Integrated Weed Management

Introduction

An integrated weed management may be defined as the combination of two or more weed-control methods at low input levels to reduce weed competition in a given cropping system below the economical threshold level. It has proved to be a valuable concept in a few cases, though much is still to be done to extend it to the small farmers' level.

Integrated Weed Management (IWM) approach aims at minimizing the residue problem in plant, soil, air and water. An IWM involves the utilization of a combination of mechanical, chemical and cultural practices of weed management in a planned sequence, so designed as not to affect the ecosystem. The nature and intensity of the species to be controlled, the sequence of crops that are raised in the rotation, the standard of crop husbandry, and the ready and timely availability of any method and the economics of different weed-management techniques are some of the potent considerations that determine the success for the exploitation of the IWM approach.

Necessity for IWM

1. One method of weed control may be effective and economical in a situation and it may not be so in other situation.
2. No single herbicide is effective in controlling wide range of weed flora
3. Continuous use of same herbicide creates resistance in escaped weed flora or causes shift in the flora.
4. Continuous use of only one practice may result in some undesirable effects.
5. Only one method of weed control may lead to increase in population of particular weed species.
6. Indiscriminate herbicide use and its effects on the environment and human health.

Concept in IWM

Use a variety of technologies in a single weed management with the objective to produce optimum crop yield at a minimum cost taking in to consideration of ecological and socio-economic constraints under a given agro-ecosystem.
A system in which two or more methods are used to control a weeds. These methods may include cultural practices, natural enemies and selective herbicides.

FAO Definition
IWM is a method whereby all economically, ecologically and toxicologically justifiable methods are employed to keep the harmful organisms below the threshold level of economic damage, keeping in the foreground the conscious employment of natural limiting factors.

IWM is the rational use of direct and indirect control methods to provide cost-effective weed control.

Among the commonly suggested indirect methods are land preparation, water management, plant spacing, seed rate, cultivar use, and fertilizer application.
Direct methods include manual, cultural, mechanical and chemical methods of weed control.

There are more experimental evidence are available which shows that better weed control is achieved if different weed control practices are used in combination rather than if they are applied separately.

Good IWM should be

a. Flexible enough to incorporate innovations and practical experiences of local farmers.
b. Developed for the whole farm and not for just one or two fields and it should be extended to irrigation channels, road sides and other non-crop surroundings on the farm from where most weeds find their way in to the crop fields.
c. Economically viable and practically feasible.

Advantages of IWM

- It shifts the crop-weed competition in favour of crop
- Prevents weed shift towards perennial nature
- Prevents resistance of weeds to herbicides
- No danger of herbicide residue in soil or plant
- No environmental pollution
- Gives higher net return
- Suitable for high cropping intensity

Integrating Weed Management (IWM)
The following are the control methods that are applied as part of IWM.

Biological Control
Biological control, as it applies to weed management, is the use of plant-feeding insects, pathogens, or diseases that are host-specific to invasive weed species, with the intention of suppressing the weed's population.

Biological control does not intend to eradicate the target weed species, but instead is used to bring the plant into balance with the rest of the landscape. It is intended to be a cost-effective for the long- term solution of weed management.

It may take several years for biological control agents to establish, but once their populations begin to build-up to appropriate levels, they provide long-term suppression and reduce management costs significantly.

Leafy spurge, purple loosestrife, and spotted knapweed are all examples of invasive weed species where biological control is successfully being used in Minnesota.

Chemical control

Chemical control is the use of synthetic or naturally occurring compounds that are applied to invasive weed species with the intent of killing them. Chemicals (herbicides) range in selectivity to certain types of plants and their persistence within the environment.

Herbicides are typically applied in dry (granular) or liquid forms. Some types of herbicides are applied before weeds germinate (pre- emergent) and others are applied after germination (post emergent).

Chemical controls are usually short-term solutions to weed problems. In some cases, herbicides have to be reapplied annually and certain weed species can begin to develop resistance or tolerance to specific chemicals. Furthermore, large-scale applications can be expensive and detrimental to the environment. However, when herbicides are used on a selective basis or as part of an IWM program, they are a very useful tool for managing weed problems.

Mechanical Control

Mechanical control consists of using machines or other human-made tools to suppress weeds. Mowers, cultivators, saws, rakes, etc., are all examples of tools commonly used in mechanical weed management.

The use of hand tools to physically pull or destroy weeds can be a very successful approach to managing small infestations of weeds. However, hand tools alone are impractical on large-scale weed problems.

Mechanical controls like cultivating and mowing are generally used on larger populations of weeds to inhibit growth or reduce seeding. When used as part of an IWM program, targeted mechanical controls can play an important role in overall weed suppression.

Other Control Methods

There are other ways to manage weeds by altering landscapes through human intervention. Three good examples of this would be:

I. using fire through prescribed burns to promote healthy regrowth of prairies,
II. manipulation of water levels to promote healthy establishment of native wetland species, and
III. Multi-species grazing using combinations of livestock like sheep and goats that have developed a palette for noxious weeds.

In each case, weeds are managed via fire, flooding, or grazing resulting in increased native or desirable vegetative regrowth which increases competition for noxious or invasive plants, thus leading to healthier habitats.

So, the take-home message is that each type of weed control has its advantages and disadvantages. The goal of any noxious and invasive IWM program should be to combine the advantages of each control method to successfully suppress populations of undesirable plant species.

In most cases, successful IWM projects save money, reduce non- target impacts, protect natural resources, and provide more long-term sustained control than using any one management technique by itself.

Integrating Weed Management (IWM) In Agricultural Crops

The following five principles should be kept in mind when designing IWM programs that are effective at reducing the opportunities for agricultural weeds to establish and become problematic.

Some of them are:

- Prevention is key
- Increase natural weed mortality
- Don't feed the weeds
- Keep weeds off balance
- Use as many "little hammers" as possible

- Prevention is key

There is a need to limit seed introduction, production and dispersal. Preventing weeds from establishing in the first place is perhaps the most effective way to minimize weed problems in your crop fields.
Using certified seeds and cleaning farm equipment after use in an infested field are two simple sanitation practices that prevent weeds from entering or spreading through fields.

Removing weeds before they produce seeds, either through spot spraying, tillage or mowing, and collecting weed seeds in chaff wagons pulled behind the combine can also help reduce the spread of weeds within and among fields.

- Increase natural weed mortality.

There is a need to enhance the abundance and effectiveness of natural enemies of weeds. During the life cycle of a weed, many mortality factors threaten its survivorship.

Since it is unlikely that all weeds can be prevented from establishing in your fields, it is important to maximize the effectiveness of the mortality factors that exist naturally within your field.

For example, studies have shown that weed seeds that are not protected by burial in the soil are more prone to be destroyed by ground beetles, mice, fungi, bacteria or desiccation. Maximizing the magnitude and impact of these mortality factors can be an important component of a successful IWM program.

- Don't feed the weeds.

There is a need to maximize resource use by crops. Crops and weeds compete for the same basic resources: sunlight, nutrients, water and space.

A key component in the design of a successful IWM program is to make sure that these resources are captured by the crop and not by the weeds. Several practices can help ensure that your crops have the advantage.

- Apply fertilizer appropriately.

Banding fertilizer near the crop row and applying it at the appropriate time enhances the ability of a crop to compete with weeds.

For example, band placement of fertilizer in the root zone has been shown to increase early plant growth and grain yield, and decrease weedy grass populations. These effects are particularly pronounced in reduced tillage cropping systems.

- Adjust planting densities and row widths.

Decreasing row spacing and/or increasing seeding rates enhances the competitiveness of the crop relative to the weeds (particularly early in the growing season) so that fewer resources are available to support weed growth.

Research showed that wild oat seed production decreased as barley seed rate increased from 67 to 156 lbs/acre (75 to 175 kg/ha).

i. Keep weeds off balance

There is a need for not allowing the weeds adapt to your weed management practices. Using the same crop rotation over and over again generates predictable environmental conditions that are exploited by weeds.

For example, jointed goat grass thrives in winter wheat-fallow rotations because it has growth requirements that are very similar to winter wheat. Likewise, early germinating weeds such as wild oat can be found in early seeded cereals, and late germinating species such as pigweed can be a problem in late seeded canola.

ii. Use as many "little hammers" as possible to achieve maximum long-term weed management.

Conventional cropping systems tend to rely on one or two "large hammers", such as herbicides and tillage, for weed management. These practices provide short-term control of weeds.

Unfortunately, over the longer-term these "large hammers" are not entirely effective because weeds are able to adapt to their predictability.

Instead of a few large hammers, growers can employ multiple management practices (many little hammers), such as adjusting seeding rates, directed nutrient placement, crop rotation, and enhancement of natural weed mortality factors to manage weeds.

Example

Use Butachlor 2.5 l/ha or Thiobencarb 2.5 l/ha or Fluchoralin 2 l/ha or Pendimethalin 3 l/ha or Anilofos 1.25 l/ha as pre-emergence application followed by one hand weeding on 30-35 days after transplanting will have a broad spectrum of weed control in transplanted rice.

Weed management in vegetable crops

Traditional vegetable-growing areas are usually situated adjacent to waterways, flood plains, river deltas, marsh zones, and, if herbicides are used, their environmental impact and usage conditions must be taken into account. Another aspect related to the complexity of herbicide use is its soil persistence that can seriously affect the next crops in the rotation as a result of soil residues or carryover. Vegetable rotations are very fast and intensive in many places, and herbicide toxicity can affect the next crop if the cycle of the previous crop is short enough.

We have to consider all these aspects, as well as consumer concerns on the probable presence of pesticide residues in fruit, leaves and roots of these crops and the strict limitations for marketing and export that can invalidate the hard labour and endurance of many workers. Therefore, a careful use of herbicide is compulsory, and good field practices must be followed, especially when recognition of a labelled production is desired. There is a great interest in the integration of tilling practices with chemical control because of the reduction of the herbicide impact and the cost of hand-labour.

Seed beds

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

Stale seed beds

Stale ('false') seed beds are sometimes used for vegetables when other selective weed-control practices are limited or unavailable. Basically, this technique consists of the following:

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

Solarization

Soil solarization is a broad-spectrum control method, simple, economically feasible and environmentally friendly. It is an effective method for the control of many weeds. It does not affect soil properties and usually produces higher yields (Campiglia et al. 2000). There are also some disadvantages in its implementation. For example, previous irrigation is a requirement, (or frequent and abundant rain) and the soil must be kept solarized (non-producing) for a period of at least one month. Results are often variable, depending on weather conditions. Cold (high latitude) or cloudy places are usually not suitable for implementing solarization. Some species can tolerate solarization (e.g. deep rooted perennials: Sorghum halepense, Cyperus rotundus, Equisetum spp. and also some big weed seeds such as legumes).

The soil must be clean, surface-levelled and wet, previously to being covered with a thin (0,1-0,2 mm) transparent plastic sheet and very well sealed. The soil must be kept covered during the warmer and sunnier months (30-45 days). Soil temperatures must reach above 40° C to exert a good effect on weed seeds.

After solarization the plastic must be recovered, and the use of deep or mouldboard tillage must be avoided. This system is more suitable for small areas of vegetables, but it has been mechanized for extensive areas of tomatoes. Soil solarization is widely used under plastic greenhouse conditions.

Chemical control in seed beds

There are even less registered herbicides for seed beds than for planting crops. Herbicide treatments under plastic cover are always hazardous and careful application should be carried out. Under plastic, high levels of moisture and elevated temperature are common and plants grow very gently. Selectivity could be easily lost and phytotoxicity symptoms may occur, while sometimes they are just temporary. The effects are often erratic. The best way to deal with it is to be prudent and make some trials before a general treatment.

Selective pre-emergence and early post-emergence herbicides for vegetable seedbeds:

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

Crop rotation

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

- Alternating crops with a different type of vegetation: leaf crops (lettuce, spinach, cole), root crops (carrots, potatoes, radish), bulb crops (leeks, onion, garlic), fruit crops (squash, pepper, melon).
- Alternating grass and dicots, such as maize and vegetables.
- Alternating different crop cycles: winter cereals and summer vegetables.
- Avoiding succeeding crops of the same family: Apiaceae (celery, carrots), Solanaceae (potato, tomato).
- Alternating poor- (carrot, onion) and high-weed competitors (maize, potato).
- Avoiding problematic weeds in specific crops (e.g. Malvaceae in celery or carrots, parasitic and perennials in general).

Mixed cropping

Growing two or more crops at the same time and adjacent to one another is called mixed cropping, or intercropping. The advantages are a better use of space, light and other resources, a physical protection, a favourable thermal balance, better plant defence against some pests and fewer weed problems because the soil is better covered. Sometimes the results are less productive than cultivating just one crop alone. Some examples are:

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

- Maize + beans + squash
- Tomato + pigeon pea
- Sugar cane + onion, tomato.

Preventive measures

It is necessary to avoid the invasion of new species through the use of clean planting material and to prevent seed dispersal on the irrigation water, implements and machines. A written record of the weed situation in the fields is very useful. Another aspect is to impede perennial weed dispersal (or parasitic weeds) through the opportune use of treatments and tillage and the use of drainage tillage to prevent propagation of some species that need high moisture levels. It is also necessary to scout the field edges to prevent invasions.

Land preparation and tillage

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

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

Mulching material
The use of plastic mulching is very popular in many vegetable-growing areas. A non-transparent plastic is used to impede the transmission of photosynthetic radiation through the plastic to the weeds so that the development of weeds is then arrested.

Chemical weed control
The best approach to minimize inputs and to avoid any environmental problems is to apply herbicides in the crop row to a width of 10-30 cm. Many herbicides are effective in the control of perennial weeds. Sometimes a combination of two herbicides having a different weed-control spectrum may be used. Mixtures of different herbicide are possible to achieve better efficacy, but previous trials are necessary. Their foliar activity is enhanced by adding a non-ionic surfactant or adjuvant. The use of any herbicide in vegetables requires previous tests to verify its effectiveness in local conditions and selectivity to available crop cultivars.

In general pendimethalin 3.3 l/ha or Fluchloralin at 2 lit/ha or metolachlor 2 l/ha as pre-emergence herbicide is recommended for most of the vegetable crops, followed by one hand weeding 30 days after transplanting.

Selective herbicides for weed control in vegetable crops:

Herbicide	Dose kg a.i./ha	Treatment moment	Crops
Alachlor	2.4	Post emergence	Brassica crops, onion
Ethalfluralin	0.8-1.7	Pre Plantation	Tomato, pepper, beans, squash
Linuron	0.50-1.25	Pre emergence	Carrot, artichoke, asparagus, faba bean
Metribuzin	0.10-0.35	Pre/Post emergence	Tomato, carrots, peas
Oxifluorfen	0.36-0.48	Pre/Post emergence	Onion, garlic, cole crops
Oxifluorfen	0.24-0.48	Pre Plantation	Tomato, pepper
Pendimethalin	1.32-1.65	Pre Plantation / pre-plant incorporated	Artichoke, cole, lettuce, leek, pepper, tomato, onion, green peas
Rimsulfuron	7.5-15(g)	Post emergence	Tomato

Trifluralin	0.59-1.44	pre-plant incorporated	Beans, carrots, celery, cole crops, artichoke, onion, pepper, tomato

Hand weeding

Apart from chemical weeding, one hand weeding is done 30 days after transplanting.

Biological control

Myco-herbicides are a preparation containing pathogenic spores applied as a spray with standard herbicide application equipment. Eg: a weevil for the aquatic weed salvinia, rust for skeleton weed, and a caterpillar (Cactoblastis sp.) to control prickly pear.

Integrating Weed Management (IWM) In Horticultural Crops

Horticultural crops are increasingly becoming very important in Indian economy. Weeds are a major problem to horticultural production as they take advantage of their initial slow growth rate.

Weeds reduce crop yields, lower their quality, act as alternate host of many pests/diseases and also have allopathic effects on crops.

Weeds also interfere with vital farm operations like weeding, fertilizer application, herbicide application and harvesting.

Both annual and perennial weeds are common in their actions. Farmers in India mostly employ biological, cultural and chemical methods in controlling weeds on their farms. To achieve success in weed management in Nigeria for increased yields and quality, there is therefore the need for an integrated weed management in horticultural production.
Weed management requires a multifaceted approach, built upon an understanding of weeds and the crop. Weed management may involve non-chemical methods, chemical methods or a combination of the two.

The major aim is to manage the weed population to a level below that will cause a reduction in economic return for the farmer. The decision on which method to be used depends on the environmental conditions, available labor, weed population, the crop, desired management technique and the cost of controlling weeds.

Conclusion

In this session, we have discussed about Integrating Weed Management (IWM) concept and its definition, Integrating Weed Management (IWM) in Agricultural Crops and Horticultural Crops.

In nutshell, IWM is a method whereby all economically, ecologically and toxicologically justifiable methods are employed to keep the harmful organisms below the threshold level of economic damage, keeping in the foreground the conscious employment of natural limiting factors.

IWM is the rational use of direct and indirect control methods to provide cost-effective weed control.

Every farm needs to be evaluated on an individual basis to determine the most efficient and economical weed control programme. Farmers need to look ahead and plan their weed control programmes for as long as practical.

In order to develop an integrated weed management programme, it is necessary to think strategically about how best to utilize all available weed control methods. This is needed in combination to give the best overall result for each crop and each rotation by developing a checklist of options as a useful tool for farmers.