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SAgri Sustainable Agriculture

Project Title

Skills Alliance for Sustainable Agriculture

Project Acronym

SAGRI

Integrated Pest Management in Plant Protection

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Contents

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1. Introduction

This manual has a main goal to give some basic achievements to the technicians and farmers about the means of control of the pests in their crops.

The concept of Integrated Pest Management (IPM) emerged from the need of crops treatment with a low impact on natural ecosystems, reducing the chemicals applied and therefore the costs, treating only when necessary. This treatment integrates a combination of cultural, physical/mechanical, biological, and microbial/chemical pesticide control methods, to keep environmental impacts to a minimum.

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2. Phytosanitary protection and disease concept

The modern agriculture is intensive and should be productive and economically profitable. For that, a great amount of inputs are needed, such as nutrients, phytohormones and, of course, chemical products as pesticides. The use in wholescale of these factors of production led to important negative impacts in the agricultural ecosystems, like soil depletion, contamination of water resources and the emergency of new pests, diseases and weeds in resistant forms.

Because of all this, the need of new approaches of production has emerged and among them the integrate use of several strategies of treatment.

But, first of all, there is one important need: recognize if a crop or a plant is diseased. By definition, a plant is diseased when is not able to carry out vital functions properly, by losing form and integrity due to pathogenic or pest attack(s). For disease to happen, three factors should be conjugated: i) the pathogen or insect pest, ii) the climatic conditions that should be appropriate to the pathogen or pest development, and finally iii) the plant host should be compatible with the pathogen and/or pest. This led to the concept of the disease triangle (Figure 1).

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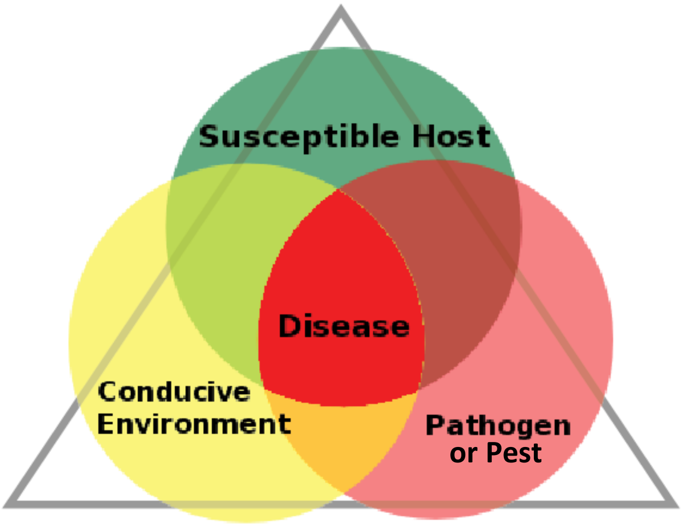

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Figure 1 – Conditions needed to occur a disease in a plant or a crop.

(Adapted from: https://www.novusag.com/2016/07/big-corn-concepts-the-disease-triangle)

To control the phytosanitary problems that can occur in a crop the farmers have several tools that they can use, several ways of disease, pests and weeds control, like: sanitary rules and quarantine measures, cultural control, genetic control, biological control, chemical control, physical control and biotechnical control.

2.1. Sanitary rules and quarantine measures

The sanitary rules are established by the government of each country or, in the case of Europe, in many cases by the European Commission. These rules concern a direct way of control to prevent the spread of important harmful organisms, with special impact in main crops of each country.

Plant quarantine is defined as the legal enforcement of the measures aimed to prevent pest and diseases from spreading or to prevent them from multiplying further in case they have already gained entry and have established in new restricted

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areas. Also, the quarantine measures are very important in cases of importation of plant material. If some susceptive plants are imported, it is important to leave them in a closed structure during a time period, for checking the presence of diseases and pests that can cause an epidemy in the country of destination.

2.2. Cultural control

Cultural control is the manipulation of the agroecosystem to make the cropping system less friendly to the establishment and proliferation of pest populations. This is the oldest phytosanitary practise and integrates a theoretical model of environmentally- and human-friendly crop production. This model takes into account the cultural practices and vegetation management to enhance natural enemy impact and exert direct effects on pest populations.

The contemporary cultural control is maintaining and increasing the biological diversity in the farm system, by the management of the abiotic and biotic environment of the crop. The manipulation of abiotic conditions includes site selection, soil practices (including irrigation and fertilizer management), and the use of mulches, row covers, etc. Manipulation of the biotic environment embraces various aspects of crop rotation, intercropping, planting dates, trap crops, companion planting, and the use of semi-chemicals, including antifeedants.

2.3. Genetic control

This kind of indirect control allows the development of pest-resistant or tolerant cultivars. To attain this, plant breeders have taken advantage of natural genetic variation or induced mutations. The methods that plant breeders use depend on the type of crop or plant they want to improve and the reproductive biology of this plant. For example, the cross-pollinization that allows to get the hybrids, a really

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good improvement to the maize production. Other examples of genetic control are the selection of tolerant or resistant plants to pests and diseases, and gene transfer using the genetic engineering methodologies.

The use of genetic control has been of great importance in the obtainment of plant lines resistant to the most important pests and diseases that can cause epidemics.

2.4. Biological control

Biological control is the use of non-chemical and environmentally friendly methods of controlling insect pests and diseases, by the action of natural control agents. In recent decades, the increased use of biological control was due to its safety, species specific and long-term action on the targeted pests. This kind of control increases the natural population of antagonist organisms and allows the reduction of the harmful agents. It's a control measure more and more used and the final products are very well valued.

The natural biological antagonists that we can use are: insects, mites, nematodes, fungi, bacteria, virus, and vertebrates, like birds. Also, the use of suppressive soils is used to exploit the presence of natural biological antagonist agents.

2.5. Chemical control

Chemical control is based on substances that can be natural or synthetized and are usually toxic to the pests involved. The chemical pesticides are grouped into five main categories, depending on the purpose they are usually applied for:

1- Fungicides, which act against fungi;

2- Herbicides which are used against weeds;

3- Insecticides that destroy harmful insects;

4- Acaricides which protect plants from mites;

5- Nematicides to control nematodes that attack the plants.

The big problem associated to these chemical products is that besides their ability to destroy the target, they also destroy other insects, mites, fungi and weeds that are not harmful to crops but that could also be a biological antagonist of the target.

2.6. Physical control

Physical control refers to mechanical, thermic, electromagnetic radiations or hand controls, where the pest is actually attacked and destroyed. Physical controls are used mostly in weed control. Tillage, fire, removal by hand, grazing and mowing are all used to destroy weeds and prevent their reproduction. Some insects may also be destroyed by tillage, which destroys their eggs or overwinter stages of growth. Weeds are not controlled with a single operation. These methods usually do not leave residues or pollute the environment (Singh and Pandey 2012).

Several examples can be mentioned to illustrate the physical control methods, like practices such as seedbed preparation, post-seeding tillage, post-harvest tillage and summer fallow (which are effective in combination against weed seedlings and perennial weeds), hot water treatment, hot dry air, soil solarization, electromagnetic radiations such as ultraviolet (UV) light, X-rays and Y-rays, burning, refrigeration, etc.

2.7. Biotechnological control

Biotechnology provides ample opportunities for effective and targeted pests control. It acts as a mean of control directly in the targeted pests. The success of these approaches has been based on the utilization of various tools and techniques of genetic engineering, molecular biology and plant biotechnology. An important

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example is the use of *Bacillus thuringiensis* (Bt)-toxin genes, which have been widely accepted in insect pest control. A range of alternative genes have also become available for exploitation as biological weapons against other species. Most of these genes find utility through transgenic plants, but others find application in improving the performance of different biocontrol agents, including microbial species and natural enemies. Also, the use of growth regulators as hormones is included in this mean of control.

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3. Integrated Pest Management

What means Integrated Pest Management (IPM)? There are several definitions available but the one from Kogan (1998) translates exactly the concept of IPM: "IPM is a decision support system for the selection and use of pest control tactics, singly or harmoniously coordinated into a management strategy, based on cost/benefit analyses that take into account the interests of and impacts on producers, society, and the environment."

Following the same author, we can analyse the words that constitutes IPM in:

• **Integration**, which is the harmonious use of multiple methods to control single pests or pest complexes. To do this, one must learn everything we can about a pest and the crop that is affected by the pest, and then put that information together as a management plan;

• **Pest**, which is any organism that is detrimental to humans and it includes invertebrates (insects, mites, spiders, etc.), vertebrates (ground squirrels, mice, rabbits, birds, etc.), weeds, and pathogens (microorganisms that cause plant diseases);

• And **Management**, which is simply a set of decisions making up a strategy or plan to control a pest based on ecological principles and economic and social considerations.

The IPM definition used by the European Commission is the following: Integrated pest management means careful consideration of all available plant protection methods and subsequent integration of appropriate measures that discourage the development of populations of harmful organisms and keep the use of plant protection products and other forms of intervention to levels that are economically and ecologically justified and reduce or minimise risks to human health and the environment. 'Integrated pest management' emphasises the growth of a healthy

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crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms.

3.1. The principles of IPM

Directive 2009/128/EC requires that all EC Member States show how their National Action Plans ensure the implementation of the eight general principles of IPM (see below), and Article 55 of Regulation 1107/2009/EC requires that professional pesticide users comply with these principles. Following Barzman et al. (2015), the eight principles and their numbering actually result from a logical sequence of events.

Principle 1 - **Prevention and suppression**: comes first because it encompasses the initial design and actions undertaken at the cropping system level to reduce the severity and frequency of pest outbreaks. Using culture rotation, combinations of tactics and multi-pest approach and crop management and ecology.

Principle 2 – **Monitoring**: Check the presence of crop enemies and their level, when the cropping system is in place.

Principle 3 - **Decision-making**: This process considers the actual or predicted pest incidence, in the event that an intervention is decided. It can be determining in season control measures based on the short-term pest situation and could be extended to integrate more systemic factors for longer-term strategic design.

Principle 4 - **Non-chemical methods**: Promoting the reduction of the chemical products, increasing the alternatives like biological, physical and genetic control.

Principle 5 – **Pesticide selection**: The use of adequate sites where are listed the selection of products minimizing impact on human health, the environment, and biological regulation of pests.

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Principle 6 – **Reduce the pesticide use**: In terms of frequency, spot spraying, or dose reduction, is a recognized tactic along the IPM continuum that can be combined with other ones.

Principle 7 – **Use of anti-resistance strategies**: The use of different products, with different components, can prevent the establishment of resistant organisms in the crop to be treated.

Principle 8 – **Evaluation**: This principle encourages farmers to assess the soundness of the crop protection measures they adopt, and this is an important aspect of sound management. It would emphasize the evaluation of yield, yield stability, and profit over multiple years at the cropping system level. An extension work at the farm community level will develop new standards of reference, and performance criteria can become widely shared among farmers.

3.2. Evaluation of the need of treatment

The concepts of 'Economic Injury Level' and 'Economic Threshold' are considered keystones of the present Integrated Pest Management (Stejskal, 2003). Economic Injury Level (EIL) was originally defined by Stern et al. (1959) as the lowest population density that will cause economic damage. The Economic Threshold (ET) implies that if the pest population and the resulting damage are low enough, it does not pay to take control measures. In practice, the expression Economic Threshold will be used: 1) to mean if the pest population attained the level at which economic loss begins to occur and 2) to indicate the pest population level at which pest control should be implemented, given the cost of control (Davidson and

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Norgaard, 1973). The EIL and ET are the most essential criteria to create decision rules and for decision-making.

3.2.1. Sampling

In order to obtain information about the EIL and ET, it is necessary to observe the presence of and damage provoked by the insects or pathogens present in the crop to protect, therefore it is necessary monitoring. The monitoring predicts and evaluates potential key pest problems and nontarget effects, provides information for choosing and timing appropriate control actions, evaluates effectiveness of management practices, and establishes a pest history for the specified area.

The sampling is a strategy of monitoring that collects repeatedly systematic data of an organism in its environment over a specified time. For sampling, several techniques can be used to quantify pest populations in the field.

a) Visual inspection

It consists in the direct count of the presence of insects or damage caused by pathogens directly in the crop (Figure 2).

Figure 2 - Example of a grapevine leaf with some insects
(Source: https://gardening.stackexchange.com)

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b) Knockdown

This technique is more important and more used to monitoring woody plants and trees. Pests are dislodged from host onto a collecting surface/container (Figure 3).

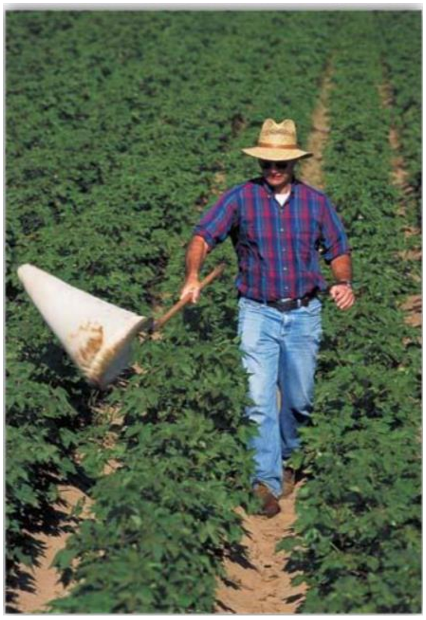

Figure 3 - Example of knockdown sampling
(Source: http://www.entnemdept.ufl.edu)

c) *In situ* counts

This kind of sampling is done directly in the crop (Figure 4), using some kind of traps and evaluates the presence and quantity of insect pests, symptoms of disease or weeds present in the crop to protect.

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Figure 4 -Example of *in situ* counts
(Source: http://www.entnemdept.ufl.edu)

d) Traps

Trapping is the most important kind of sampling used for monitoring insect abundance and their behaviour. Traps are used mostly for insects that have mobility. The traps are left out in the field for a period of time, and after that they are collected, and the number of insects is counted.

The traps can be: i) attractive (active), that kind of traps to lure the insects to them because they are visually (colour, size or shape) or chemically (food or pheromone) attractive; ii) passive, that catch insects occasionally.

There are a large number of traps that can be used, depending of the insect and the crop to monitor (Figure 5).

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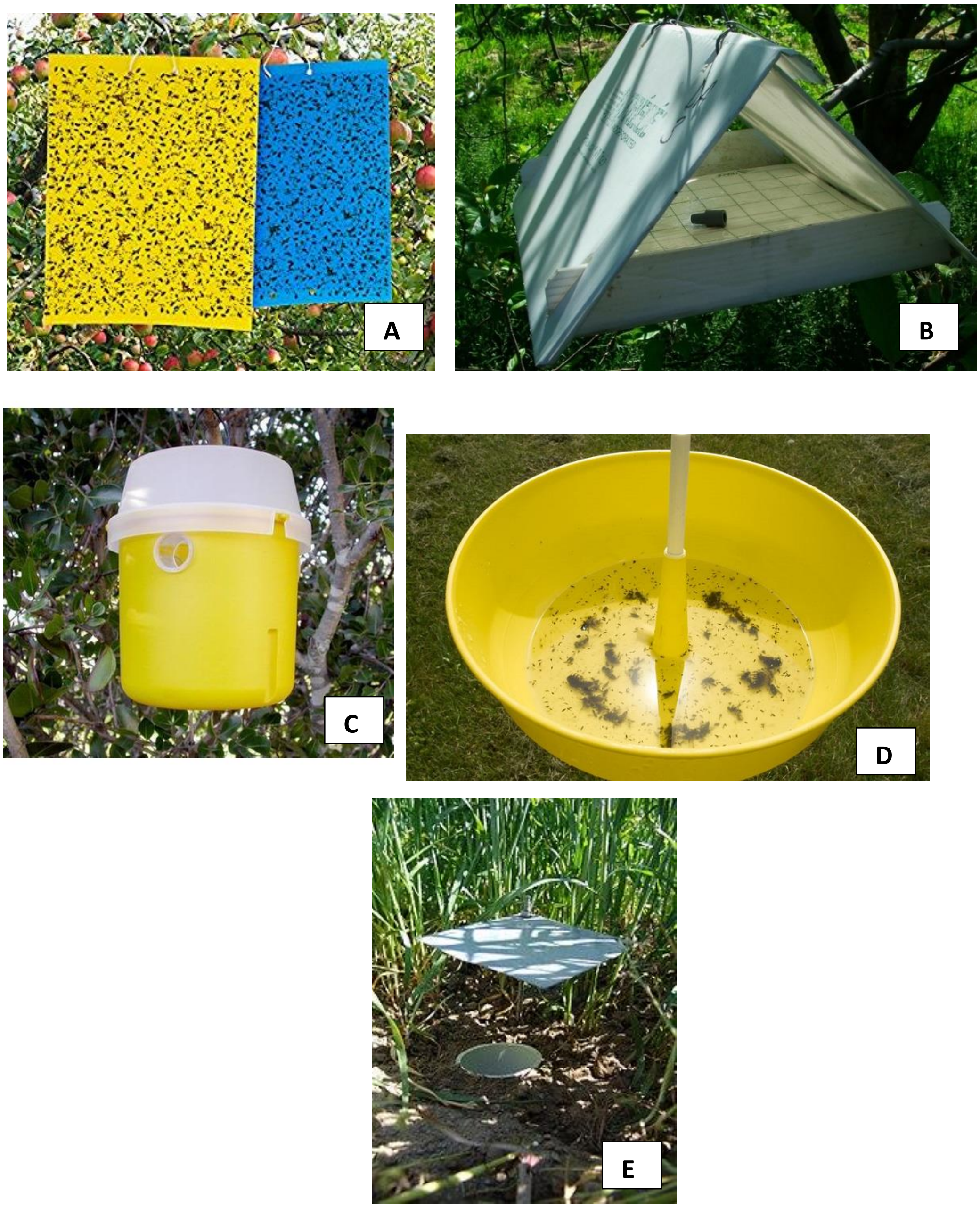

Figure 5 – Different trap examples: A - Sticky traps; B - Wing trap; C – Bucket trap; D - Pan trap and E – Pitfall trap. (Sources: https://www.fera.co.uk/crop-health/insect-monitoring; https://www.amazon.com/Springstar-S508-Apple-Maggot-Replacement/dp/B007UTO2SA; https://apples.ces.ncsu.edu/trapping-to-monitor-apple-insect-pests-ipm; https://www.indiamart.com/proddetail/fruit-bucket-trap-13493869112.html; https://en.wikipedia.org/wiki/Pitfall_trap).

Sticky traps (cards) can be attractive if they are made of different colours or passive if they have only glue. These traps are used to catch white flies, aphides and trips;

Wing traps can be attractive if they have pheromones, or passive. They are mostly used to monitor adult Lepidoptera.

Bucket traps are attractive because they use colour and pheromones, and they are also used to monitor Lepidoptera.

Pan traps can be attractive if they have attractive food or colours, or passive if they have only water with soap to kill the insects that land in them. These kinds of traps are used when monitoring aphides or flies.

Pitfall traps are passive traps because they are placed in soil and the insects fall into them. They can be used to catch and monitor ground beetles, mites, spiders and hunts.

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3.3. Decision-making

During decades, Economic Threshold (ET) was the basis for decision-making but in modern IPM the emphasis is given on agro-ecological situation. In IPM decisions are based on: i) the information that exists for the key-pests for each crop, ii) natural enemies and iii) weather. First efforts were focused on production agriculture analyses and in the ratio cost/benefit. Recently, IPM started to involve the landscape and urban pest management, attempting to consider not only economic profits, but also the aesthetic value of pest control as well. For that, efforts were focused also in incorporating the costs to environment and society from pest control practices.

The decision-making is a process resulting in the selection of an action among several alternative solutions (see Figure 6). All decision-making processes produce a final choice.

Decision-making starts with: i) the identification of a problem, which requires the collection of all relevant information for critical analysis of the problem; ii) this leads to the development of a set of available alternative courses of actions to solve the problem; only realistic solutions should be selected considering multiple criteria as effectiveness, benefits, costs and the constraints like ease of implementation and technical or legislative limitations; iii) based on the analysis, the best solution should be selected, and the decision is changed into an action (Singh and Gupta, 2017).

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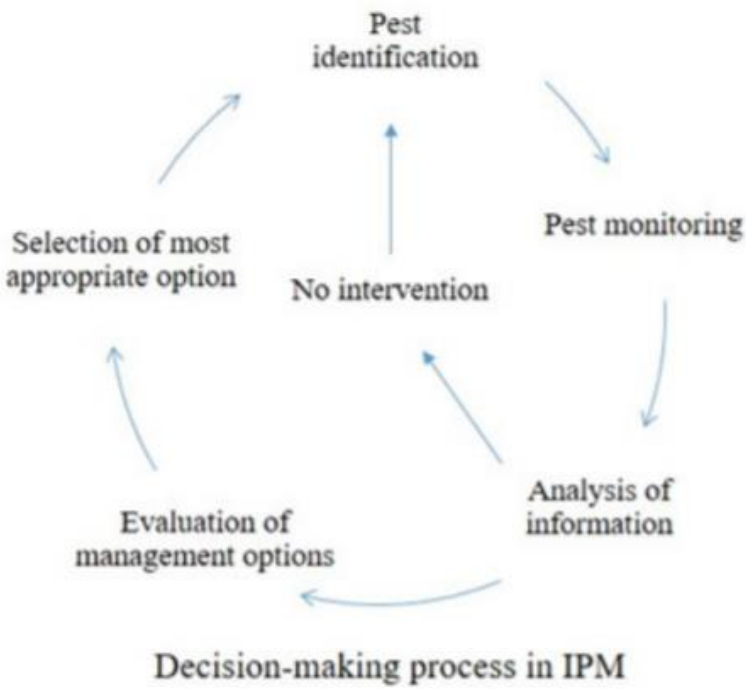

Figure 6 – Scheme of the decision-making process (Source: Singh and Gupta, 2017).

4. Pesticides

Pesticides are chemically synthesized products that are used to control crop enemies, destroying or repelling them. There are several kinds of pesticides depending the target to control, such as: i) insecticides, that are pesticides used to control insects, ii) herbicides, that are pesticides used to control weeds, iii) fungicides, that are pesticides used to control fungi, and iii) nematicides, that are pesticides used to control nematodes.

In Integrated Pest Management pesticides should have a judicious use, to avoid problems as pest resistance to pesticides; increased costs; toxicity to fish and wildlife, beneficial natural enemies of pests, and other non-target organisms; concerns about human health and safety; ground water contamination; and overall environmental quality.

Despite the above mentioned potential problems caused by the indiscriminate use of pesticides, there are no doubt that they provide important advantages and benefits and they were a good tool available to plant protection. Adding to this:

1. Pesticides are readily available and easy to use.
2. Where resistance is not a problem, pesticides are generally highly effective for controlling pests.
3. Pesticide treatments can be rapidly implemented as needed with minimal lag time.
4. Pesticides can be used over large areas to control large populations of pests.
5. Pesticide treatments are often cost effective, especially if the alternatives require large increases in human labour.
6. No effective, reliable, non-chemical alternatives are available for many pests and chemical pesticides are the last resort.

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Pesticides are used in IPM programs when no effective alternatives are available, or alternatives are not sufficient to keep pest populations from reaching damaging levels. The main goal is to maximize the benefits and advantages that pesticides offer, while minimizing any potential risks.

Following https://ipm.tamu.edu/about/pesticides (accessed in September 2018), several problems can occur caused by the overuse of pesticides:

1- **Pesticide Resistance:**
To achieve better or total pest control, resistance problems have increased because pesticides are applied more frequently and at higher dosage rates. These tactics have resulted in increased selection pressure. Naturally resistant individuals in a pest population can survive to pesticide treatments. The survivors breed and pass on the resistance trait to their offspring. With each passing generation, the pest population becomes more difficult to control with the same pesticides as compared with earlier generations. Reducing pesticide use and alternating among classes of pesticides with different modes of action can help to lessen the possibility of pest resistance. Managing pest resistance is very important in helping to prolong the effective life of needed pesticides.

2- **Toxicity to Natural Enemies and Other Non-target Organisms:**
Natural enemies of pest species can be very helpful in keeping pest populations at lower levels. These beneficial organisms include organisms that are predators, parasites, or competitors to the detriment of the pest species. For example, aphids do not reach pest levels every year because many different natural enemies help to keep them in check. Unfortunately, many broad-spectrum, non-selective pesticides are more detrimental to numerous beneficial species than to the pests. The use of such pesticides often causes a resurgence in pest populations and at a much faster rate

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compared to the natural enemies. Without the natural controls, primary (established) and secondary (new) pests are often free to reach damaging levels at faster rates. An increase in pest levels usually results in additional pesticide treatments, which further depresses or eliminates the natural enemies and further encourages the potential for pest resistance. Selecting effective alternatives that are less toxic to non-target organisms, will increase natural enemy survival, and overall effectiveness of pest control.

3- **Public Health and Environmental Concerns:**

The public has become increasingly concerned about the use of pesticides and the possible adverse effects on human health, wildlife, ground water, and overall environmental quality. Pesticide exposure from drift to non-target areas; contamination of ground and surface waters; and residues on food are topics of concern to the general public. Applicators should be especially concerned because they may have the highest potential for exposure and thus, may have the greatest health risks. All applicators must be sensitive to public concerns about pesticide use and apply materials only in a safe and judicious manner.

4- **Cost of Pesticides:**

The cost of developing new pesticides has risen at an increasingly rapid rate. Government regulations and more stringent registration requirements have also slowed the rate of development and increased the costs of new products. Concerns about potential product liability have discouraged companies from introducing new products. Increasing problems with pest resistance have likewise resulted in shorter market lives for many pesticides than in the past. All of these factors result in higher costs and potentially lower profits for chemical companies. In turn, this leads to higher prices for pesticide users. Maintaining the economic viability of agriculture is also one of the goals of Integrated Pest Management.

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There are several types of pesticides that can be used, depending on the organism target to control (Table 1).

Table 1: Types of pesticides and organisms that they can control.

Pesticide types	Organism to control
Acaricide	Mites
Bactericide	Bacteria
Fungicide	Fungi
Herbicide	Weeds
Insecticide	Insects
Molluscicide	Mollusca
Nematicide	Nematodes
Rodenticida	Rodents

Whenever a pesticide treatment is needed, the chemical selection should take into account the ratio benefits/risks, and laws and regulations established. The used products should be the least toxic to humans and other non-targeted organisms, protect the auxiliary organisms and should not be pollutants to soil and surface waters.

4.1. Pesticide formulation

The pesticide formulation was established to inform the user about the kind of substance that constitutes the pesticide, and for that several acronyms were created and are world recognized (see Table 2).

For all of the formulations available in pesticides used in Integrated Pest Management and plant protection the mostly current used are from two kinds:

1. Water miscible formulations, which include:

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- EC Emulsifiable concentrate
- WP Wettable powder
- SL Soluble (liquid) concentrate
- SP Soluble powder

2. Non-powdery formulations with reduced or no use of hazardous solvents and with improved stability:

- SC Suspension concentrate
- CS Capsule suspensions
- WG Water dispersible granules

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Table 2: Acronyms of different pesticide formulation (Source: https://en.wikipedia.org/wiki/Formulation)

E	Aerosol dispenser	MC	Mosquito coil
AL	Other liquids to applied undiluted	ME	Micro-emulsion
AP	All other products to be applied undiluted	MR	Matrix Release
BR	Briquette	OD	Oil dispersion
CB	Bait concentrate	OF	Oil miscible flowable concentrate (oil miscible suspension)
CP	Contact powder	OL	Oil miscible liquid
CS	Capsule suspension	OP	Oil dispersible powder
DC	Dispersible concentrate	PA	Paste
DP	Dustable powder	PR	Plant rodlet
DS	Powder for dry seed treatment	RB	Bait (ready for use)
DT	Tablets for direct application	SC	Suspension concentrate (= flowable concentrate)
EC	Emulsifiable concentrate	SD	Suspension concentrate for direct application
EG	Emulsifiable granule	SE	Suspo-emulsion
EO	Emulsion, water in oil	SG	Water soluble granule
EP	Emulsifiable powder	SL	Soluble concentrate
ES	Emulsion for seed treatment	SO	Spreading oil
EW	Emulsion, oil in water	SP	Water soluble powder
FS	Flowable concentrate for seed treatment	ST	Water soluble tablets
FU	Smoke generator	SU	Ultralow volume (ULV) suspension
GA	Gas	TB	Tablet
GD	Gel for direct application	TC	Technical material
GE	Gas generating product	TK	Technical concentrate
GL	Emulsifiable gel	UL	Ultra-low volume (ULV) liquid
GR	Granule	VP	Vapour releasing product
GS	Grease	WG	Water dispersible granule
GW	Water soluble gel	WP	Wettable powder
HN	Hot fogging concentrate	Ws	Water dispersible powder for slurry treatment
KK	Combi-pack solid/liquid*	WT	Water dispersible tablets
KL	Combi-pack liquid/liquid*	XX	Others
KN	Cold fogging concentrate	ZC	A mixed formulation of CS en SC
LB	Long-lasting storage bag	ZE	A mixed formulation of CS en SE
LN	Long-lasting insecticidal net	ZW	A mixed formulation of CS en EW
LS	Solution for seed treatment		

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4.2. Warning symbols

Pesticide warning signs must alert people about pesticide use, because most of them can cause numerous health problems. To avoid accidents, the Environmental Protection Agency (EPA) established special requirements for pesticide warning signs. The EPA demands that pesticide warning signs must warn agricultural workers and other people about pesticide applications. Any pesticide warning sign must be visible and readable in the packing.

a) Poisonous

Skull and cross bones warn that the pesticide is poisonous if it gets into the body. Such products must be kept out of reach of children. It is necessary to use suitable safety measures while working with poisonous products.

b) Flammable

Flame warns that the pesticide is inflammable. The pesticide must be kept away from heat, sparks, or fire.

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c) Explosive

This symbol shows that the pesticide can explode.

d) Corrosive

Corroded hand shows that the compound can burn the skin and eyes and it is necessary to protect the skin and eyes while working with these products. (http://www.ccohs.ca/oshanswers/chemicals/pesticides/health_effects.html - Accessed in September 2018).

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Globally Harmonised System (GHS) of Classification and Labelling of Chemicals.

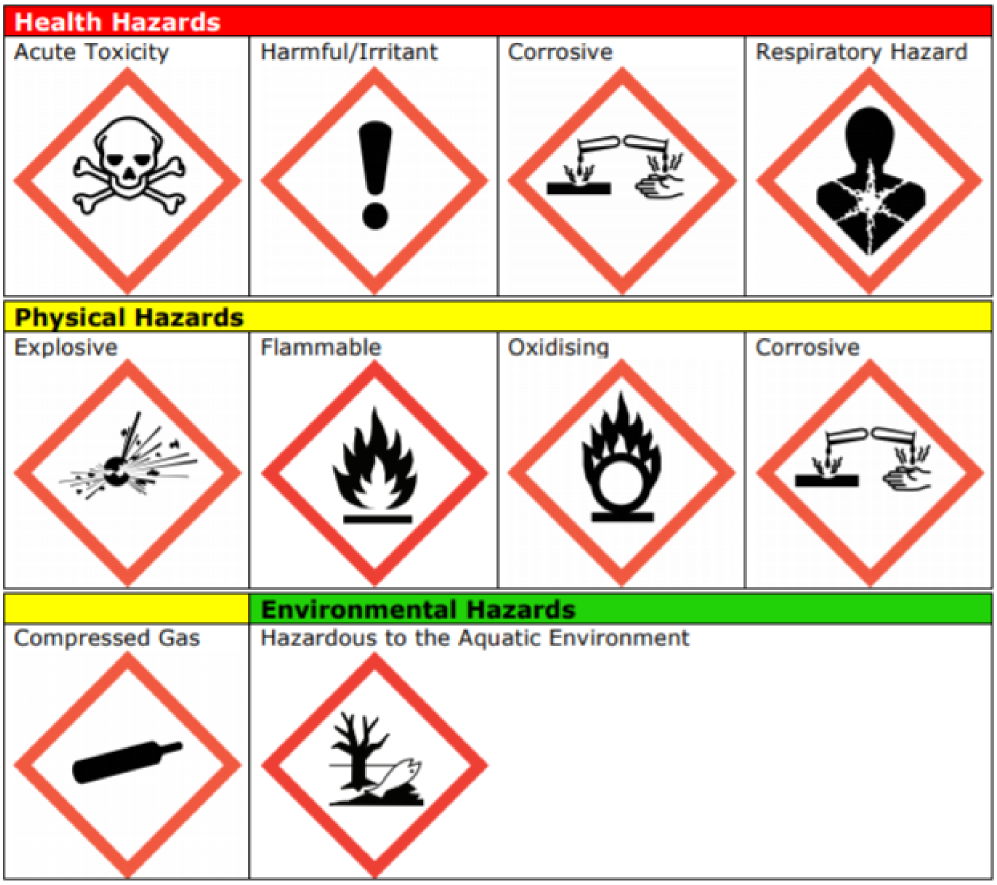

Figure 7 – In European Union, the Classification and Labelling of Chemicals Regulation, which came into force in December 2010, implemented the use of GHS in place of the EHS (European Hazard Symbols for Chemicals) labels. (Source: https://www.tcd.ie/Biology_Teaching_Centre/assets/pdf/by1101practicals/hazard-warning-labels-2011.pdf)

4.3. Toxicity symbols

Toxicity of a pesticide refers to the effects from a single dose or repeated exposure over a short time, such as an accident during mixing or applying pesticides. The toxicity is measured by Lethal Dose (LD_{50}) and Lethal Concentration (LC_{50}) values.

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LD_{50} value is the amount of pesticide which kills 50% of the population of test animals. These values are given in milligrams per kilogram of body weight of the animal (mg/kg body wt.).

LC_{50} value is a measure of the toxicity of a pesticide when test animals breathe air mixed with pesticide dust, vapours or spray mist. It is the concentration of pesticide which is lethal to 50% of a population of test animals and is usually determined for a specific exposure period. The length of exposure is important because shorter exposure periods generally require higher pesticide concentrations to produce toxic effects. LC_{50} values for pesticides in air are expressed as the ratio of pesticide to air, in parts per million (ppm) or parts per billion (ppb). LC_{50}values are also determined for fish and aquatic organisms based on the concentration of the pesticide in water (http://www.ccohs.ca/oshanswers/chemicals/pesticides/health_effects.html - Accessed in September 2018).

a) Danger Poison

Is defined as a LD_{50} of less than 500 mg/kg and is considered high toxicity.

b) Warning Poison

Is defined as a LD_{50} from 500 to 1,000 mg/kg and shows moderate toxicity.

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c) Caution Poison

The caution sign is for LD_{50} from 1,000 to 2,000 mg/kg that show low toxicity.

Finally, LD_{50} greater than 2,500 mg/kg is referred to products with a very low toxicity.

4.4. Pesticide handling and personal protection

There are mainly three entrance ways of chemical substances in the body:

1. Accidental or deliberate ingestion;
2. Dermal, through handling, measuring and pouring the concentrate;
3. Inhalation of small particles or dust during handling and spraying.

Despite these three ways, the dermal exposure is the most common hazard. To avoid risks of contamination, the operator should use personal protective equipment, like masks, protective clothes and boots. This equipment should be in accordance with the label recommendation, should be comfortable and in good conditions.

5. Link to European commission data base about Integrated Pest Management

https://ec.europa.eu/food/plant/pesticides/sustainable_use_pesticides/ipm_en

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