whether they normally act through the shoot or the root.

1. Classification of herbicides based on time of application

There are generally three distinct times when herbicide may be applied.

i. Pre-planting application

Pre planting application is done before the crop is planted. A preplant herbicide may be applied broadcast on the foliage to kill fallow vegetation such as paraquat or it may be the type, such as trifluralin, that is incorporated into the soil during tillage operations.

ii. A pre-emergence herbicide application

This is the application that is done after planting but before the crop emerged. The weeds may or may not have emerged by the time of pre-emergence application. If the weeds have not emerged, then a herbicide such as diuron or ametryne that acts on un-emerged seedlings can be used. If the weeds have emerged already, paraquat can be used to kill the emerged weeds

iii. A post emergence herbicide application

This is the application of herbicide that is done after the crop has emerged. Again weeds may or may not have emerged at the time of herbicide application. Example of post emergence herbicides are 2,4-D propanil, paraquat etc. A post emergence herbicide must find a way to avoid herbicide damage to the emerged crop.

2 Classification of herbicide based on type of plants killed

All herbicides kill plants either selectively or non selectively:

i. **Nonselective herbicides** are those herbicides that exert toxic effects on all plants that may come in contact with them. Example, diquat, glyphosate, paraquat and sodium chlorate.

ii. **Selective herbicides** are those that will preferentially kill certain plants species at recommended rates but will not harm other plants that they come in contact with. Example, 2,4-D, diclofop-methyl, fluometuron and metolachor.

3. Classification of herbicides based on movement in plants

i. Contact herbicides

These are herbicides that kill the tissues they touch. Contact herbicides commonly in used in the tropics include the following: paraquat, propanil, oryzalin and diquat.

ii. Systemic herbicides

These are those herbicides that are transported in the xylem or phloem vessels of the treated plants. Examples of systemic herbicides are atrazine, dalapon and glyphosate. Systemic herbicides are particularly useful in controlling perennial weeds because underground perennating organs and roots are killed in addition to the shoot.

iii. Soil-acting herbicides

Are those which act primarily in the soil. They are usually applied to the soil where they retard or inhibit the germination of weed seeds. Such herbicides usually have long residual action so that they can prevent the growth of weeds for a substantial part of the cropping season.

3.6 Preventive Methods of Weed Control

Preventive weed control refers to those measures necessary to prevent the introduction of new weed species into a given geographical area as well as multiplication and spread of existing weed species. Preventive weed control includes all sanitation measures that should be routinely used in the farm, including the vigilance that keeps a farmer alert to the presence of a strange plant on his farm land. Its generally accepted wisdom that it is easier to prevent the spread of a weed to a new site than to get rid of it after it is well established.

i. Fallowing

This is an effective method of suppressing annual grasses and troublesome perennial weeds such as speargrass. Although fallowing has been used for controlling weeds, proper management of fallows can be used to prevent weeds from going to seed and reduce weed population in a given ecology. An example of preventive weed management by bush fallowing is the live mulch cropping system. In this system the living cover of legumes such as *Centrosema pubescens* and *Mucuna pruriens* provide complete cover, smother weeds, prevent erosion and return organic matter to the soil.

ii. Preventing weeds from setting seeds

Annual weeds and simple perennials produce large quantities of seeds that end up in the seed bank already in the soil. Late germinating weeds in the field crops are the main sources of weed seeds in newly harvested field because these weeds usually complete their life cycle after crop harvest.

Methods of preventing weeds from going to seed

a. Post- harvest weed control will be necessary to prevent these weeds from going to seed (producing seeds).
b. Enlightening the farmers on the adverse effects that seeds produced by these volunteer weeds will have on their subsequent use of the land.

c. Repeated mowing and hand-slashing can be used to deplete the food reserve in the storage organs of perennial weeds there by reducing their competitiveness.

Preventing the spread of weeds and their propagules by

a. Use of clean seeds for planting.
b. Weed spread through the use of contaminated crop seeds can be prevented by keeping crop plants in the field weed-free.
c. By thoroughly cleaning the seeds intended for planting in the following cropping season.
d. Planting weed-free crop seeds is one way of avoiding the introduction of new weed seeds to the newly cleared crop land.
e. Cultivating tools play a role in spreading weed seeds and vegetative perennating organs. Routine sanitary measure involving careful cleaning of farm machinery immediately after use is an important preventive measures for weed control.
f. Seeds of many weeds are spread by animals. Care should be taken by the farmer to organize carefully the transfer of farm animals between fields.
g. Preventive weed control can also be achieved by screening irrigation canals to prevent weed seeds from being transported from infested fields to clean areas.
h. Well-decomposed manure is unlikely to contain viable weed seeds but poorly prepared manure which is a potential source of weed seeds, therefore, should be avoided.
i. Strict enforcement of quarantine laws is necessary to prevent the accidental introduction of noxious weeds through seeds and propagules.

3.7 Integrated Weed Management System

Integrated weed management (IWM) is neither a method nor a system of weed control, but a philosophy whose goals is to use all available knowledge in weed science to manage weeds so that they do not cause economic loss to humans and subsequently minimizing hazards to the environment.

Reasons that made IWM desirable

i. Inability of any one method of weed control to completely solve the weed problem of a given crop at all times and without adverse effect.
ii. The ability of weeds to develop resistance to a herbicides that is frequently used.

4.0 CONCLUSION

By now you must have learnt the different methods of weed control including cultural, biological, chemical or integrated weed control programme. The emphasis has been on "Prevention is better than cure" so your knowledge of weed science should help you to manage weeds so that they do not cause economic loss to the farmer and subsequently minimize hazards to the environment. Understanding the different types of herbicides, their mode of action, time of application and types of plants they commonly kill is essential for an effective weed control programme. The integration of cultural, biological and chemical methods of weed control in other words integrated weed control is the most sustainable and effective method of weed control programme.

5.0 SUMMARY

At the end of this unit you should have learnt the basic principles of weed control, the cultural methods of weed control, and the biological and chemical methods of weed control. In this unit, the advantages and disadvantages of each method of weed control were highlighted. Emphasis was particularly made on the prevention not the total eradication of weeds. Herbicides are classified based on time of application, movements in plants and types of plants killed for easy identification and utilization. Effective weed control programme should be hinged on utilizing all available knowledge of weed science to manage weeds so that they do not cause economic loss to the farmer and thereby minimize hazards to the environment.

6.0 TUTOR-MARKED ASSIGNMENT

1. a. State the principles of weed control.
   b. What is weed eradication? And what are conditions necessitating it?
2. a. What are the advantages and disadvantages of mechanical weeding?
   b. State the advantages and disadvantages of manual weeding.
3 a. Enumerate five methods of preventing the spread of weeds by their seeds and propagules.
   b. Briefly describe measures to prevent weed from going to seed.
4 a. Give the classification of herbicides based on movements in plants and time of application.
   b. Write short notes on the following:
      - Live mulch.
      - Allelopathy.

- Crop rotation as a measure of weed control.
- Burning.

7.0 REFERENCES/FURTHER READING

Akobundu, I. O. (1987). *Weed Science in the Tropics*. Principles and Practices. John Wiley and Sons Inc.

Martin, J. H, Waren H. L. & Stamp, D. L. (1976). *Principles of Field Crop Production* (3rd ed.). New York: Macmillan Publishers.

Onwueme, I. C and Sinha, T. D. (1999). *Field Crop Production in Tropical Africa*.

Netherlands: CTA, Wageningen

MODULE 3 HERBICIDES

UNIT 1 DEFINITION AND CLASSIFICATION OF HERBICIDE

CONTENTS

1:0 INTRODUCTION

For plants to exist free from diseases, pests and weeds, there is the need to control crop fields with cultural chemical, preventive and biological means. Chemicals used in the control of weeds are known as herbicide and you have learned abut these in your previous unit (weed control). However, this unit and others will broad your knowledge on herbicide, their classification, formulation, application calculation and precaution to take when applying them on crop fields.

2:0 OBJECTIVES

At the end of this unit you should be able to:

- Define herbicide
- Explain the different classification of herbicides
- State examples of herbicide in each classification
- Differentiate the different classification of herbicide

3:0 MAIN CONTENT

3:1 Definition

Herbicides are chemicals capable of killing or inhibiting the growth of plants. The practices by which weeds are killed with herbicides is called chemical weed control. Although all herbicides kill plants, the effects of these chemicals are often modified by the environment, the stage of maturity and type of weeds that are sprayed, part of the treated weeds that are sprayed, part of the weeds treated and how they move in the plant, the concentration of the herbicide and the time they are applied

3:2 Classification of herbicide

Herbicides have been classified into several groups on the basis of:

(a) When they are applied
(b) Where they are applied
(c) How they move in plants
(d) Type of plant killed and
(e) Chemical structure or composition of the active ingredients.

Since herbicide must be introduced to the weed / crop environment in order for it to exert its efficient, the stage of crop and weeds at the time of herbicides application play an important role in herbicide grouping.

3:2:1 Classification based on point of application

Herbicides used for weed control on terrestrial habitats (land) are either applied to the foliage (leaves) of the crop and weeds or to the soil. All foliar applied herbicides enter the plant primarily through the foliage and can either exert their toxic effects on the foliage or translocate to other parts of the plant that are move susceptible to them. The activity of water-soluble foliar applied herbicide is affected by rainfall and wind pre-planting and post emergence herbicides are applied in this form.

Pre-emergence herbicide are applied on the soil and they kill plants as a result of their imbibitions by germinating weed seeds, or up take by the coleopile and plumule of germinating grasses and broadleaves respectively since soil applied herbicide need to go unto soil solution prior to up take, soil moisture conditions play an important role in their activity. Application of herbicide on dry soils drastically reduces activity or herbicide performance.

3:2:2 Classification base on chemical structure.

Herbicides can be classified into distinct chemical groups on the basis of structural formula into organic and inorganic herbicides. Over 200 herbicide in use today are organic compound, but there are still a few inorganic herbicide in use today. In addition to these, new types of herbicides known as biological herbicides are now available for weed control. These biological herbicides are concentrates of specific fungi and are used for weed control in crops. Chemical classification of herbicides attempts to group herbicides on the basis of the molecular structure of their active ingredients.

SELF ASSESSMENT

i. Define herbicides
ii. Classify herbicide based on point of application

4:0 CONCLUSION

Classification of herbicide gives you options on how best to control weeds using chemicals depending on the nature, age and concentration of the weed in a given locality. For a successful weed be taken on selection of the herbicide and the type of action needed to have effective weed control.

5:0 SUMMARY

Herbicides are chemicals used in killing plants and these herbicide are classified based on time of application, movement in plants, types of plants killed, point of application and chemical structures for easy identification and utilization.

6:0 TUTOR-MARK ASSESSMENT

1. Classify herbicide base on time of application
2. Classify herbicide base on movement in place

7:0 REFERENCE/FURTHER READING

Akobundu, I. O (1987). *Weed Science in the Tropics*.Principles and Practices. John Wiley and Sons Inc.

UNIT 2 HERBICIDE FORMULATION

CONTENTS

1.0 INTRODUCTION

Herbicides are chemical used in killing plants. These chemical are formulated in different form and contain concentrated element that need to kill plant through their action in the plant. Just as you have tablets, syrups, injection that are used in human as chemical formulation used in control of diseases, so also herbicide are formulated to be used either directly or indirectly through mixture with other compound for application on plants. This unit affords you the opportunity to know herbicide formulation and why they are formulated.

2.0 OBJECTIVES

At the end of this unit you should be able to:

- Know What is herbicide formulation
- Explain the different form of herbicide formulation
- Symbols used for each form of herbicide formulation

3.0 MAIN CONTENT

3.1 Herbicides formulation

Herbicides in natural state may be solid or liquid, volatile or non-volatile and soluble or insoluble. These cannot be applied in original form; these have to be made into suitable and safe forms for their field use. Such forms are called herbicide formulations. The herbicide formulations are diluted by the user, in water but sometimes in oil also, before their application in the target area. Dry granules of herbicide formulations, however, are applied either as such or after their dilution with dry sand, and like material.

Herbicide formulation is prepared by the manufacturers by blending the toxicant (active ingredient) with substances like solvents, invert carriers, surfactants, anti farming agents, stickers, stabilizers etc. The two major objectives of formulating herbicide are to ensure their.

(a) To reduce the concentration of the active ingredient through dilution in appropriate solvents
(b) To reduce the level of contamination and hazard during handling and application
(c) To improve the efficacy of the herbicide through slow release of the active ingredient
(d) To reduce the cost of weed control with that particular herbicide
(e) High controlled activity on the target plant.

3:2 Forms of herbicide formulation

Herbicides are formulated in many ways in response to various application equipments, chemical properties of the active ingredients, cost of manufacture, availability and cost of adjustment, toxicity of the herbicide and other safety consideration.

A commonly used herbicide formulation are slat, water soluble concentrate, wettable powder, emulsifiable concentrates, flowable water dispensable granules pellets and most recently gels and microencapsulated formulation.

3:2:1 Salts (S, SP)

They are water soluble power which are infact salts of metals such as Na^{+}, K^{+} and Ca^{++}. Herbicide formulated as solid dry salt must be very soluble in water to ensure that a herbicidal concentration of the solution can readily be obtain for field application example of salt formulated of

herbicides used in the tropics are Hexaxinone, sodium salt of dalapon sodium salt of TCA, sodium salt of 2, 4-D.

3:2:2 Water Solution Concentrates (SL, S2, ULSC)

These are liquids, homogenous formulation of herbicides. The formulation consists of the active ingredient, water as a diluents and a surfactant to increase foliar uptake. Examples are Amine Diquat, paraquat, Ammonium hexazinone.

3:2:3 Emulsifiable concentrates (E, EC)

These are herbicide formulation that forms an emulsion when water is added to form them. Some herbicide not soluble in water may dissolve in organic solvents. The concentration of these herbicides is usually indicated on the label as 360E, 480E, 480EC or 500E. This means that the formulation contains 360, 480 or 500 active ingredients per litre of the formulated product respectively. Examples of emulsifiable concentrate formulation in use in the tropics are Bifenon, metalachor, Alachor, sendimethalin.

3:2:4 Wettable Powder (W, WP)

These are herbicides that are neither soluble in water nor in organic solvent to be formulated as emulsifiable concentrate. The formulation consists of finely grounded solid particles of the active ingredients, solid carrier or duluent, wetting agents of dispersing. The diluents are an inert material of clay material or organic matter origin. Examples of wettable powder are Atrazine 70% WP, Diuron 80% WP, Isoproturon 70% WP primextra.

3:2:5 Water dispersible granules (WDG, SG, WG, DG)

They are also known as dry flowable. They consist of five granules that have been impregnated with the active ingredient of the herbicide. These granules also contain dispersing agents and other surfactant that enables them to break up when pouted into water. Examples are Lexus (50DF), Linuron, Metribuzin.

3:2:6 Granular formulation (G)

The granular formulation consist of the active ingredient on inert carrier which may be clay, sand, vermiculate or organic matter such as grounded plant parts. The herbicide granules vary in size from 0.04mm to 1.0mm in diameter. Herbicide granules smaller than 0.04mm are not

used because they drift easily with wind. Examples are Butachlor, 2, 4 – DEE.

Advantages of granular formulation over other herbicides formulation

(1) They can be used for selective weed control.
(2) Water is not required for application
(3) Herbicides spraying equipment is not required. For application. Only hand gloves are required.
(4) There are no herbicide drift.
(5) Granules make it possible to release the herbicide at specific doses over a period of time.
(6) Herbicide spoilage problems are minimized. Disadvantages of granular formulation.
(1) Granules are bulky to transport and this increase cost per unit of active ingredient.
(2) Uniform application requires considerable experience.

3:2:7 Pellets (P) or tablets (TB)

These are prepared in the same way as granules but differ from granules by having large particles usually larger than 100mm. pellets and tablets are frequently used for spot application and the herbicide is released as the pellet or tablet disingrate. This herbicide formulation is useful in weed control in forestry.

3:2:8 Micro encapsulated formulation (ME)

This is new development is herbicide formulation technology. The active ingredient of the herbicide is encased in an inert microscopic capsule. The inert material may be gelatin or various polymers. They are also called capsule suspension and they may be more expensive to manufacture.

3:2:9 Gels (GL)

Gels are relatively new products that are thickened emulsifiable concentrate packed in water soluble begs. Gel can be formulated so that users know exactly how much herbicide is being added to the spray tank.

3:2:10 Flowables (F, FW, DF) or liquids.

These are herbicide formulation that consists of finely grounded solid of the active ingredient. If a given herbicide is slurry and made up of water

and adjuvants,the solid may settle to the bottom of the jar when the herbicide formulation is in storage but goes readily into suspension when the jar is shaken vigorously. Example are Atrazine,Linuron, Metribuzine.

4:0 CONCLUSION

Deferent herbicides are formulated differently and as such different type of application method, solvent, inert material and precaution are required. While pallet and granules are applied directly on target weed or area it does not required sprayer, other are applied at random and required sprayer.

5:0 SUMMARY

Herbicide formulation is prepared by the manufacturer by blending the toxicant with substances like solvent, surfactants etc. The objectives of herbicide formulation are to ensure their ease of handling and controlled the activity of the target plants. The forms of herbicide formulation includes emulsifiable concentrate, salts, water soluble concentrate, wettable poweder, flowable, gels, pellet, granular formulation and microencapsulation Granular formulation has more advantages over other forms of herbicide formulation which include.

(a) Required water for application
(b) Release the herbicide at specific doses over time
(c) Required no spraying equipment etc.

6:0 TUTOR-MARK ASSESSMENT

1. List the forms of herbicide formulation you know
2. What are the objectives of herbicide formulation
3. State 3 advantages of granules over other forms of herbicide formulation
4. State 2 disadvantage of granules.

7:0 REFERENCES/FURTHER READING

Akobundu, I. O (1987). *Weed Science in the Tropics*. Principles and Practices. John Wiley and Sons Inc.

UNIT 3 HERBICIDE CALIBRATION AND DOSAGE CALCULATION

CONTENTS

1.0 INTRODUCTION

Herbicides are intended to control or eradicate weeds in farm, homes, roads e.t.c. were they hamper the activities of human and animals. When the herbicides are applied at the right quantity, time and on the target weeds, it becomes effective but when the herbicide is applied otherwise, it causes adverse effect on crops, human and the environment. It is therefore very important to apply the herbicide correctly to avoid adverse effect of any kind. In this unit, you would be studying the calibration and calculation of herbicides for application.

2.0 OBJECTIVES

At the end of the unit you should be able to:

- State the importance of sprayer calibration
- State the procedures used in herbicide sprayer calibration
- Calculate herbicide dosage for small area and large area

3.0 MAIN CONTENT

3.1 Herbicide Calibration

Herbicide calibration is the determination of the quantity of herbicide required to spray or cover a particular area without causing any negative

effect to the crop and environment. Avoiding crop injury, good weed control, good economics and environmental considerations are among the reasons for careful calibration of sprayers. The objective of all sprayers' calibration is to ensure that the sprayer uniformly distributes herbicide solution at the dose per unit area of the target plant and at the volume rate recommended. Since herbicides are always applied in small doses, they have to be diluted in sufficient carrier to permit a uniform distribution of the herbicide on the target plants. Sprayer's calibration is particularly necessary for sprayers equipped with hydraulic nozzles. This is because there is a wide selection of nozzles and these have different capacities (flow rates), spray angles and spray patterns.

The rate at which the herbicides solution is pushed towards the nozzle is determined by the pressure on the liquid inside the tank in the case of sprayers with pressurized tanks, or on the pressure imposed on the liquid in the pipe for powered sprayers. In the case of hand-held CDA sprayers, where the liquid is fed to the nozzle by gravity, a constant walking speed of one meter per second is all that is needed to ensure uniform application of herbicides in most field situations. However, volume rate in CDA sprayers can be altered by changing the orifice disc which controls the flow rate of the spray solution in the sprayer.

Before beginning calibration it is important to check out the sprayer to make sure that all parts are working properly. First clean the sprayer, set the pressure gauge to the pressure setting at which the sprayer will be operated and fill the tank with water. Pump to pressurize the tank, and check the sprayer for leaks. Give a gentle squeeze to the trigger handle and check for trips. If there are no leaks, then proceed with sprayer calibration. It is important to maintain a constant nozzle lances. Changes in nozzle height will alter swath width and application rate without affecting nozzle flow rate. Each nozzle type has a recommended swath width at a given nozzle height.

3.2 Procedures of calibration

There are two easy-to-flow procedures for calibrating knapsack sprayers. These are the area-volume method and the time-volume method.

3.2.1 The time-volume method

Proceed as follows:

1. Peg out a $100m^2$ area (10m x 10m, but preferably 4m x 25m to allow for a reasonable walking distance.
2. Add water to the tank to two-thirds of full capacity.

3. Walk at a pace comfortable to you, and spray the marked-out area (test plot) using a moderate pump pressure. Record the time taken to spray the test plot.
4. Repeat step 3 at least twice for reproducibility, and record the average time taken to spray the test plot. Note that the swath width should be constant.
5. Fill the sprayer once again, and this time spray into a measuring jug using the same operating conditions and time as used in steps 3 and 4 above. Note the volume of solution collected.
6. Repeat step 5 at least twice more, and note the average volume collected. This is the volume rate of your knapsack sprayer.
7. Calculate the delivery rate of the sprayer from the data in step 1 to 6 as follows:

(a) Determine area of test plot:
From step 1 above, the area of the test plot = 0.01 ha.
(b) Determine area rate of test plot:
From step 4, time required to spray test plot = 50 s.

Therefore, area rate

$$= 0.01 \text{ ha} \div 50 \text{ s}$$

$$= \frac{0.01 \text{ ha} \times 60 \text{ s}}{50 \text{ s} \times 1 \text{ min}}$$

$$= 0.012 \text{ ha min}^{-1}$$

(c) Determine volume rate:
From step 6, volume collected = 2 liters
Therefore area rate

$$= 21 \div 50 \text{ s}$$

$$= \frac{21 \times 60 \text{ s}}{50 \text{ s} \times 1 \text{ min}}$$

$$= 2.4 \text{L min}^{-1}$$

(d) Determine application rate of sprayer:
Application rate (1/ha)

$$= \frac{\text{Volume rate}}{\text{Area rate}}$$

$$= \frac{2.4 \text{L min}^{-1}}{0.012 \text{ ha min}^{-1}}$$

$$= 200 \text{ L ha}^{-1}$$

This is the application rate of the sprayer. For herbicide solutions the 200 liters represents a solution made up the herbicide and the diluent. The information from sprayer calibration is useful in determining the quantity of water needed for diluting herbicides during spray applications. The above application procedure can be modified in many ways. One way to do this is for the operator to adjust his walking

speed to one meter per second (1 ms^{-1}). This can surprisingly be done after a few practice runs. One advantage of establishing this standard walking speed is that, when a sprayer is calibrated at this walking speed, anybody can use the same sprayer if he too uses the same walking speed, swath width and tank pressure.

3.2.2 The area-volume method

The area-volume method is not very suitable for knapsack sprayers but is more appropriate for tractor-mounted sprayers. It involves filling the spray tank to a predetermined point, spraying a known area of the target and determining the volume of water used for the application. Since most knapsack sprayers have translucent tanks it is not always easy accurately to determine the volume of liquid used by this method. Also, it is both laborious and time-consuming to spray an area large enough so that a measurable amount of liquid in the tank can be used up. For knapsack sprayers the time-volume method gives more accurate determination of volume rate than the area-volume method.

3.3 Herbicide dosage calculations

Plant response to herbicides is a function of herbicide concentration and application conditions, as well as the age and physiological state of the plant. Herbicides may be applied on the soil to control germinating weed seed, or to the foliage to kill established weeds. The dose of a herbicide recommended for weed control in a given cropping situation is the result of extensive field evaluation of crop and weed responses to the herbicide in various environmental and soil conditions. Crop injury can be minimized if the amount of herbicide needed to control weeds is carefully determines. Safety of the sprayer operator, and safety of crops, is among the reasons for herbicide calculations. Other reasons for herbicide calculation are: to determine accurately the amount of herbicide necessary to kill the weeds, to improve herbicide efficacy, to reduce cost of chemical weed control, to minimize environmental pollution and to make farming more economical.

Herbicides are used at low doses for weed control. The quantity applied on a target may vary from a few grams to a few kilograms per hectare, depending on the phytotoxicity of the herbicide and on the weed problem. Accurate calculation of the quantity of herbicide to apply on a target is an important step in herbicide use. Failure to calculate the quantity of herbicide properly leads to wrong measurements, unsatisfactory weed control and possibly crop injury. A few examples of herbicide calculations will be given to illustrate common problems encountered with herbicide use in the field:

(a) The amount of quantity of the commercial product needed to apply on a target.
(b) The rate of application of the active ingredient of a herbicide.
(c) The area that can be treated with a given quantity of product and
(d) The concentration of a herbicides when the quantity to be applied is known.

Use of formula for solving problems

The relationship between herbicide concentration, the rate of application and the area to be treated is given as follows:

$$Q = \frac{R \times A}{C}$$

Where Q = the quantity of formulated product, A = area of the target to be treated, R = rate of application of the herbicide in weight of the active ingredient (or acid equivalent) per ha, and C = concentration of the active ingredient (or acid equivalent) in grams per unit volume (usually liter) of the formulation. For dry formulations C is expressed as percentage weight of the formulation.

Information on any three of the above factors is all that is needed to determine the fourth factor. Students are encouraged to familiarize themselves with this formula and use it as a tool in the calculation of herbicide rates.

SELF ASSESSMENT

i- State the two procedure used in herbicide calibration
ii- Explain the relationship between herbicide concentration, the rate of application and the area to be treated with a herbicide

3.3.1 Large hectarage application

Problem 1 Gesaprim 80 WP (atrazine) was applied reemergence in maize planted in a newly cleared 15 ha forest land. If the herbicide was applied at the rate of 2.0 kg a.i./ha, what quantity of the formulated herbicide was used?

Solution to problem 1 Atrazine in the formulation = 8.0 kg a.i. kg^{-1} If the field in problem A.1 Application rates is 2kga.i in a hectare. Therefore the quantity of product used in 1 hectare is 2.0 kg a.i.ha^{-1} ÷ 0.8 kg a.i. kg^{-1}. Quantity atrazine for 15 ha

$$Q = \frac{R \times A}{C}$$

$$= \frac{2.0 \text{kg a.i. ha}^{-1} \times 15 \text{ ha}}{0.8 \text{ kg a.i. kg}^{-1} \text{ product}}$$

= 37.5kg of product

Problem 2. If the field in problem A.1. had been infested with *Rottboellia cochinchinensis*, what quantity of Stomp 330E (pendimethalin) did the farmer need to make a 1:1 ratio of atrazine plus pendimethalin mixture for the same field. Note that the rate of atrazine was not changed.

Solution to problem 2. Pendimethalin in the formulation = 330 ga.i. 1^{-1} Application Therefore the quantity of product used in Quantity of pendemethalin for 15 ha

$$Q = \frac{R \times A}{C}$$

$$= \frac{2.0\text{kg a.i. ha}^{-1} \times 15\text{ ha}}{0.33\text{ kg a.i. } 1^{-1}}$$

= 91 liters of product

3.3.2 Small plot application

Problems 3. Oxadiazon is to be evaluated at a research station for weed control in transplanting paddy rice. If the herbicide formulation available is Ronstar 25E, what quantity should be measured out for a treatment in which Ronstar is to be applied at the rate of 1.5kg a.i. per ha? Assume that the plot size is $18m^2$ and the material is be measured for 4 replications.

Solution to problem 3. concentration of the herbicide = 250g a.i./1, i.e. 0.25g/m1. If oxadiazon is to be applied at the rate of 1.5kga.i. per ha, the quantity of the active ingredient that will be applied per square meter is 1.5kg divided by 10000 m^2.

Quantity of oxadiazon per unit square meter = $\frac{15\text{ g a.i.}}{0.15\text{ g.a.i.}}$

Quantity of formulated oxadiated per square meter = 0.25 g.a.i.ml^{-1}

= 0.6ml of product

Quantity of formulated oxadiazon for $18m^2$ = 0.6ml x 18

= 10.8ml

Therefore quantity of product for the four replications = 42.2ml of product using the formula.

$$Q = \frac{R \times A}{C}$$

(Area (A) = $72m^2$; Concentration (C) = 250 ga.i. 1^{-1} Rate ® = 1.5kg a.i. ha^{-1})

$$\frac{1.5\text{kg a.i. ha}^{-1} \times 72\text{m}^2}{250\text{ ga.i. 1}^{-1}}$$

By Converting kg, 1, and ha ml, and m^2 respectively, the above expression becomes:

$$\frac{1.5\text{kg a.i. ha}^{-1} \times 1000\text{gkg}^{-1} \times 72\text{m}^2 \times 1000\text{m11}^{-1}}{250\text{ ga.i. 1}^{-1} \times 10\,000\text{m}^2\text{ ha}^{-1}}$$

= 43.2ml of product

While the above formula works well for computing herbicide formulations for large plot (more than 1 ha), it is not convenient where small plots (less than 1 ha) are involved unless it is modified. Computation for small plots can be simplified as follows.

$$Q = \frac{100(R \times A)}{C}$$

Where R is rate in kg a.i./ha, A = area in m^2 and C is concentration in g.a.i. per liter of kg of product. The constant, 100, is derived, as shown above, from the convertion of kg, 1, and ha to g, mi and m^2 respectively.

By applying this new formula for small plots to the last problem, the solution simplifies to:

$$Q = \frac{100(1.5 \times 72)}{250}$$

= 43.2mI

Problem 4. Ordram 10G (molinate) is to be applied in five paddy rice plots 4m x m. If the herbicide is recommended for use at the rate of 3 kg a.i./ha, what quantity should be weighed out for each plot?

Solution to problem 4. The quantity of the product, Q, is calculated as follows:

$$\frac{100(R \times A)}{C}$$

(R = 3 kg a.i/ha; A = 28 m^2; C = 100 ga.i/kg)

$$Q = \frac{(3.o \times 28)}{100}$$

= 84 g of product

This is the quantity of Ordram 10G that should be weighted out for one 4 m x 7 m plot.

Calculations involving rate of herbicides

Problem 5. A farmer sprayed his 6-hectare field infested with Guinea grass, *Panicum maximum.* When the work was completed he discovered that he had used up 80 kg of Basfapon. At what rate did he apply the herbicide? (label information on Basfapon reads ingredients: sodium salt of 2,2- disloropropionic acid … 85 percent (74 percent acid equivalent); inert ingredients … 15 percent).

Solution to problem 5.

(R x A) therefore (Q x C)

$$\text{If } Q = \frac{C}{\quad} \qquad R = \frac{A}{\quad}$$

(Q = 80 kg, C = 0.85 x i.e. 0.62kg a.e/kg product, A = 6 ha)

$$R = \frac{80 \text{ kg product x } 0.62 \text{ kga.e. kg}^{-1} \text{ product}}{6.0 \text{ ha}}$$

$$= 8.4 \text{ kg a.e. ha}^{-1}$$

Problem 6. You are required to apply 450ml of Gramoxone 200S (paraquat) in enough water to cover 1800 m^2 . What rate of paraquat (in k g a.i. per ha) does this represent? (Note: Grameoxone is formulated as a water-soluble concentrate containing 200 g/1 paraquat.)

Solution to problem 6. By transposition of factors in the formula:

$$Q = \frac{100(R \times A)}{C} \qquad R = \frac{Q \times C}{100A}$$

(but A = 1800m^2 C = 200 g/1, Q = 450ml, and R is kg a.i. per ha).

$$R = \frac{450 \times 200}{100 \times 1800}$$

$$= 0.5 \text{ kg a.i. per ha.}$$

For A > 1 ha, use the formula:

$$Q = (R \times A)/C.$$

Calculate involving the area of a field to be trained

Problem 7. A research technician was given 600ml of a flowable formulation of a herbicide for preemergence used a test crop. If the herbicide is to be applied at the rate of 2 kg a.i./ha, what size of plot can be treat if this herbicide is formulated as 400F?

Solution to problem 7.

$$A = \frac{Q \times C}{R} = \frac{600 \times 400}{100} = \frac{100 \times 20}{100} = 1200m^2$$

The area that can be treated is $1200m^2$

Calculations involving the connection of herbicides

Problem 8. Forty-five liters of an EC were applied to a 15 ha noncrop site for brush control. If the herbicide rate was 0.45 kg a.i./ha, what is the concentration of the active ingredient in the herbicides formulation used?

Solution to problem 8. Using the formula for A > 1 ha,

$$Q = \frac{R \times A}{C}$$

And then transposition of factors:

$$C = \frac{R \times A}{Q}$$

Therefore

$$C = \frac{0.45 \times 15}{45} \quad C = 150g \text{ a.i./L, or } 150 \text{ EC}$$

The concentration of the active ingredient in this formulation is 150 g/L.

4.0 CONCLUSION

Sprayer calibration and dosage calculation is very important to farmer to achieve an effective and efficient weed control and to reduce or eliminate the negative effect of herbicide application on crops and the environment. Calibration and dosage calculation enables the farmer use herbicide economically to minimize cost while maximizing profit.

5.0 SUMMARY

Herbicide calibration is the determination of the quantity needed to cover a specific area of land and this is done to avoid crop injury, environmental pollution and for economical reasons. The procedures used for calibrating sprayer are area volume and time volume methods. Dosage calculation involves the used of formular to calculate the quantity, concentration, rate or area to apply herbicide. The calculation can be for small plot or for large hectarage.

Relationship between herbicide concentration, the rate of application and the area to be treated is given as follows:

$$Q = \frac{R \times A}{C}$$

Where Q = the quantity of formulated product, A = area of the target to be treated, R = rate of application of the herbicide in weight of the active ingredient (or acid equivalent) per ha, and C = concentration of the active ingredient (or acid equivalent) in grams per unit volume (usually liter) of the formulation. For dry formulations C is expressed as percentage weight of the formulation.

6.0 TUTOR MARK ASSESSMENT

1. Explain the two procedure used in sprayer calibration
2. State the importance of dosage calculation of herbicide
3. Gesaprim 80 WP (atrazine) was applied reemergence in maize planted in a newly cleared 15 ha forest land. If the herbicide was applied at the rate of 2.0 kg a.i./ha, what quantity of the formulated herbicide was used?

7.0 REFERENCES/FURTHER READING

Akobundu, I. O (1987). *Weed Science in the Tropics*. Principles and Practices. John Wiley and Sons Inc.

UNIT 4 METHODS OF APPLICATION OF HERBICIDES AND EQUIPMENT USED

CONTENTS

1.0 INTRODUCTION

When herbicides are formulated then they can be applied to the target area or plant using different methods so that they can be effective and result achieved. Application methods depend on the type of plant to be controlled, area to be applied and point of application. In this unit we shall consider the different methods of herbicide application in relation to the equipments used for their application.

2.0 OBJECTIVES

At the end of the unit you should be able to:

- List methods used in herbicide application
- Know methods suitable for the different herbicide formulation.
- Know the equipment used for applying herbicide

3.0 MAIN CONTENT

3.1 Methods of herbicide application

There are different methods used in application of herbicide which are in relation to the equipment used. There are five methods of herbicide application.

3.1.1 Sprayer

This is the use of knapsack prayer for herbicide application. The sprayer has a tank pump pressure regulator, filters hose and nozzles. It uses the pressurized system to apply the herbicide on the target plants or area. Usually the operator control the spray and the spray is done against wind direction to avoid been blown to other area. Contact herbicide such as paraquat can be applied using this method. The area applied using this method is usually not large.

3.1.2 Tree Injectors

This equipment is used in forestry for herbicide application on individual trees. The tree injector applies a measured amount of a herbicide concentrate, which may be a water soluble concentrate or an emulsifiable are the tabular type and the axe injector.

3.1.3 Granular applicator

These come in various models and are used for the application of granular herbicides. They are broadcast applicators with multipurpose functions that range from broadcasting seeds and fertilizer to broadcasting granular herbicide. The models with a metering device are preferred. An improvement in packaging has led to the availability of special containers perforated to serve as hand – held granular applicators, thus removing the need to transfer herbicide to other container.

3.1.4 Herbicide Injectors

These are designed to inject herbicide into the soil. They are used for the application of fumigants or highly volatile herbicides. Herbicides application by injection should be performed by trained operators. Situations where herbicide injector is likely to arise in the tropics include chemical control of parasitic weeds, plastic mulching and in aquatic weed control. The type of injection equipment will vary with type of weed problem.

3.1.5 Aircraft Sprayer

Aircraft have been used for weed control in the tropics in a variety of crops, usually by multinational corporations, large scale estate and government Herbicide application with aircraft is a technology beyond the resources of majority of farmers in the tropics, but large – scale farmers and government owned farms do get involved with this level of herbicide application. Aircraft application of herbicide may be done

with helicopters or with fixed-wing airplanes. The basic components of regular sprayer namely; a tank, pump, filter, pressure regulators and nozzles are also found in the aircraft used for herbicide application. The advantages of aircraft spraying are the speed with which the work can be done and the large area common with aircraft spraying.

4.0 CONCLUSION

Selection of herbicide application method to be used in any weed situation depends on the weed type, herbicide formulation and the area to be covered. The most commonly used method by farmers in the tropics is the knapsack sprayer which are different sizes.

5.0 SUMMARY

There are five methods of herbicide application based on the equipment used. They include sprayer, tree injector, granular applicator, herbicide injector and Aircraft sprayer. The most commonly used herbicide application method by farmers is the sprayer (knapsack) Aircraft sprayer is usually used by government or commercial famers.

6.0 TUTOR MARK ASSESSMENTS

1. List 5 methods of herbicide application
2. Explain briefly 3 of the methods listed above.

7.0 REFERENCES/FURTHER READING

Akobundu, I. O (1987). *Weed Science in the Tropics*. Principles and Practices. John Wiley and Sons Inc.

UNIT 5 HERBICIDE RESISTANCE IN PLANT

1.0 INTRODUCTION

Herbicide are chemical that killed plant and on application on plant community it is expected to kill the plants, however, there are times that you apply the herbicide at the correct dose but there will not be any effect on the plants or it could only cause temporary growth retardation and loss of vigour from which the plant usually recovers. This unit deals with herbicide resistance in plants and reasons for such resistance.

2.0 OBJECTIVES

At the end of this unit you should be able to:

- Know resistance of herbicide in plant
- Why some plants resist herbicides
- Know some selected plants that resist herbicide.

3.0 MAIN CONTENT

3.1 Herbicide resistance in pants

Plants respond to herbicide in ways that range from stimulated growth, through temporary growth retardation and loss of vigour from which the plant growth recovers to irreversible growth inhibition and finally death. The plant and the environment interact to accentuate or modify plant responses. Susceptibility, tolerance and resistance are the terms used in grouping plants in relation to their response to herbicide.

3.1.1 Susceptibility

Susceptibility in relation to plants is a measure of the degree to which normal growth and development can be disrupted in a plant to a herbicide treatment. The sensitivity of a plant to a herbicide is dictated by many factors that include the genetic make-up of the plants, age of the plant at the time of treatment, the type of herbicide, its formulation and dose. A susceptible is generally killed, or its growth hindered.

3.1.2 Tolerance

Tolerance of a plant to herbicide refers to its capacity to withstand a herbicide treatment at normal use dose without injury or lasting damages to its growth and development. It depends either on the ability of the plants to prevent the entry and movement of a herbicide within that plant, or a capability to rapidly deactive the herbicide that it has taken up before it dose any harm to the plant. Plants vary greatly in their ability to tolerate different herbicides and varying concentration of the same herbicide.

Differences exist in the level of tolerance among cultivars of the same species, among different species of the same genus, and among plants from different genera. Therefore selective weed control is based on differences in the level of tolerance that crops and weeds have to different herbicides.

SELF ASSESSMENT

i. Define susceptibility
ii. Define Tolerance

3.1.3 Resistance

Resistance of a plant to herbicide refers to the ability of that plant to grow normally inspite of its exposure to a normal use dose of a herbicide. Unlike a tolerant plant, the resistant plant does not depend on preventing the entry of the herbicide to which it is resistant, or on rapidly breaking it down in the plant, but rather lack a metabolic site of action for the herbicide. Thus, the herbicide fails to kill the plant because the plant biotype does not have a site that is sensitive to the herbicide.

4.0 CONCLUSION

Herbicide resistance in plants should be a basis for selective weed control in crop weed environment and the type of plant age of the plant should be taken into consideration in selecting herbicide to be applied.

5.0 SUMMARY

Plants respond to herbicide in different ways and susceptibility, tolerance and resistance are the terms used in grouping plants in relation to their response to herbicide.

Susceptible plants are killed or their growth hindered by herbicide while tolerant and resistant plant survive even when herbicide are applied on them at the right doses. Selective weed control is based on the differences in the level of tolerance that crops and weeds have to different herbicide.

6.0 TUTOR MARK ASSESSMENT

1. Define Susceptibility, tolerance and resistance in relation to plant.
2. List factors that leads to tolerance to herbicide in plants
3. List 5 plants that are tolerance to herbicide
4. List 3 plants that are resistant to herbicide.

7.0 REFERENCES/FURTHER READING

Akobundu, I. O (1987). *Weed Science in the Tropics*. Principles and Practices. John Wiley and Sons Inc.

UNIT 6 HERBICIDE HANDLING, STORAGE AND DISPOSAL AND SAFETY

CONTENTS

1.0 INTRODUCTION

Herbicide kill weed and increase productivity. However, they have harmful effect when they are not properly used or have residue effect in areas they are used for a long time. They could have effect too on human and animal. This unit discusses details on how you handle, dispose and safety measures to consider when using herbicides.

2.0 OBJECTIVES

At the end of this unit you should be able to:

- Know how to handle herbicides when using them
- Know how to disposed herbicide
- Know safety measures to take when mixing and applying herbicide
- List the major information that should be on herbicide label.

3.0 MAIN CONTENT

3.1 Herbicide Handling

Herbicides should at all time be handle with serious care from the point of purchase up to the field were they are to be applied so that they do not break or leak or splash to cause pollution or injury to handlers. Keep herbicides away from passenger, livestock and foodstuffs with special care that no persons or their belonging or foodstuffs are put at risk from leaking or contaminating container. They must not be carried along with

food. They must be only used when and where needed and access to them only to authorized personnel.

3.2 Safety Measures in herbicide use.

Safety precaution should be taken before, during and after using herbicide. There is need to read and understand the instructions or information on the label of the herbicide before using them. The best source of information concerning the safety and effective use of herbicide is the label of the herbicide container. It is also a legal document that requires government approval. Every herbicide product label should contain the following types of information if the product is designed for crop:

i. Trade or brand name
ii. Ingredient statement
iii. Chemical name
iv. Type of formulation
v. Net content of the package
vi. Name and address of manufacturer, distributor or formulator
vii. Registration or license number
viii. Warning or signal word's
ix. Hazards to humans and domestic animals
x. Environmental hazard
xi. Physical and chemical hazards
xii. Statement of practical first aid treatment
xiii. Re-entry statement – time before giving to the field
xiv. Storage and disposal statement
xv. Warranty period
xvi. Misuse statement
xvii. Use areas – crops to be used on.
xviii. Direction for use harvesting statement.

SELF ASSESSMENT

i. Explain herbicide handling.
ii. List 10 information that are found on herbicide label.

3.2.1 Safety precautions during measuring and mixing of herbicides

The risk of exposure to pesticides is greatest when ignorance and carelessness prevail. Operators and handlers of herbicide products who dilute and mix the concentrates and those who fill the spray tank of application equipment are prone to undue exposure. The hazard of exposure to herbicides in the field:

1. Understanding and implementing recommended dilution and rate of application.

(a) Read the herbicide label under the topic recommended for use
(b) Dilution rates of liquid and wettable powder are expressed in terms of tablespoon per spray tank capacity (10, 15, 16 or 20 liters capacity depending on sprayer type or model).
(c) Spraying rates are expressed in terms of volume of spray per hectare (leters/ha) or tank load per hectare.
(d) One tank load is equivalent to the sprayer capacity (depending model).
(e) Granules are pre-mixed and are applied directly without mixing in water.

2. Use proper equipment and containers

a) Liquids
a) Plastic measuring caps marked with tablespoon scales (or milliliters) and with handle
b) Measuring jugs for large volume spray mixtures.
b. Powders
a) Plastic measuring caps marked with tablespoon scales (or milliliters) and with handle.
b) Weighing scales for large volume spray mixtures.

3. Proper mixing procedure

a) Liquid concentrates – cam mix readily with water. The required amount can be poured directly into sprayer tank partly filed with water then filled with water to the correct level.
b) Wettable powders – wettable powders should be mixed first with a small amount of water to form a "creamy" state then poured into the sprayer tank. Water is then added to the correct level and then stirred well.
c) Ready to use products such as granules can be scooped from their packs into plastic buckets (container) for broadcast application.

4. Proper precautions to be observed while mixing and measuring

a. Do not fill sprayers to full. It may spill during use or while mounting knapsack sprayers to the applicator.
b. Do not mix spray volume in excess to what can be applied during the same day.
c) Avoid skin contamination. Wear recommended hand gloves during mixing.

d) Do not measure or mix herbicides in or near building where animals are kept.
e. Keep children and animals away.
f. Do not contaminate water supplies, water can, containers from which animal may drink.
g. Never use hands to scoop or stir herbicides spray mixtures
h. Use cleanest water available for diluting spray mixtures.
i. Handle wettable powders carefully to void "fluffing".
j. Keep herbicides in closed original containers.
k. Do not transfer liquid concentrates into empty softdrink bottles or other food containers.
l. Wash all measuring equipment after use.

5. Follow these procedures in case of herbicide spillage.

a. Wash contaminated skin with soap and water.
b. Remove immediately contaminated clothing and wash.
c. Keep people and animals way.
d. Do not smoke or light match near spillage
e. Use soil or sawdust to absorb liquids; sweep carefully and bury in a place away from wells and waterways.
f. Thoroughly wash down contaminated equipment.
g. Wear protective clothing during clean-up operations.

3.2.2 Safe guidelines during field application of herbicides

1. Cause of exposure due to faulty application equipment.

a) Use of leaky equipment.
b) Clogged nozzles
c) Faulty equipment

2. Precautionary measures during field application of herbicides

a. Wear appropriate protective clothing. Wearing a hat, face mask, long sleeved shirt and long pants made of cotton are recommended.
b. Do not spray during presence of strong winds. Do not spray against the wind to avoid inhalation of the spray droplets.
c. Never leave herbicide containers and equipment open and unattended in the field.
d. Do not blow clogged nozzles or hoses with your mouth.
e. Never eat, drink or smoke when mixing or applying herbicides.
f. Keep all people and animals away.
g. Do not allow children to apply herbicides.

h. Always have plenty of water available for washing.

3.3 Disposal Procedures

The following are recommended procedures and safety precautions to observe when disposing herbicide containers and leftovers:

1. Pesticide containers

a. Cartoons and papers – by burning
b. Glass bottles - by breaking and burying
c. Plastic/cans – to be punctured and buried
d. Pressurized containers – by burying. Bury these containers in a landfill at least 18 inches deep
e. Burn cardboard packing in open field away from dwelling and cropped areas. Do not stand in the smoke of such fires and keep people away.
f. Do not throw herbicide containers into rivers, streams and ponds.
g. Never empty herbicide containers for storing food, drinking water for human or animals.

2. Excess herbicide mixtures

a. Burying
b. Re-spray treated areas

3. Spills – to be absorbed in sawdust or soil and be buried.

3.4 Storage

Herbicides must always be stored under lock and key in a secure place, out of the reach of unauthorized people, children and animals. Storage area must be away from food or feed storage, stoves or lamps, or fires. Prevent deterioration of packaging materials and keep lid of bottles lightly closed. Do not put herbicides into drinking bottles or food container keep it in their original containers. Smoking, drinking or eating is forbidden inside the stock area. Put on protective clothing (groves, boots and eye protection) as recommended in the label when cleaning leaks or spillage of herbicides.

When handling herbicides, it is important to heed safety precautions. Always wear gloves and safety goggles while moving, pouring or otherwise handling herbicides. Wear protective clothing as possible, to limit exposure to the skin. Do not drink or smoke while handling herbicides. Once you finished using herbicides mixture, wash your hands. When discarding herbicides, make sure you follow environmental guidelines.

4.0 CONCLUSION

For safety of the farmer, his animals and the environment, herbicide safety precaution should be adhered to strictly. This will ensure the health of the farmer, animals and the ecosystem in general.

5.0 SUMMARY

Herbicide should be handle with care and should not be handled by unauthorized personnel. When handling herbicides, it is important to heed safety precautions and always wear protective cloths gloves, and goggles. Information on herbicide label should be adhered to strictly to avoid misuse of the product. The safety precaution includes safety before, during and after herbicide use. Always avoid contact with herbicide when spraying and incase of contact with skin apply a lot of water, and see a doctor.

6.0 TUTOR MARK ASSESSMENT

1. State 5 safety precaution during field application of herbicide.
2. Briefly explain storage and disposal of herbicide
3. State the causes of exposure due to faulty application equipment.

7.0 REFERENCES/FURTHER READING

Akobundu, I. O (1987). *Weed Science in the Tropics*. Principles and Practices. John Wiley and Sons Inc.

UNIT 7 HERBICIDE SELECTIVITY

CONTENTS

1.0 INTRODUCTION

The need to control weeds in field is very paramount and this would lead to increase in crop yield. However, there is need to be cautions on the type of herbicide applied on weeds because their responses to herbicide application varies. While some herbicide select weeds and kill them, some kill all the plants they some in contact with. This unit deals with herbicide selectivity by plants.

2.0 OBJECTIVES

At the end of the this unit, you should be able to:

- Explain herbicide selectivity
- State reason why selectivity occur in plant
- State the basis of herbicide selectivity.
- Explain herbicide selectivity on the basis of

i Plant characteristic.
ii. Relationship to herbicide properly

iii Time of herbicide application.

3.0 MAIN CONTENT

3.1 Herbicide selectivity

Herbicide selectivity vary in their actions, starting from those that will kill all plants come in contact with them (nonselective) to those that will kill certain plants (weeds) while leaving others (crops) unharmed. The ability of some herbicides to kill some plants but not others is known as herbicide selectivity. It is a measure of the differential response of several plant species to a herbicide, or the response of a given plant species growing in a particular habitat to different herbicides. Selectivity may occur because (a) the herbicide is exposed to a mixed vegetation cover and kills some of the plant species but not others in the same community; (b) the herbicide is placed in the vicinity of the plant in such a manner that it does not come into direct contact with those plant that escape injury; or (c) the action of the herbicide is inhibited in the plant by the presence of another chemical which is non-phytotoxic when used alone on plant. True selectivity requires that the herbicide cause no injury to the tolerant plant to which it has been exposed.

Some herbicide such as the phytoxyl carboxylic acid derivative, preferentially kill broadleaf weeds and not grasses; while other herbicides, such as the dinitroanilides, kill mainly grasses. Some other herbicides, such as paraquat and the urea herbicides, control mainly annual weeds when used at normal rates but do not control perennials. Herbicide selectivity is indeed a manifestation of the complex interactions between a plant, a herbicide and the environment in which the plant is growing. Many of the reasons for the various ways in which herbicide selectivity is manifestated in plants include plant factors, herbicide and soil factors, application techniques and type of equipment used in applying the herbicides.

3.2 Basis for herbicide selectivity

Selectivity to herbicides is achieved by: (a) the crop’s inherent ability to prevent the entry, movement and persistence of the herbicide within its internal system; (b) deliberate action by man to prevent contact between a crop and a herbicide achieved through physical manipulation of the crop, or the herbicide, or by taking advantage of environmental factors that affect herbicide action; (c) modifications in the crop’s genetic composition to confer resistance to the action of a herbicide; (d) the use of herbicide safeners to protect the crop from a herbicide to which it is otherwise susceptible; and (e) the crop’s lack of enzymes that can activate the herbicide to phytotoxic molecules.

3.2.1 Selectivity based on plant characteristics.

Plant characteristics that affect selectivity are age, morphology, uptake and transport of herbicides, biophysical and biochemical properties, and genetic make-up.

3.2.1.1 Age

Plant age affects herbicide uptake, translocation activity in plants, thus moderation herbicide selectivity. Young plants have susceptible to herbicides than are older plant, mainly because these young plants have more meristematic tissues than the older plants. Meristematic tissues are the centers of biological activities in plants. Consequently, herbicides that affect metabolic processes, such as nitrogen metabolism and other processes associated with carbohydrate utilization will be expected to be very toxic to plants that have lots of meristematic tissues while having reduced or no activity on older plants with fewer meristematic tissues. Thus, most preemergence herbicides kill seedling weeds but are ineffective on older plants.

3.2.1.2 Plant morphology

Plant morphology affects herbicide selectivity by its effects on herbicide retention, uptake and translocation. Some of the morphological differences exploited in selective weed control include differences in the degree of hairiness of leaf surfaces, leaf angle, location of the growing point, and anatomical differences between plant species. Plants with smooth leaf surfaces are readily wetted by aqueous spray solutions, while those with pubescent or waxy leaves are not, and many escape herbicide injury. *Adropogon* and *Hyparrhenia spp* are among tropical grasses with epicuticular waxes and hairs that make it difficult to wet their leaves. Many broadleaf weeds also have waxes and hairs that may reduce the retention of foliar-applied herbicides.

3.2.1.3 Herbicide uptake and transport

The uptake of soil-applied herbicides depends to a large extend on the distribution of plant roots in the soil. When plants with different rooming depths grow together in the same environment this provides an opportunity for selective weed control. Differences in rate of herbicide uptake affect selectivity. A preemergence herbicide that is not readily leached can be applied on the soil surface and moved into the top 5 cm of the topsoil by rainfall, where it will control the shallow-rooted annual weeds while the deeper-rooted crop escapes injury.

3.2.1.4 Biochemical properties

The biochemical properties of plants affect how much of the absorbed herbicide gets to site of action and also whether they reach this site in a concentration that is high enough for toxicity to be manifested. Plants vary in their ability to detoxify herbicides. Generally, resistant plants are able to detoxify the herbicide rapidly before it can exert its toxic effects on the plant. suceptible plant and block important metabolic processes (glyphosate), they may block photosynthesis (diuron) or respiration, or they may affect cell division (trifluralin. Herbivides may be adsorbed as relatively innocuous chemicals (2,4DB) and activated to deadly compounds (2,4-D) within susceptible plants. We also have different metabolism which is the ability of one plant to break down a herbicide more rapidly than another. It is the most common form of selectivity. Rapidly degradation of a herbicide can prevent it from reaching the target site at toxic concentrations. Other herbicides (atrazine) may be detoxified within some plants (com) while killing weeds which fail tometabolize the herbicide.

3.2.1.5 Genetic inheritance

Plant resistance to herbicides varies not only from one genus to another but also from species, and within cultivars in the same species. For example, atrazine at the low dose that will kill *Euphorbia hirta* has no effect on *Euphorbia heterophylla*, and some cultivars of cowpea such as Vitas 1 and 5 are resistant to alachlor while other cultivars such as Vita 4 are susceptible to that herbicide. Variations in crop sensitivity have also been reported in such other crops as maize, soybeans and other legumes, rice, sugarcane and yams. The genetic component of a plant determined the manner in which the plant responds to herbicide. Herbicide selectivity can be increased in crops by having the proper gene components to tolerate doses of herbicides that would otherwise adversely affect growth in other plants lacking that particular gene complement. An example of herbicide selectivity based on crop selection is the introduction of the soybeans cultivar Tracy M, which is more tolerant of higher levels of metribuzin than other soybean cultivars.

3.2.2 Selectivity in relation to herbicide properties

Many properties of a herbicide affect selectivity. This include: chemistry, stability of molecules, concentration, formulation, and placement in the crop-weed environment.

3.2.2.1 Chemistry

Herbicides vary in chemical structure from the simple molecules found in TCA to the highly complex molecule of a typical amide derivative. The nature of the molecule affects the mode of action of the herbicides and consequently herbicide selectivity. Some herbicides such as dinoseb and the birpiridyluims, have molecules so reactive that they kill virtually all the plant they contact. On the other hand, the molecule of a systemic herbicide must either possess enough water-solubility to move in the conducting vessels of a treated plant, or be capable in combining with other soluble substance in the plant that will carry to its site of action. Herbicides such as the benzoic and alphatic acids that do not have very reactive molecules are able to enter the living tissues of plants and be translocated to their site of action. The solubility of herbicide in water also affects its selectivity and use.

3.2.2.2 Stability of herbicide

Some herbicides, such as chloramben phenylureas, bipyridyliums, trifluralin and ioxynil, are prone to photodecomposition, either on the leaf or soil surface. In either situation the uptake and efficacy of the herbicide, and hence its selectivity, will be affected.

3.2.2.3 Concentration

Herbicides concentration is important in selective weed control. In cropping situations where crops are able to tolerate higher doses of some herbicides than weeds, selective weed control becomes the major weed control option to many farmers. Generally, herbicide selectivity is more pronounced at low to intermediate doses that at high herbicide doses. Virtually all selective herbicides lose their selectivity at every high dose.

3.2.2.4 Formulation

The main reason for formulating herbicides is to improve their uptake by plants. The efficacy of selective such as bentazon in maize is greatly improved by the addition of a surfactant to the spray solutions. An amine formulation of 2,4-D is virtually ineffective on such broadleaf weed as focus and because of the difficulty in wetting the pubescent leaves of these weeds, but the ester formulation of the same herbicidere controls them. Granular formulations of herbicides can be used in established crops for prermergence weed control, thus minimizing herbicides contact with the crop. The use of safeners is another development in herbicide formulation to increase herbicide selectivity and crop safety. Many herbicides formulated as combinations not only to increase the spectrum of weeds controlled, but also to increase crop

selectivity. For example, the introduction of the formulated mixture of atrazine and metalachlor (primextra) makes it possible to use atrazine at low rates in cassava without the danger of phytotoxicity that could occur if this herbicide is used alone at rates necessary to control weeds in this crop.

3.2.2.5 Herbicide placement.

The inherent toxicity of a herbicide determines where and how it is applied. Contact herbicides can be used for selective weed control, especially where cost of the operation makes the used of the contact fiebicide cheaper than of a herbicide selective in that crop. Whenever a nonselective herbicide is used for selective weed control the contact herbicide invariably has to be applied as a directed spray with or without a shield. Paraquat is often used as a directed spray for weed control in maize, legumes, root and tuber crops as well as in plantation crops.

3.2.3 Selectivity based on time of herbicide application.

The time of herbicide application has profound influence on selective weed control. A herbicide may be applied preplant incorporated, preemergence, and even late postemergence, to provide selective weed control in specific crops, the choice of a particular timing will depend on many considerations, including the mode of action of the herbicide as well as environmental conditions, type of weeds and the crops.

4.0 CONCLUSION

The knowledge of herbicide selectivity helps the former to know the type of herbicide to apply on crops/weeds field based on the plant characteristics, herbicide properties and time of application to achieve result.

5.0 SUMMARY

Herbicide selectivity is the ability of some herbicide to kill some plant weed but not other (crops). It is a measure of differential response of several plant species to herbicide. Selectivity can occur if.

- The herbicide is exposed to a mixed vegetation cover and kills some weed species but not others.
- The herbicide is placed in the vicinity of the plant in such a manner that it does not come in contact with those that escape injury.

- The action of the herbicide is inhibited in the plant by the presence of another chemical which is non-phytotoxic when used alone on plants.

Herbicide selectivity is based on plant characteristics, herbicide properties and time of application. Plant characteristics that affect selectivity are age, morphology, uptake and transport of herbicide, biochemical properties and genetic molecules while herbicide properties the affect selectivity include stability of molecules, concentration, formulation and placement in the crop-weed environment.

6.0 TUTOR MARK ASSESSMENT

1. List the plant characteristics that affect herbicide selectivity.
2. Explain herbicide selectivity base on time of application.
3. What is herbicide selectivity?

7.0 REFERENCES/FURTHER READING

Akobundu, I. O (1987). *Weed Science in the Tropics*. Principles and Practices John Wiley and Sons Inc.

UNIT 8 HERBICIDES PERFORMANCE ASSESSMENT

CONTENTS

1.0 INTRODUCTION

Herbicides are targeted to control weeds and are usually applied on the field of crops-weeds. The effectiveness of any herbicide depends on its concentration, formulation, nature of the plant, time of application, weed type and sprayer calibration. Herbicide performance or effectiveness is assessed to know whether it has killed the targeted weeds. This unit gives you an insight on how to assess the performance of herbicides when they are applied.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- Explain assessment of herbicide performance
- List factors affecting herbicide performance
- Know how to have an effective herbicide efficacy
- How to evaluate herbicide performance

3.0 MAIN CONTENT

3.1 Assessing herbicide performance

Understanding how different herbicide work is paramount when assessing herbicides performance. It is important to remember that the rate at which plants die after the application of herbicide depends on the product and rate applied as well as the weather conditions following application. For example, the effect of paraquat/diquat on weed can be observed shortly after spraying, with initial effects being observed within hours in bright sunlight and significant effects evident in a few days. Herbicides such as the sulfonylureas, however, are slower acting

and it may be up to 6 weeks after application before final assessments of their effectiveness can be made.

In addition, it is important to understand the 'claims' made by the herbicide manufacturer. Some products registered for the control of weeds do not claim to kill the weed but, competition against the crop.

Herbicide failures occur for numerous reasons, including application error, adverse environmental conditions, plant stress and herbicide resistance. Spray and paddock records play an integral role in the effective assessment of herbicide performance.

Evaluation the likelihood of application error by asking:

- Has the target weeds been accurately identified?
- What product was used, and was it a correct choice for the target weeds?
- Was the correct product rate used at the correct rates?
- Were appropriate adjuvant used at the correct rates?
- Did the product reach the target? Certain herbicides may be intercepted and bound
- To other plant material (e.g stubble) or soil and thus not reach the target weeds.
- Was the product measured accurately when making up the spray tank mix?
- Was the quality of the water used satisfactory? The performance of some pesticides is affected by water quality characteristics such as hardness, pH salinity and clay content.
- Was the water volume per hectare appropriate?
- Was the boom spray accurately calibrated?
- Were there equipment problems, e.g. blocked nozzles, erratic pump performance?
- Were the correct nozzles, pressure settings, boom height and boom speed used to achieve the desired uniform coverage?
- Were label directions regarding environmental spray conditions observed?
- What else was added to the tank mix? Some pesticide mixtures, while being physically compatible (i.e. can mix together), may be biologically incompatible. Biological incompatibility can result in reduced weed control and/or increased crop damage. Performance may also be reduced if insufficient time has been left between separate applications of antagonistic products.
- Was the tank solution mixed properly and was agitation adequate to keep it mixed?

Environmental factors or conditions at the time of spraying can influence the performance of herbicides. When assessing performance problems, good records of the conditions at the time of spraying are critical.

Herbicides labels provide some guidance as to desired conditions or, alternatively, conditions to avoid when spraying weeds. Unfortunately, due to the nature of weather, the number of 'ideal' spray days in a season is limited. Critical environmental factors to consider include:

- The time of day applied
- The presence of heavy dew
- The temperature at time of application and up to 10 days before or after application
- Clear skies versus heavy clouds/overcast conditions.
- Rainfall events, e.g. whether rainfall has occurred after application and fore the rain-fast period of the post-emergent herbicide has elapsed. Heavy rain shortly after use of soil-applied herbicides can move them into the crop root zone, increasing crop damage.
- Stressed weeds due to many factors, including: - too dry or wet or frosts before or after application, poor nutrition, disease or insect attack, competition from other weeds or the crop.
- Soil pH affecting herbicide availability to weeds /or to the crop
- Whether the product leached or was otherwise destroyed so that uptake by target weed was limited.

Once again, good records help determine the reason for herbicides failures. Their importance cannot be emphasized enough. If no reason can be found for a spray failure and herbicide application records indicate that resistance is likely, confirm suspicions and conduct some from of herbicide resistance test.

3.2 Factors affecting herbicide performance

A. Sprayer calibration

- Sprayer must be calibrated before applying herbicides to be able to apply the correct dosage
- Incorrect herbicide dosage may either cause crop injury or ineffective

B. Time of calibration

- Apply herbicide at the right time as prescribed in the label
- Pre-emergence herbicides should be applied before weeds have emerged
- Post-emergence herbicides should be applied after weeds have emerged
- Apply herbicides preferably early morning to avoid spray drift brought about by strong winds

C. Weed type

- Herbicides must target weed species or weed groups e.g. broadleaved weeds, grasses or sedges
- Herbicides designed to control broadleaved weeds will control only broadleaved weeds but not control grasses, similarly herbicides designed to control grasses will not control broadleaved weeds
- Some herbicides are designed to control the three types of weeds, however, there are still species within each group that cannot be controlled by the herbicide

D. Reaching the target plant

- Volatility of the herbicide product- the herbicide is easily lost by vaporization before it is absorbed by the plant
- Leaf properties- leaf may have thick waxy covering that prevent retention of the herbicide on the leaf surface
- Location of growing points is not reached by herbicide applied
- Water level in the field is too deep that weeds are not directly hit by spray solution.

4.0 CONCLUSION

Assessment of herbicide performance is very important in crop production so that the farmer would know whether the herbicides they applied were effective or not and this leads to either increase or decrease in production.

5.0 SUMMARY

Assessment of herbicide performance is to checking whether the herbicide applied has taken effect on the weeds or not. The factors affecting herbicide performance are sprayer calibration, time of application, weed type and reaching the target plant.

6.0 TUTOR MARKED ASSESSMENT

1. List the factors affecting herbicide performance
2. What is volatility

7.0 REFERENCES/FURTHER READING

Assessment of herbicide performance (2013). www.assessment of herbicide performance

MODULE 4 WEED CONTROL IN CROP AND NON CROP SITUATION

Unit 1 Weed control in crop situation
Unit 2 Weed control in non-crop situation

UNIT 1 WEED CONTROL IN CROP SITUATION

CONTENTS

1.0 INTRODUCTION

You have know about weed as unwanted plants, their characteristics which make them difficult to control, herbicide that can be use control weed as well as other measures of controlling weeds and the safety precautions to be taken before, during and after using herbicide. It is worthy to know that the application of herbicide in a crop situation is different from non crop situation since the crops are of importance to human and animals. This unit explains weed control in crop situation so that you know how to apply your herbicide to have effect on only weed and not your crops.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- know how to apply herbicide on different crop field
- method of application of herbicide in crop situation.
- know how to apply herbicide in rice field and the herbicide to use.

3.0 MAIN CONTENT

3.1 Weed Control in Crop Situation

Weed control in crop situation are control measures carried out on the field of crops when crops are planted on a field. Usually cultural biological, chemical and preventive weed control methods are applied on crop field in one stage or the other in the life of the crop (see weed control for details) cultural weed control applied in crop situation include tillage, burning, flooding, hand or hoe weeding while preventive weed control method include fallow management, sanitation measures quarantine etc. In chemical weed control were herbicides are used, they are applied at one or more distinct stages of the life of the crop. The stage s of application of herbicide in crop situation is:

1. **Pre-planting application:-** Application of herbicide to kill all vegetation on the field before any farming operation is carried out in the field e.g contact or non selective herbicide are applied e.g. glyphosate, paraquat, diquat.
2. **Pre-emergence application:-** Application of herbicide to kill germinating weed seeds e.g. alacglor, atrazine, diuron and metolachlor.
3. **Post emergence application:-** Application of herbicide to kill weeds and allow crops to grow. That is the principles of selectivity are applied here. E.g. of post emergence herbicide are 2,4-D bentazon, Otyzalin.

SELF-ASSESSMENT EXERCISE

i. State 3 stages of herbicide application in crop situation.
ii. Give 2 examples of herbicide used in each stage.

3:2 Weed control in rice

Herbicides are applied at one or more of three distinct stages of the life of the rice crop.

3.2.1 Pre-mergence

Herbicides are applied to the weeds a few days after seeding or before transplanting or within a week transplanting. Pre-emergence herbicide will not kill transplanted rice because they kill only germinating weed seed. E.g. bifenox 1.5-20kgaiha^{-1}

3.2.2 Post emergences

Herbicides are applied to the weed and rice usually 2-3 weeks after rice seedling emergence or after transplanting. The early post emergence herbicides are usually a mixture of herbicides that contain grass killer and a broadleaf killer e.g. monilate / MCPB mixture or a mixture of a selective contact herbicide with a pre-emergence herbicide e.g. propanil / flouridifen 3 – 5kg ai/ha and propane Oxadiazon mixture at the rate of 1.8-2:5 + 1.0 – 1.5kg ai/ha. This can be applied to all type of rice to control annual broadleaf weed and grasses.

3.2.3 Late Post Emergence

Herbicides are applied at about 2 months after seeding or transplanting. The late post emergence treatment generally consist of such foliar applied herbicide as pentagone at the rate of 1.5-3.0kg ai/ha, MCPA at 1.0 – 1.5 to dry seeded or wet seeded and 2,4-D (liquid) at 5.0 – 1.5kg ai/ha to all type of rice and 2,4-D (granules) at 0.5 – 1.0 to wet seeded and transplanted rice to control broadleaf and sedges.

4.0 CONCLUSION

The stages of application of herbicide in crop situation to control weed could be applied to all arable annual crop in the field at one or more of three distinct stages of life of the crop.

5.0 SUMMARY

Weed control in crop situation can bead lived through cultural, biological, preventive and preventive weed control. Herbicide can be applied to the crops in the field to control weeds as pre-planting application, pre-emergence application and post emergence application. In rice, weeds are control through application of herbicides as pre-emergence, early post emergence and late post emergence.

6.0 TUTOR MARK ASSESSMENT

1. Give the 3 methods of herbicide application in crop with one example each.
2. Explain weed control in rice.

7.0 REFERENCES/FURTHER READING

Akobundu, I. O (1987). *Weed Science in the Tropics*. Principles and Practices John Wiley and Sons Inc.

UNIT 2 WEED CONTROL IN NON-CROP SITUATION

CONTENTS

1.0 INTRODUCTION

In the last unit you studied weed control in crop situation using herbicides. Weed control in non crop situation takes different approach depending on what the land would be put to use after the weed control. In this unit you would study wed control in non crop situation.

2.0 OBJECTIVES

At the end of the unit, you should be able to:

- Explain weed control in non crop situation.
- State purposes for controlling weed in non-crop situation.

3.0 MAIN COURSE

3.1 WEED CONTROL IN NON-CROP SITUATION

This is the control of weed not for the purposes of growing crops. It is different from controlling weed in crop situation because no crop is at stalk. The purposes for non crop weed control could be.

i. For environmental sanitation.
ii. Control of breeding areas of pest insect and diseases which could affect crops, animal and human
iii. For clear visibility and easy movement in our high ways, rail way, airports and water ways.
iv. For construction purposes e.g. estate, industry, road, dams construction etc.

The methods applied in weed control in non crop situation depend on the type of weed, the area to be covered and their location (terrestrial or

aquatic). Cultural and chemical weed control method and be applied in controlling weed in a small area. For example in our home, hoe or hand weeding and herbicide are use to control weed. To enhance visibility and movement on our high way, railway airport slashing and heavy machines such as mover are used while for clearing of vegetation, weeds inclusive, for construction.

Purposes, bulldozers machines are used. The herbicide use in controlling weed in non crop situation is non selective herbicides.

SELF-ASSESSMENT EXERCISE

i. State 3 purposes of weed control in non crop situation.

4.0 CONCLUSION

When control for either crop or non crop situation is very important so as to keep our farm and environment free from pest, insects and disease as weed harbor them.

5.0 SUMMARY

Weed control in non crop situation is the control of weed for other purposes. These purposes could be for environmental sanitation, construction, visibility and easy movement etc. The method used for weeding control in non crop situation includes cultural and chemical method as well as the use of heavy machines such as mover and bulldozers.

6.0 TUTOR MARK ASSESSMENT

1. Explain the purposes for weed control in non weed situation.
2. State the methods used for weed control in non crop situation.

7.0 REFERENCES/FURTHER READING

Personal note on weed control on non weed situation