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Integrated Weed Management strategies in Himachal Pradesh

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Introduction

Integrated weed management (IWM) involves the concept of multiple tactics of weed management, maintenance of weed population below economic injury level and conservation of environmental quality. A successful IWM strategy has the principle of enhancing farmers' profitability, environmental protection and responsiveness to consumer preference.

Description of a Weed

There are numerous definitions of a weed, including:

- a plant out of place and not intentionally sown
- a plant growing where it is not wanted
- a plant whose virtues have not yet been discovered. (R.W.Emerson)
- plants that are competitive, persistent, pernicious, and interfere negatively with human activity (Ross, et. al.) and many others

No matter what definition is used, weeds are planting whose undesirable qualities outweigh their good points, according to man. Our human activities create weed problems since no plant is a "weed" in nature. Though we may try to manipulate nature for our own good, nature is persistent. Through the manipulation process, certain weeds are controlled, while, other more serious weeds may thrive because favorable growing conditions for them also have been meet. Weeds are naturally strong competitors and those weeds that can best compete always tend to dominate. Both humans and nature are involved in plant breeding programs. The main difference between the two programs is that man breeds plants for yield, while nature breeds plants for survival.

Characteristics of weeds

Certain characteristics are associated with and allow the survival of weeds. Weeds posses one or more of the following:

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- Abundant seed production
- Rapid population establishment
- Seed dormancy
- Long-term survival of buried seed
- Adaptation for spread
- Presence of vegetative reproductive structures
- Ability to occupy sites disturbed by human activities.

There are approximately 250,000 species of plants worldwide; of those, about 3% or 8000 species behave as weeds. Weeds are troublesome in many ways. Primarily, they reduce crop yield by competing for water, light, soil nutrients, and space. Other problems associated with weeds in agriculture include:

- reduced crop quality by contaminating the commodity
- interference with harvest
- serve as hosts for crop diseases or provide shelter for insects to overwinter;
- limit the choice of crop rotation sequences and cultural practices
- production of chemical substances which are toxic to crop plants (allelopathy), animals, or humans.

Costs of weeds

Weeds are common on all 485 million acres of U.S. cropland and almost one billion acres of range and pasture. Since weeds are so common, people generally do not understand their economic impact on crop losses and control costs. In 1991, the estimated average annual monetary loss caused by weeds with current control strategies in the 46 crops grown in the United States was $4.1 billion. If herbicides were not used, this loss was estimated to be $19.6 billion. Losses in field crops accounted for 82% of this total (Bridges; WSSA, 1992).

Another source estimates that U.S. farmers annually spend $3.6 billion on chemical weed control and $2.6 billion for cultural and other methods of control. The total cost of weeds in the United States could approach $15 to $20 billion dollars (Ashton and Monaco, 1991). Also, weed control and other input costs (e.g., seed, fertilizer, other pesticides, fuel) vary with the crop. For example, in the mid-90s, herbicides for soybeans cost $30/acre or about 47% of the $63/acre in total purchased input. For corn, the cost was $32/acre or about 28% of the $114/acre in total purchased input. And for wheat it was $6 or about 6%

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of the total $96/acre inputs. Several factors help determine the relative costs of herbicides from one crop to another and include the competitive ability of the crop, the weeds present, the contribution of non-chemical control practices, the tillage method, management decisions, and the value of the crop. (Ross and Lembi, 1999)

Benefits of weeds

Despite the negative impacts of weeds, some plants usually thought of as weeds may actually provide some benefits. Some attributes include:

- Soil stabilization;
- Habitat and feed for wildlife,
- Nectar for bees;
- Aesthetic qualities;
- Add organic matter;
- Provide genetic reservoir;
- Human consumption; and
- Provide employment opportunities.

Weeds have a controversial nature. But to the agriculturist, they are plants that need to be controlled, in an economical and practical way, in order to produce food, feed, and fiber for humans and animals. In this context, the negative impacts of weeds indirectly affect all living beings.

Weeds vary so much in their growth habit and life cycle under different ecosystems and growing seasons that no single method of weed management can provide effective weed control. Continuous use of one method of weed control creates problems of buildup of weeds that are tolerant to that particular method of weed control. Similarly, shift in weed flora from annual grasses to sedges and appearance of resistant biotypes due to continuous use of some herbicides has been reported. Long term strategy to minimize weed problem is through IWM than with weed control. Major components of IWM include:

- Monitoring weeds, shifts in weed flora, appearance of resistant weeds and introduction of new weeds,
- Emphasis on ecological, biological and biotechnological methods of environmental safety, and
- Low cost agronomic strategy for weed management in IWM systems

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- Stale seedbed,
- Balanced fertilizer use,
- Higher plant population,
- Intercropping / relay cropping, and
- Use of competitive cultivars,
- Supplement herbicide use at minimum possible rate.

Ecological management

Ecological management (cultural management) aims by attacking ecological weak points of weeds during field operations such as ploughing, water management, crop season, crop rotation, intercropping etc.Ploughing is usually done at optimum soil moisture content by which time the weeds seeds start emerging. Hence emerging weed seedlings are buried or exposed to hot Sun for drying in perennial we eds, ploughing is effective to control emergence whose propagules are formed at relatively shallow position within soil. Intensive puddling is very effective for weed control in lowland rice.

Water management practices are very effective for weed control especially in lowland rice. Continuous land submergence beyond 5cm depth for rice is very effective against several weeds and can substitute for weed control. Lowland rice crop rotation with an upland crop is effective against moisture loving weeds. The population of scirpus maritimus and echinochloa increases with continuous cropping of lowland rice but decline when rice is rotated with and upland crop. Similarly, population of celosia Argentina increases due to continuous growing of short saturated crops such as groundnut but decreases considerably when rotated with tall crops such as sorghum, maize, pearl millet etc.

Biological management:

Biological weed control using insects, pathogens, fish and snails (bio agents) appears to be ideal for reducing the inputs of herbicides. Some promising examples include:

Weed Biocontrol agent

Alternanthera philozeroid Cassida sp.

Salvania molesta Paulinia acuiminata (insect) and *Myrothecium rovidium* (fungus)

Eichhornia crossipes Alternaria eichhornia (pathogen) and *Neochetina bruchi* (insect)

Cyperus rotundus Bactra minima (insect) and *Athespacuta cyperi* (weevil)

Use of Maxican beeitle (Zygograma bicolorata) in Parthenium

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Bio herbicides:

Although herbicides are effective for weed control, there has been increasing concern about their safety for food products, their adverse effect on environment and widespread weed resistance to herbicides. These factors along with rising prohibitive costs have provided the impetus to develop alternative weed management strategies. In this contest, biological control has an alternative or supplement weed management appears to play a major role in crop production. Biological approach includes bio control agents such as insects, nematodes, fungi and bacteria as well as plant-based chemicals that exhibit herbicidal properties. A bio-herbicide is a plant pathogen use for weed control through application of its inoculums.

Bio-technology in weed control

The microbial toxins and allelochemicals could be manipulated to produce commercial herbicides. Bioherbicides Collego and Biopolaris are used for controlling grass and broad-leaved weeds in rice. In India, bioherbicides for weed control have not yet developed to the extent of practical application.

Agronomic practices

Agronomic measures necessary for higher yields are at the same time are directed at preventing mass multiplication of weeds.

Stale seed bed

It involves the removal of successive flushes of weeds before sowing a crop. Weeds that germinate after land preparation are destroyed mechanically, manually or chemically. In mechanical or manual method, soil disturbance should be as shallow as possible.

Crop stand

Closure the spacing or higher the seed rate, better the crop can compete with weeds due to its smothering effect on weeds.

Nutrient management

Nutrient application should be timed to prevent weed proliferation and yet to obtain maximum benefit from the applied nutrient.

Intercropping and Relay cropping

Intercropping upland rice with groundnut, soybean, or green gram minimizes weed density leading to yield advantage. A pulse crop is usually broadcast as relay crop into standing

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rice crop 10-15 days before harvest. As soon as rice crop is harvested the pulse crop cover the field in dry season and suppress the weed growth.

Cultivars

High yielding cultivars are less competitive against weeds than traditional cultivars. For rainfed areas, heavy tillering varieties of medium stature may be better suited than semi-dwarf varieties.

Herbicides

Non chemical methods of weed control when integrated with one manual weeding are as effective as standard rice herbicides at different ecosystems throughout the country.

Integrated weed management in different crops

- Study on IWM under Palampur conditions has shown that intercropping of soybean with maize (1:1), 75000 maize plants per hectare with 25% higher than recommended fertilizer and application of Lasso @3 l/ha or Pendimethalin 1.5 kg/ha as pre-emergence gave effective control of weeds. In case chemicals are not available, substitute with one weeding within 30 days of sowing.
- Integration of adequate density of crop plants by drilling or line planting at proper row spacing, timely fertilizer application and water management practices can reduce the crop weed competition in rice.
- Mechanical/physical weed control: Use of cono and rotary weeder in rice
- Growing wheat in closer rows with 15 cm spacing or cross row sowing at 22 cm with half of the seed and fertilizer distributed ion each direction resulted in decreased number of *Phalaris minor* and wild oat plants which can be controlled using 0.75kg/ha Iso prouron as post emergence.
- Stale seed bed preparation before the sowing of Kharif crops.

Conclusion

A framework for Integrated Weed Management (IWM) in wheat should consider the whole life cycle from emergence to seed production. An IWM strategy should aim at minimizing one or more of the following: weed establishment, weed competition, and seed production/production of vegetative organs. As highlighted in this review a number of weed management tools are available to the farmers, but most of them are not as effective or reliable as herbicides (Lutman et al., 2013) and need to be combined into a strategy and IWM has

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therefore been referred to as the "many little hammers" (Liebman and Gallandt, 1997). Some weed management options like mechanical weeding may be more expensive than chemical control, which needs to be balanced against the potential long-term benefits of more sustainable IWM strategies. Moreover, IWM is more knowledge intensive than chemical weed control and will require understanding of the biological processes in the field (Swanton and Weise, 1991), and unfortunately, IWM has not received much attention in the scientific literature where papers on "weed control" outnumber the one on "IWM" by 14 to 1 (Harker and O'Donovan, 2013).

Future IWM strategies need to be context specific considering the different cropping conditions in the different parts of the world. IWM tools that are suitable for more humid conditions like cover crops may not be suitable for more dry conditions where water conservation is of high priority. Adopting IWM will often lead to a reduction in herbicide use (Bürger et al., 2012; Chikowo et al., 2009) but from a point view of weed management sustainability, preventing weed resistance and weed population shifts, a reduced reliance on herbicides is more important than a reduction in the amount of herbicide applied. From an environmental point of view a reduction in herbicide use may be beneficial, but very few studies have explored this aspect. Deytieux et al. (2012) using a life cycle assessment approach concluded that most environmental indicators were improved in IWM-based systems when expressed per unit cultivated area; however, the ranking changed when evaluated per unit harvested agricultural goods reflecting a lower productivity of some IWM systems.A number of genes have been employed for the generation of genetically-modified crops possessing tolerance to herbicides in an effort promote crop growth and discourage the growth of competing plants such as weeds. Herbicide-resistant genes are also invaluable for use as selectable markers in the genetic transformation of plants. The majority of herbicide-resistant genes are derived from soil bacteria such as Agrobacterium and Streptomyces, organisms which have never been utilized as ingredients in products for human consumption. With respect to the use of plant-derived genes for herbicide tolerance, attention may be paid in order to facilitate public awareness and acceptance of the technologies involved.

References:

Bürger, A. Günther, F. de Mol, B. Gerowitt. Analysing the influence of crop management on pesticide use intensity while controlling for external sources of variability with linear mixed effects models Agric. Syst., 111 (2012), pp. 13-22

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C.J. Swanton, S.F. Weise. Integrated weed management: the rationale and approach Weed Technol., 5 (1991), pp. 657-663

K.N. Harker, J.T. O'Donovan. Recent weed control, weed management and integrated weed management Weed Technol., 27 (2013), pp. 1-11

M. Liebman, C.L. Mohler, C.P. Staver. Ecological Management of Agricultural Weeds Cambridge University Press, Cambridge (2001)

P.J.W. Lutman, S.R. Moss, S. Cook, S.J. Welham A review of the effects of crop agronomy on the management of *Alopecurus myosuroides* Weed Res., 53 (2013), pp. 299-313.

V. Deytieux, T. Nemecek, R.F. Knuchel, G. Gaillard, N.M. Numier-Jolain. Is Integrated weed management efficient for reducing environmental impacts of cropping systems? A case study based on life cycle assessment Eur. J. Agron., 36 (2012), pp. 55-65