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Weed Management in Wheat

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ABSTRACT: Weed infestation is one of the major biotic constraints in wheat production. Wheat is infested with diverse type of weed flora, as it is grown under diverse agroclimatic conditions, different cropping sequence, tillage and irrigation regimes. The yield losses due to weeds vary depending on the weed species, their density and environmental factors. Among weeds, *Phalaris minor* Retz. is single most dominant grassy weed in northern Indian plains causing significant yield losses. For controlling weeds in wheat, growers mostly rely on herbicides due to cost and time effectiveness. For control of diverse weed flora in wheat combination of herbicides either as tank mixture, if compatible (sulfosulfuron + metsulfuron; mesosulfuron + iodosulfuron) or as sequential, if not compatible (fenoxaprop or clodinafop or pinoxaden with metsulfuron or 2, 4-D) are required. Further, the herbicide efficacy can be improved by use of adjuvants, safeners and proper spray technology. A greater focus on spray technology by imparting training to growers, field functionaries and industry personnel is required.

However, sole dependence on herbicides is also not desirable as it contributes to shift towards difficult-to-control weeds and the rapid evolution of herbicide resistance, which is a threat for sustainable wheat production. Presently some of *P. minor* populations have shown the evolution of multiple herbicide resistance across three modes of action (Photosynthesis at photosystem II site A, ACCase and ALS inhibitor). Studies on the quantification and characterization of herbicide resistance in *P. minor* have revealed that some of the populations had GR50 (50% growth reduction) values for clodinafop > 12 times greater than that of the most S (susceptible) population. Population resistant to clodinafop exhibited cross-resistance to fenoxaprop (fop group), tralkoxydim (dim group) and pinoxaden (den group). Similarly, population resistant to sulfosulfuron showed cross-resistance to mesosulfuron and pyroxulam. Management strategies must be developed to prevent selection and spread of herbicide resistant populations. For control of multiple herbicide resistant *P. minor* populations (resistant to isoproturon, clodinafop and sulfosulfuron) pendimethalin, trifluralin, pyroxasulfone, metribuzin and terbutryn are effective. Also, the multiple herbicide resistant populations showed sensitivity to glyphosate and paraquat. However, for efficient weed management, the non-chemical weed management tactics should be adopted in conjunction with chemicals (like herbicide mixture and rotation, optimum spray time, dose and methods). Some of the non-chemical agronomic strategies like tillage, sowing time, sowing methods, competitive crop cultivars, higher crop density, closer spacing, irrigation, fertilization, crop rotation and sanitation practices (weed-free crop seeds and manure) can be adjusted and adopted in such a manner that they provide the competitive edge to the crop over weeds. As the introduction of herbicide having new mode of action has slowed down, therefore, there is need to revive some of the old herbicides (viz. pendimethalin and trifluralin) as well as to develop wheat varieties tolerant to less selective herbicides like metribuzin and resistant to non-selective herbicides like glyphosate and glufosinate. Integration of knowledge of weed biology and non-chemical methods of weed control with chemical methods will help in increasing the life of existing herbicides and make the weed management cost-effective and efficient.

KEYWORDS: wheat, weed, management, crop, herbicides, integrated, pest, tolerant, biocontrol

International Journal of Innovative Research in Science, Engineering and Technology

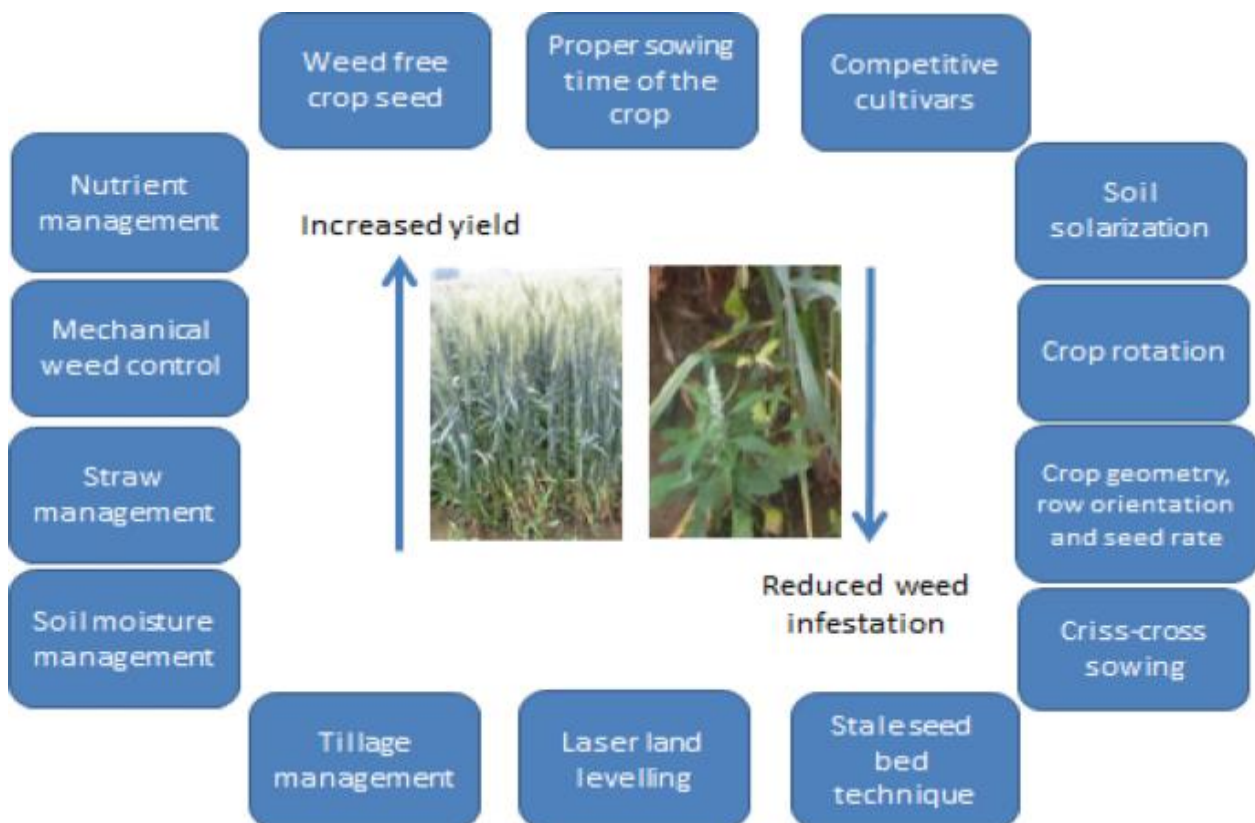
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Vol. 7, Issue 1, January 2018

I. INTRODUCTION

Since ancient times, the cultivation of wheat (*Triticum aestivum* L.) has played an important role in sustaining humans. Together with barley (*Hordeum vulgare* L.), wheat constituted the principal grain stock that founded Neolithic agriculture, allowing the establishment of permanent human settlements; a major milestone in the development of civilisation as we know it (2). Today, wheat is grown on approximately 220 million hectares globally (3), with a global harvest forecast of 732 million tonnes of wheat in 2016 (1).



Key reasons for the importance of wheat in the diet of humans include its agronomic adaptability, properties of the grain including its nutritional profile, ease of storage and transport, and ready conversion into flour (2,3). It was reported that, at the global level, wheat contributes about 20% of humans' daily dietary calorie intake, compared with rice (19%), and maize (*Zea mays* L.) (5%). Wheat is also the world's most important protein source, and provides about 21% of humans' daily dietary protein intake. Dependence on wheat as the main source of cereal calories and proteins is highest in Central Asia (89 and 91%), followed by Eastern Europe and Russia (81 and 84%), Australia (78 and 85%), West Asia (78 and 84%), North America (73 and 80%), and North Africa (66 and 71%) (4).

Weeds have a direct impact on the productivity of wheat systems, including costs of labour, equipment, chemicals and other management inputs. Weeds also impact wheat production indirectly, by competing with the crop for resources, harbouring crop pests, interfering with water management, reducing the grain yield and quality, and increasing the cost of processing (5). While estimates may vary between regions and seasons, literature from around the world conveys a clear message – weeds cost agriculture a great deal of money, and this is inevitably reflected in the price of food (6).

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Vol. 7, Issue 1, January 2018

Without effective control practices in wheat, yield loss due to weeds has the potential to overshadow that of pest animals (arthropods, nematodes, rodents, birds, slugs and snails), pathogens (fungi and bacteria) and viruses (6).



Since the first herbicides were released (1947), chemical weed control has had a major impact on world agriculture (7). Herbicides control weeds effectively, with reduced damage to soil structure, increased water conservation, lower fuel costs, and decreased greenhouse gas emissions compared with conventional tillage (7). Importantly, herbicide use also has low labour requirements (6,7). Historically, in the wake of industrialisation there has been migration of people from rural to urban areas, followed by labour shortages and increased herbicide adoption (7). This pattern is now being repeated throughout Asia, (8).

Herbicides are not, however, a complete solution to the complex challenge that weeds present (4). Herbicide-resistant weed populations are evolving rapidly as a natural response to selection pressure imposed by modern agricultural management activities (6). Herbicide-resistant weeds first became a problem in the USA and Europe in the 1970s (6). Today, the International Survey of Herbicide Resistant Weeds summarises the facts as follows: 471 unique cases (species x site of action) of herbicide-resistant weeds globally; resistance documented in 86 crops in 66 countries; 250 herbicide-resistant species (144 dicots and 105 monocots); resistance to 23 of the 26 known herbicide sites of action; and resistance to 160 different herbicides (International Survey of Herbicide Resistant Weeds, 2016). The discovery of new herbicide options is becoming increasingly rare, due in a large part to mounting regulatory and economic pressures on the agro-chemical industry, and the difficulty of identifying suitable chemical 'safeners' (or protectants) to prevent herbicidal injury to crop plants (7).

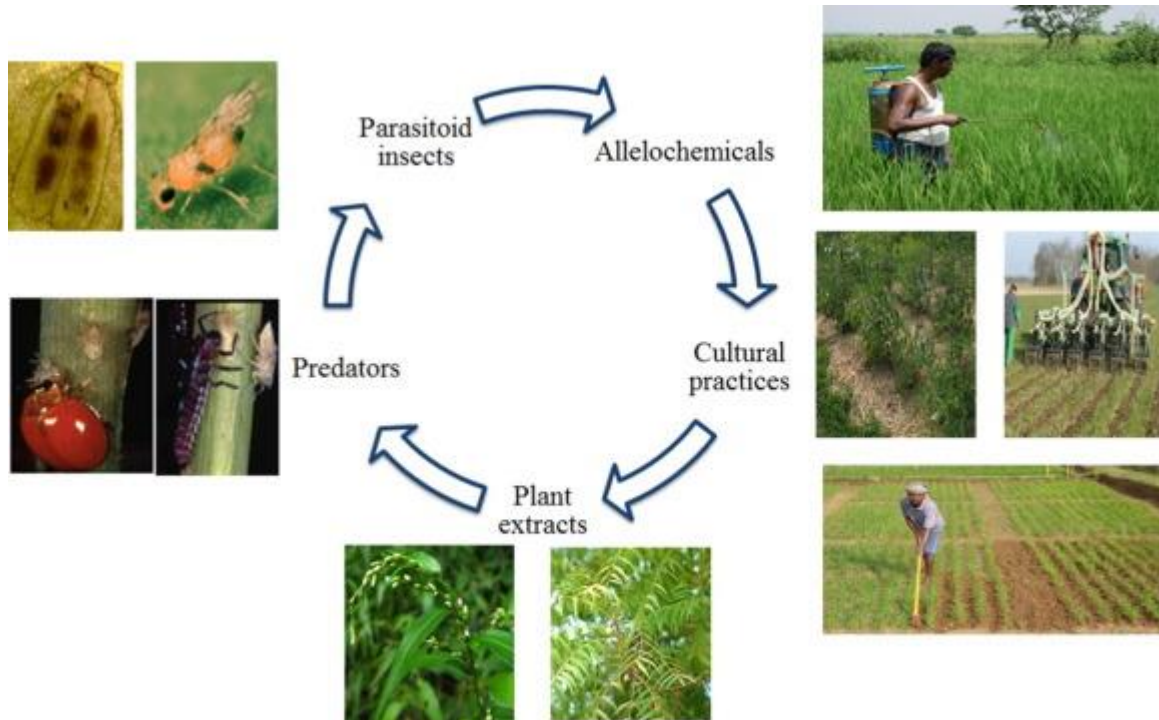
Acknowledgment of the threat posed by herbicide resistance has prompted calls for a new paradigm of weed control in large-scale crop production systems (7). Additionally, there is increasing concern over the impact of herbicides on non-target organisms, including humans and organisms considered critical to ecosystem function .

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Vol. 7, Issue 1, January 2018



One concept that is gaining increasing attention is that of developing cropping systems in which crops themselves are better able to compete with weeds (8). Recognition of the role of crop competitiveness in weed suppression is not new but during the last 15 years, crop competitiveness has increasingly become the target of dedicated research – largely prompted by the rapid acceleration of herbicide resistance. In cereals, the use of crop competition is now considered an important and cost-effective tactic for enhancing weed suppression and optimising crop yield (8), and has also been flagged as a key area for future weed management research (9). In this article, the potential for managing weeds using crop competition will be explored through a review of world literature, with specific reference to wheat. The review is structured under the following headings: a) Weed-competitive cultivars, including allelopathy; and b) Planting strategies, including planting density (sowing rate), row spacing, crop orientation, and sowing pattern. As this is a global review of crop competition for weed management, every attempt has been made to include studies conducted in wheat growing countries around the world, to gain insights into the use of crop competition over a wide range of wheat-growing environments.

II. DISCUSSION

Weed control is important, because weeds can:

- rob the soil of valuable stored moisture
- rob the soil of nutrients
- cause issues at sowing time, restricting access for planting rigs (especially vinetype weeds such as melons, tarvine or bindweed, which wrap around tines)
- cause problems at harvest
- increase moisture levels of the grain sample (green weeds)
- contaminate the sample
- prevent some crops being grown where in-crop herbicide options are limited, i.e. broadleaf crops
- be toxic to stock

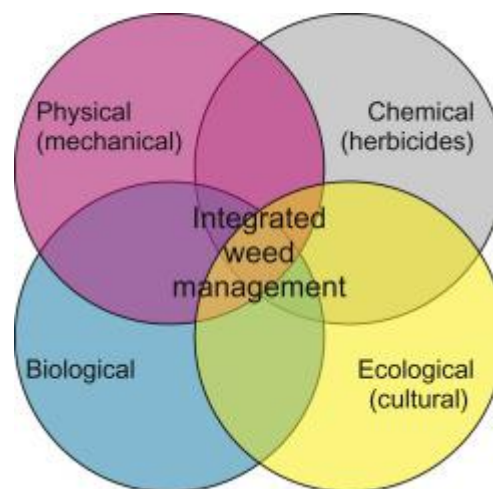
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Vol. 7, Issue 1, January 2018

- carry disease
- host insects



Weeds may be controlled through cultural, mechanical, and chemical means. Judicious use of these methods individually or in combination can manage weeds effectively without causing economic loss or environmental harm. Choose the proper management strategy according to the target weed(s) and the infestation level. The type of crop will play a major role in determining the timing of mechanical measures. (10)

- Use weed-free seed to protect against weed infestations.
- Thoroughly clean the harvesting equipment before moving from one field to the next, and require custom harvesters to clean their equipment before entering the field.
- In conventional tillage systems, use mechanical tillage or preplant burndown herbicides to remove initial weed flushes before planting. This will reduce or eliminate the potential for continued infestation.
- Rotate crops that physically outcompete certain weeds, resulting in their gradual decline. Remove light or spotty infestations of weeds by hand hoeing or spot cultivation to prevent weed seed production and the spread of rhizomes or roots. When plowing perennial weeds, take care to prevent the transport and spread of plant parts to other areas of the field.

For fields in wheat production, plant certified seed to avoid spreading ryegrass to non-infested fields. Also, thoroughly clean the tillage and harvesting equipment before moving from ryegrass-infested fields. Several herbicide products are available to control ALS and ACC-ase resistant ryegrass at different points in the season:

International Journal of Innovative Research in Science, Engineering and Technology

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Visit: www.ijirset.com

Vol. 7, Issue 1, January 2018



- Before planting, a burndown application of Roundup (glyphosate) or Gramoxone (paraquat) can control emerged ryegrass.
- Between spiking and the 2-leaf stage, Axiom DF (flufenacet + metribuzin) can be applied to wheat to provide residual control of ryegrass. (11)
- At delayed preemergence or early postemergence, Zidua (pyroxasulfone) and Anthem Flex (pyroxasulfone + carfentrazone) provides residual control. Note: the addition of metribuzin is needed if ryegrass has emerged at the time of application
- From the first leaf stage of wheat until the flag leaf is visible, apply Prowl H2O (pendimethalin) for some residual control or suppression of ryegrass.
- Between the 2-leaf stage and pre-boot, control with Axial XL* (pinoxaden)

*Note: Axial XL will NOT control ryegrass biotypes resistant to ACC-ase herbicides.

Spray Isoproturon 800 g/ha as pre-emergence spraying 3 days after sowing followed by one hand weeding on 35th day after sowing.

If herbicide is not applied, give two hand weedings on 20th and 35th day after sowing.

Critical period of weed control	15 – 30 DAS
Cultural method	a) Hand b) Inter c) Criss-cross sowing Hoing cultivation
Chemical method	<ul style="list-style-type: none"> • 2, 4D (1 – 1.5 kg ai/ha) • MCPA (1 – 1.5 kg ai/ha) dissolved in 700 – 800 litres applied at 25 – 30 DAS Efficiency can be increased by mixing urea@ 3% • Mixture of Isoproturon (0.75 kg ai/ha) and 2, 4D (0.4 kg ai/ha) during 30-35 DAS
Remarks	<p>II. Complimentary weed control methods</p> <ul style="list-style-type: none"> • Cultivars • Seedling age /planting method • Fertilizer management • Cropping system

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 7, Issue 1, January 2018

Biological methods of weed control

1. Bioagent like insects, pathogen etc., and other animals are used to control weeds.
2. Insect and pathogens infest weeds and they either reduce growth or kill weeds.
3. Biological control method can reduce weeds but it is not possible to eradicate weeds.

Examples of Biological Weed Control

Bioagent	Weeds
Insect	
Two beetles: <i>Octotoma scabripennis</i> and <i>Uroplata giraldi</i>	<i>Lantana camara</i>
Scale insect <i>Dactylopius tomentosus</i> .	Prickly-pear weed - <i>Opuntia</i>
Flea beetle <i>Agasicles hygrophyla</i>	Alligator weed <i>Alternanthera philoxeroides</i>
Fish	
Common carp (<i>Cyprinus carpio</i>) Chinese carp	Aquatic weeds
Mammals Manatee or sea-cow	Water hyacinth
Snails <i>Marisa</i> sp and other fresh water snails	Submerged weeds like coontail and algae
Fungi <i>Rhizoctinia</i> blight.	Hyacinth
Mites	
<i>Tetranychus</i> sp	Prickly pear
Plants Cowpea as intercrop in sorghum	Effectively reduces the growth of weeds in sorghum

III. RESULTS

Integrated pest management is the best way of weed control

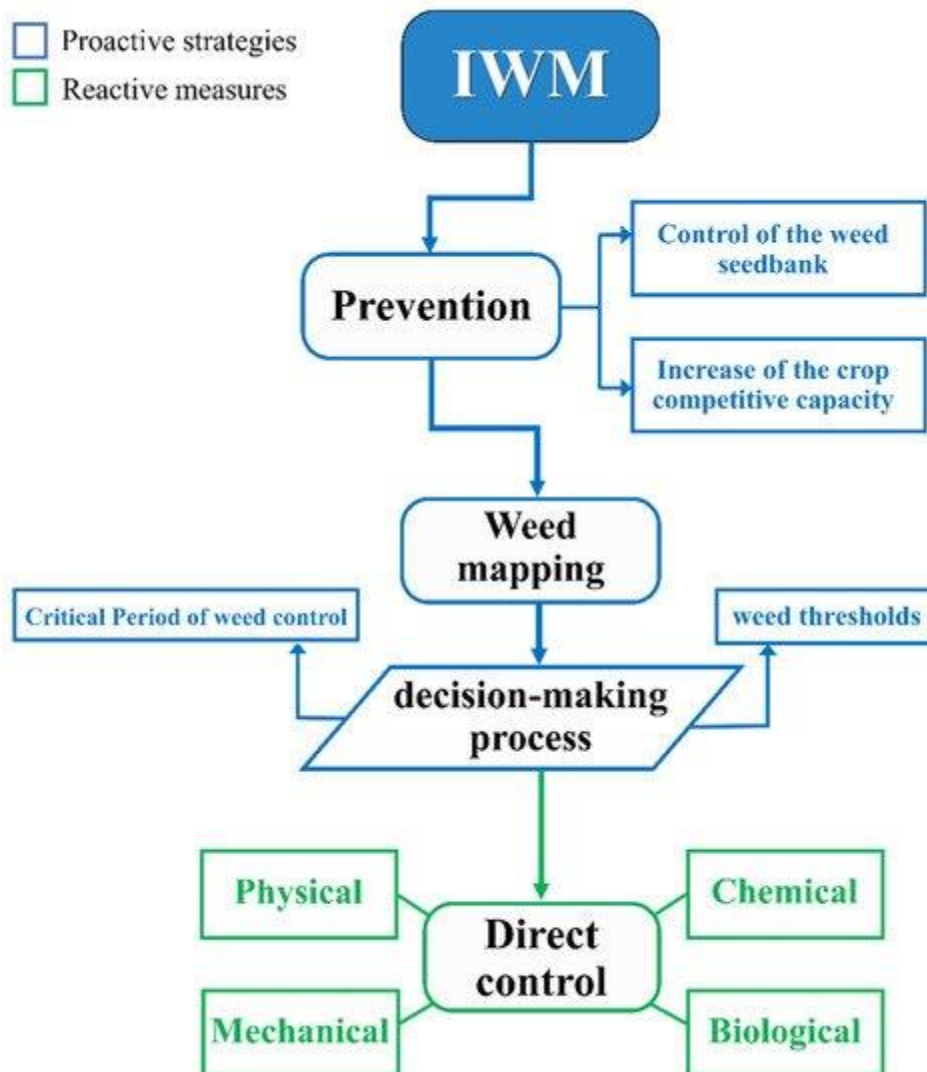
After grain is planted, weeds typically emerge along with the crop. Cultivation is not possible and producers must rely on herbicides and good agronomic practices for effective control. Depending upon the amount of rainfall after planting, one to three nitrogen top dressings may be required for wheat.

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 7, Issue 1, January 2018



Herbicides

Postemergent herbicides are applied to the crop, usually at the 2- to 3-leaf and tillered stages. Fall-planted grains are treated between December to mid-March, depending on time of planting and on growing conditions. Generally, spring-planted grains at higher elevations are treated from April to June. Depending on weeds present, one or two herbicide applications or combinations may be required. Application must be properly timed for maximum weed control and avoidance of crop injury. Grass and broadleaf weeds germinate with the beginning of the rainy season. Depending upon species, they can sometimes be controlled at the same time, permitting the use of tank-mixed herbicide combinations, but often grass and broadleaf control need separate applications. A tank mix can mean an important savings of time and cost. Refer to herbicide labels for mixing recommendations.(12)

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 7, Issue 1, January 2018

Broadleaf Weed Control

Typically only postemergent herbicides are applied after the crop has emerged. Fall-sown small grains usually are treated between December and mid-March, depending on the sowing date and growing conditions. Spring-sown small grains in the intermountain area of northern California are treated between April and June. Several postemergent herbicides are registered for use.

Phenoxy herbicides, including 2,4-D and MCPA, commonly are used in small grains alone or in combinations. Dicamba, another hormonal-type herbicide, often is included in the phenoxy herbicide group because of its similar mode of action. These herbicides are most effective when applied to small and succulent weeds. Small grains vary in their sensitivity to these herbicides; for example, oat is more tolerant to MCPA than to 2,4-D. Ester and amine formulations of 2,4-D and MCPA control many broadleaf weed species encountered in small grains. The ester form usually is more effective than the amine form. However, ester use is not permitted in most counties or applications are limited to certain times of the year.



Apply phenoxy herbicides after the small grains are well tillered but before they reach the boot stage (see DEVELOPMENTAL GROWTH STAGES) in order to avoid yield reductions caused by phytotoxicity. Best control is obtained when weeds are small and before the crop has reached the jointing stage. Late applications are sometimes ineffective because the crop canopy shields the weeds, preventing herbicide contact. Dense weed populations require a more thorough application with a greater spray volume to ensure herbicide/weed contact. The use of aircraft often facilitates timely herbicide application, but care must be taken to make applications at the appropriate

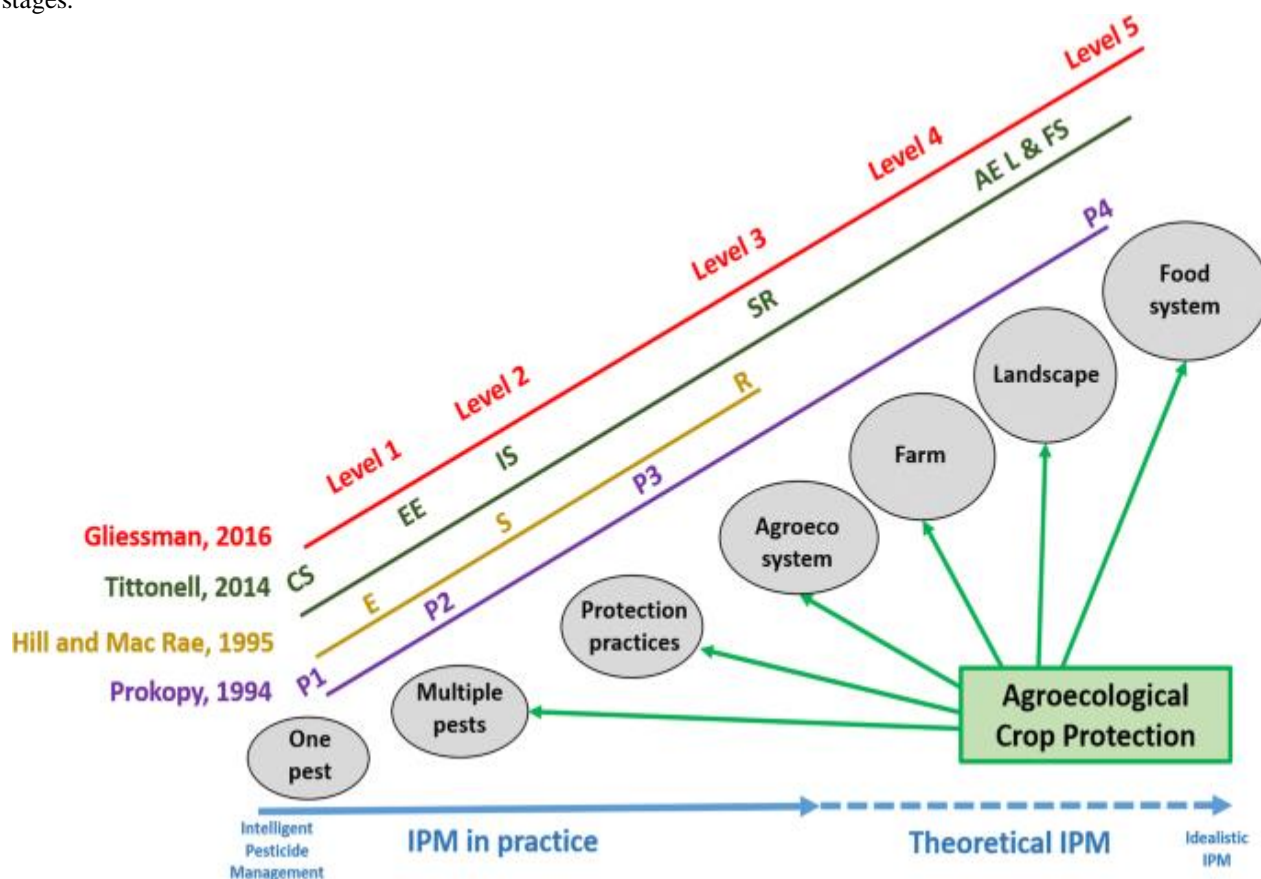
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Visit: www.ijirset.com

Vol. 7, Issue 1, January 2018

time to avoid injury to adjacent crops from drift or volatilization. MCPA does not control large weeds as well as 2,4-D amine and 2,4-D ester herbicides but has greater crop safety especially when applied to small grains in early growth stages.



Dicamba (Banvel, Clarity) is effective for broadleaf weed control; however, small grains generally are more sensitive to it than to 2,4-D. It is safer when applied at early growth stages (2- to 5-leaf stage). Dicamba cannot be used on fall-sown barley. It controls small chickweed and fiddleneck, which are not controlled by 2,4-D or MCPA. Dicamba usually is combined with bromoxynil and MCPA or carfentrazone (Shark). When applied early, this combination is very effective and increases the weed spectrum controlled compared to either of the herbicides used alone. (13)

Bromoxynil (Buctril), a contact herbicide, is effective on young seedling weeds with no more than two to four leaves. It is less effective on older weeds and must be tank-mixed with other herbicides when larger mustards are present. Bromoxynil is not translocated, or moved, from the site of absorption like the phenoxy herbicides. Therefore, higher volume application and thorough coverage is more important with bromoxynil than with phenoxy herbicides. An advantage of bromoxynil is that it controls the toxic weed fiddleneck. Bromoxynil also is recommended in areas with phenoxy-sensitive crops (grapes, cotton, tree crops) and can be tank-mixed with grass herbicides.

Chlorsulfuron (Glean) is registered for use on wheat in a wheat/fallow rotation. It is a sulfonyl urea herbicide with a very low use rate. It is not widely used in California because it has a long soil life (at least 18 months) that prevents its use in areas where many different crops are grown. Most broadleaf weeds, including fiddleneck and chickweed, are controlled. Apply it to small weeds when the small grain crop is in the 2–3 leaf stage to boot stage (see DEVELOPMENTAL GROWTH STAGES) and should not be used on soils with pH above 7.5.

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 7, Issue 1, January 2018

Clopyralid (Stinger), a picolinic acid, is registered for use on wheat, barley and oats. It translocates systemically through weeds, similar to phenoxy herbicides. It has a longer soil persistence than phenoxy herbicides, which limits planting of many broadleaf crops before 12 and 18 months. It is effective on a different spectrum of weeds than 2,4-D, MCPA or dicamba. Clopyralid is especially effective for control of legumes and composites (such as Canada and yellow starthistle). It does not control many common broadleaf weeds such as mustards, so must be tank-mixed for complete control of the wide range of broadleaf weeds found in small grains. The timing of application on wheat is from the 3-leaf stage to early boot stage (see DEVELOPMENTAL GROWTH STAGES), complimenting the timing of 2,4-D and MCPA.



CROP ROTATION



IRRIGATION



SELECTING DISEASE-RESISTANT VARIETIES



**INTER-ROW
CULTIVATION**



PLOUGHING



**WEED
MANAGEMENT**

Carfentrazone (Shark) is a contact herbicide that controls weeds by disrupting cell membranes. It is effective at very low use rates on fiddleneck, malva sp., burning nettle, and other weeds that are difficult to control with other herbicides. Adding surfactants to carfentrazone often causes temporary crop burn. Tank mixing with UN-32 may enhance weed control. Tank mixing with dicamba provides good control of chickweed. Combining carfentrazone with phenoxy herbicides broadens the weed spectrum controlled, lowers herbicide application rates, and can reduce the risk of weeds building up herbicide resistance. Avoid air applications during inversions (e.g., foggy conditions) to prevent off-target movement to sensitive crops (e.g., almonds). Several San Joaquin Valley counties have additional restrictions for carfentrazone, along with most of the other cereal herbicides.(14)

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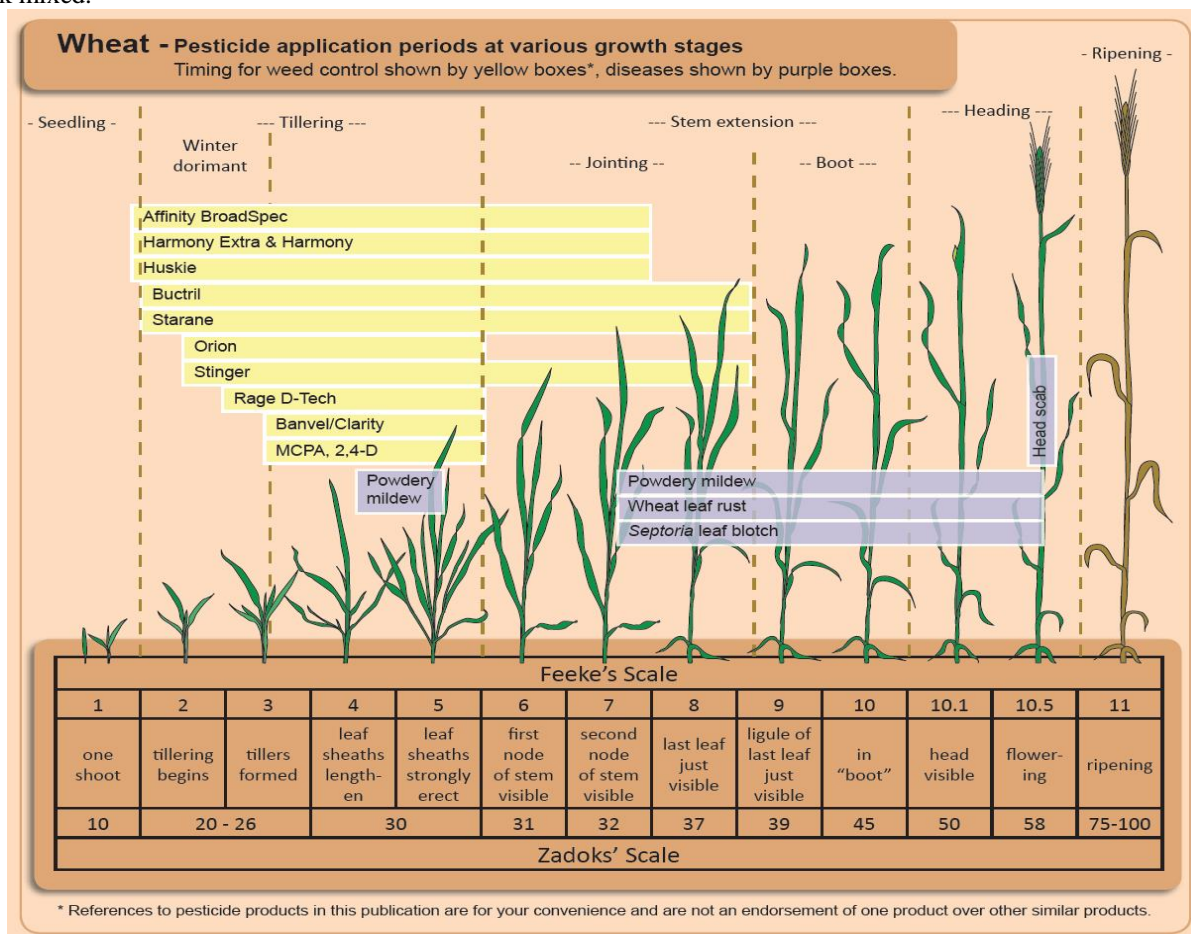
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Vol. 7, Issue 1, January 2018

Pyraflufen-ethyl (ET) is another contact herbicide that controls weeds by disrupting cell membranes. It is effective at very low use rates on *Malva* spp., burning nettle, and other weeds that are difficult to control with other herbicides. Tank mixing with dicamba provides good control of chickweed. Combining ET with phenoxy herbicides broadens the weed spectrum controlled, lowers herbicide application rates, and can reduce the risk of weeds building up herbicide resistance.

Grass Weed Control

Fenoxaprop (Puma) controls canarygrass, wild oat and several *Setaria* spp., including yellow and green foxtails. It also suppresses mustards. It has a wide window of application, providing effective control when applied between the 1-leaf and 6th leaf grass stage. For best control of wild oat, delay application until most wild oat plants have emerged, which often pushes this to the 5- to 6-leaf stage. A tank mixture with bromoxynil allows for a wide range of weed control at an early timing. Fenoxaprop cannot be tank-mixed with phenoxy herbicides because it often reduces grass control when tank mixed.



Mesosulfuron (Osprey) controls most grassy weeds and many broadleaf weeds in wheat. It is especially effective on Italian ryegrass, wild oat, little seed and hood canarygrass, and annual bluegrass. It controls ripgut brome and other brome species depending on weed size at application. Most California wheat cultivars have good tolerance to the herbicide. However, wheat plants will turn a lighter green color for a couple weeks following application. If soil nitrogen levels are low, this symptom will persist longer and require an application of supplemental nitrogen. When

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Vol. 7, Issue 1, January 2018

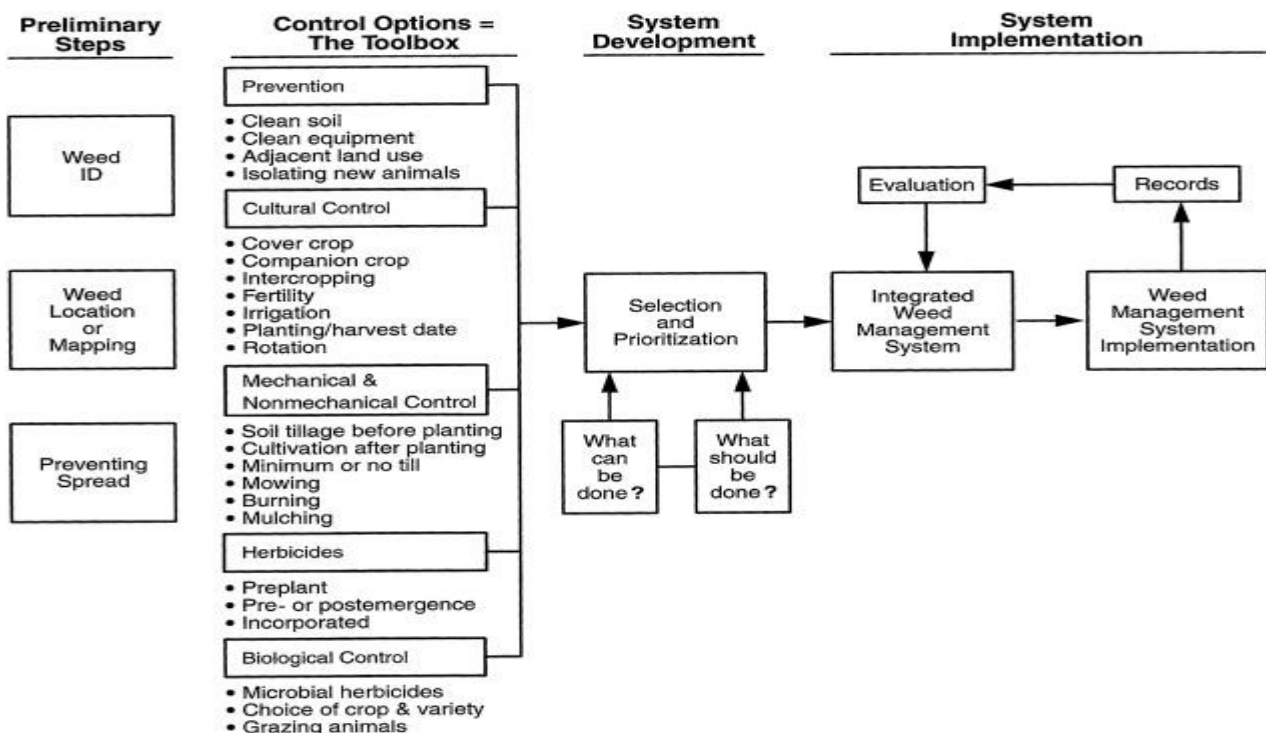
treated beyond the one-tiller stage, temporary growth suppression and shortening of the wheat plant will occur. The crop will recover more quickly from these symptoms under good growing conditions.

Mesosulfuron is effective on certain broadleaf weeds including chickweed, wild radish, and mustards. It also provides partial control of many other broadleaf weeds including common groundsel, common malva, fiddleneck, yellow starthistle and milk thistle. Mesosulfuron can be tank mixed with bromoxynil and MCPA and may be applied from the 1-leaf to 1-tiller wheat stage and up to the 2-tiller stage of grass weed development (see DEVELOPMENTAL GROWTH STAGES). A methylated seed oil or a non-ionic surfactant is required; ammonium sulfate or low rates of UN-32 added will enhance weed control on difficult to control weeds. Restrictions on crop rotations are greater than with Fenoxaprop.

Pendimethalin (Prowl H20) is a selective herbicide applied after the wheat has emerged but before the weeds have emerged. Pendimethalin controls most annual grasses and certain broadleaf weeds as they germinate. Adequate rainfall or irrigation after application but before weed seedling emergence is needed to provide effective weed control. (15)

Harvesting

Uncontrolled weeds delay maturing grains and create harvest problems. Field bindweed, prostrate knotweed, Russian thistle, fivehook bassia, lambsquarter, smartweed, and johnsongrass are examples. Heavy concentrations of green vines, stalks, or stems slow down combines and raise the moisture content of the harvested crop. Green debris and weed seeds mixed into grain causes heating in the grain bin; grain may be discolored and acquire off-flavors. Unclean storage also invites insect and mold damage. A mature grain field contaminated with immature weeds may be harvested in one of two ways: (1) the crop may be swathed (cut and left in windrows) or (2) where permitted, formulations of 2,4-D and glyphosate (Roundup) that are registered as preharvest aids can be applied to mature grain to kill and dry out weeds. In either case, grain is harvested after weeds have dried. Windrows are harvested with a combine equipped with a pickup attachment. Dry weeds and their seeds usually can be separated from grain during combining. In the San Joaquin Valley, use of 2,4-D is restricted between March 15 and October 15.



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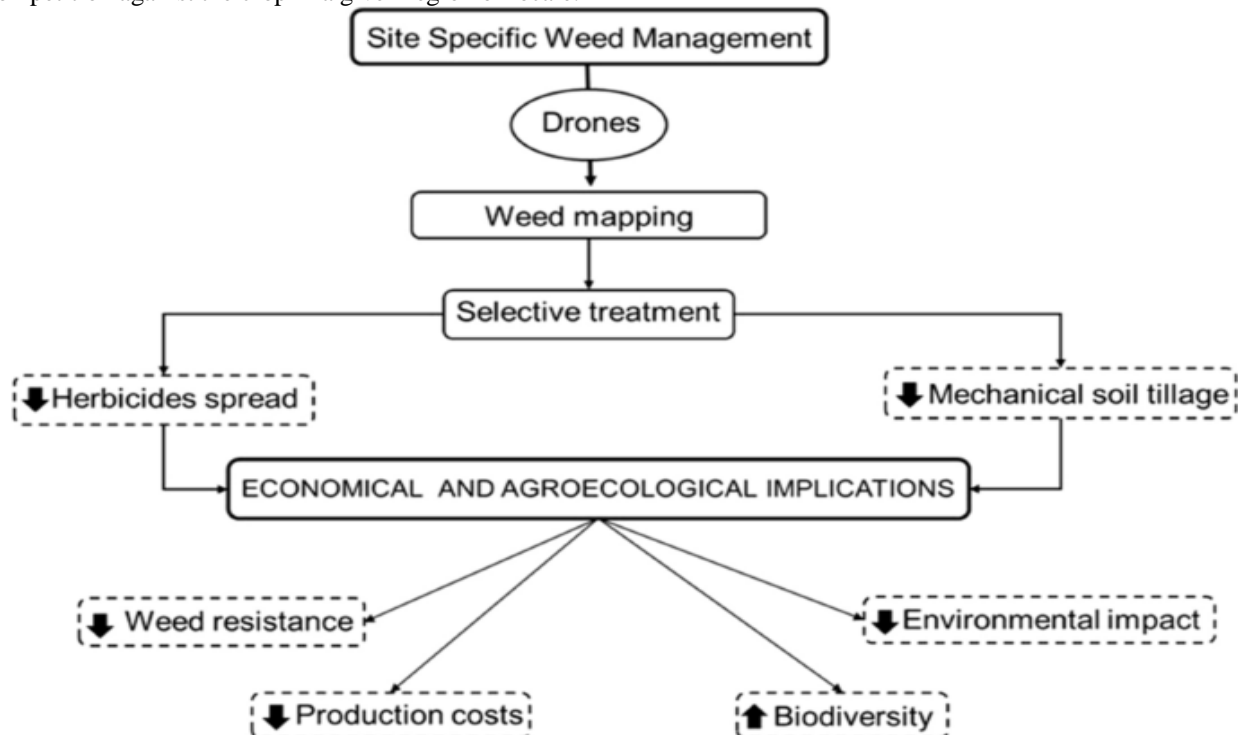
Fallow

For rainfed production systems, fields can be fallowed every other year to prevent weed seed build up and conserve moisture for maximum small grain growth. Do not allow weeds to grow and produce seed during the fallow season. Summer fallowing is practiced in dryland areas of the state that generally receive less than 18 inches of annual rainfall. The fallow season starts in fall after the crop is harvested. Depending on local rainfall patterns and availability of time and equipment, primary tillage is often performed in fall or winter when the following year's crop is being planted. Tillage tools of choice for primary tillage vary from plows in the Sacramento Valley to chisel plows along the Central Coast. If primary tillage cannot be accomplished before heavy winter rains begin, it is often delayed until spring to reduce erosion hazards. One or more traditional tillage trips, with disks or field cultivators, are performed through the fallow season, depending on additional weed growth. Often, one of the final tillage trips in late summer or early fall is used to inject nitrogen fertilizer into the soil. In some areas, small grains are seeded in early fall to take advantage of the first rains and the ability to still move equipment across dry fields.

IV. CONCLUSION

Integrated Pest Management (IPM) aims to protect agricultural crops from economic damage by insect pests, weeds, plant pathogens, and other harmful organisms, while reducing reliance on hazardous pesticides. The term *integrated* means the practitioner implements a coordinated pest management strategy utilizing multiple tools and practices that are compatible with one another and with the health and stability of the farm as a living system. The most effective IPM programs are based on an ecological understanding of the pests' interactions with the crops, other organisms, and the environment (12).

Since the advent of synthetic pesticides in the mid-20th century, conventional pest management has consisted of spraying whenever pests appear, or even on a "calendar schedule" based on a worst case scenario for the target pests. Herbicides are routinely applied pre- and postplant, based on the major weed species, emergence patterns, and expected competition against the crop in a given region or locale.



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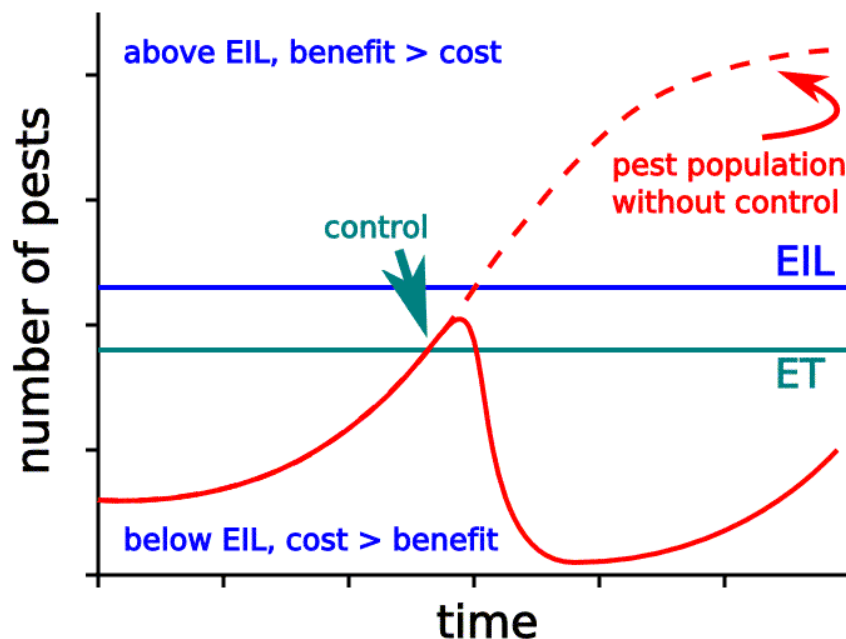
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Vol. 7, Issue 1, January 2018

During the 1970s, heavy pesticide use on the nation's farmlands raised human health and environmental concerns, as well as increasing pest resistance to the chemicals. In response, agricultural scientists explored ways to control pests more effectively with fewer pesticide sprays. Practical on-farm applications of these endeavors became Integrated Pest Management, or IPM.

Early students of IPM sought to understand both crop and pest within the larger context of the farm ecosystem or agroecosystem—consisting of all the living organisms on the farm and its immediate surroundings, and the interactions among those life forms and their physical environment. The agroecosystem includes the farm's crops, weeds and natural vegetation; livestock, wildlife, insect and other pests, and their natural enemies; soils and their tremendous diversity of micro- and macroorganisms; ground and surface waters, topography, and climate. Understanding these interactions and how they can impact the crop and its pests can point the way to nontoxic and non-disruptive practices that limit pest species' ability to proliferate and become a problem that requires a pesticide treatment. Early IPM programs emphasized cropping system planning based on this knowledge, and preventive measures, as well as a "spray only when really necessary" approach to pest occurrences (13). Several principles guided these efforts:

- Restore and maintain natural balance within the farm ecosystem, rather than attempt to eliminate species. Higher biodiversity usually confers greater stability.
- Monitor pest and beneficial populations; take steps to protect and enhance natural pest controls.
- The mere presence of a pest does not automatically mandate a pesticide application. Appropriate decision making criteria, such as Economic Thresholds (ETs) are applied to determine whether and when control measures are warranted (14).
- All pest control options—physical, cultural, and biological, as well as chemical—are considered before action is taken.
- Integrate a set of complementary techniques and tools that work additively or synergistically, taking care that one tactic does not interfere with another.(16)



In Integrated Pest Management, the Economic Injury Level (EIL) is defined as that pest population level at which the dollar cost of crop yield loss to the pest begins to exceed the dollar cost of the recommended control measures for the pest. The Economic Threshold (ET) is that level of pest population at which the pest, if left untreated, is likely to reach

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or exceed the EIL. Therefore, the ET is almost always lower than the EIL, and is considered the point at which the farmer should take action against the pest. Therefore, the ET is sometimes called an Action Threshold (AT).

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