INTEGRATED PEST MANAGEMENT

Research Study

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1. INTRODUCTION

Dependency on pesticides for protection of crops is associated with undesirable effects on the environment, health, and the sustained efficacy of their use. An aggressive use of pesticides on crops has developed resistance among the insect–pests, posing a serious threat to the rural economy in the country (Peter, 2005). Hence, this situation has highlighted the need to promote the concept of Integrated Pest Management (IPM) among the farmers. Integrated Pest Management (IPM) approaches are based upon the judicious mix of physical, cultural, biological and chemical control methods, employed to manage and control pests. It is an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices (Hoyt, 2001, Ofuoku et al.2008). IPM has come a long way since the introduction of "integrated control" defined as "applied pest control which combines and integrates biological, mechanical and chemical control".

The concept was initially developed by entomologists, who faced with indiscriminate broad-spectrum insecticide use and insect outbreaks caused by the elimination of natural enemies and the emergence of pesticide resistance. IPM now applies to all aspects of plant protection and creates synergies by integrating preventive methods drawing from a diverse array of approaches. It builds on agronomic, mechanical, physical, and biological principles, resorting to selective pesticide use when addressing situations that cannot be successfully managed with other tools. Reliance on a wide diversity of solutions is needed to ensure the long-term sustainability of control measures.

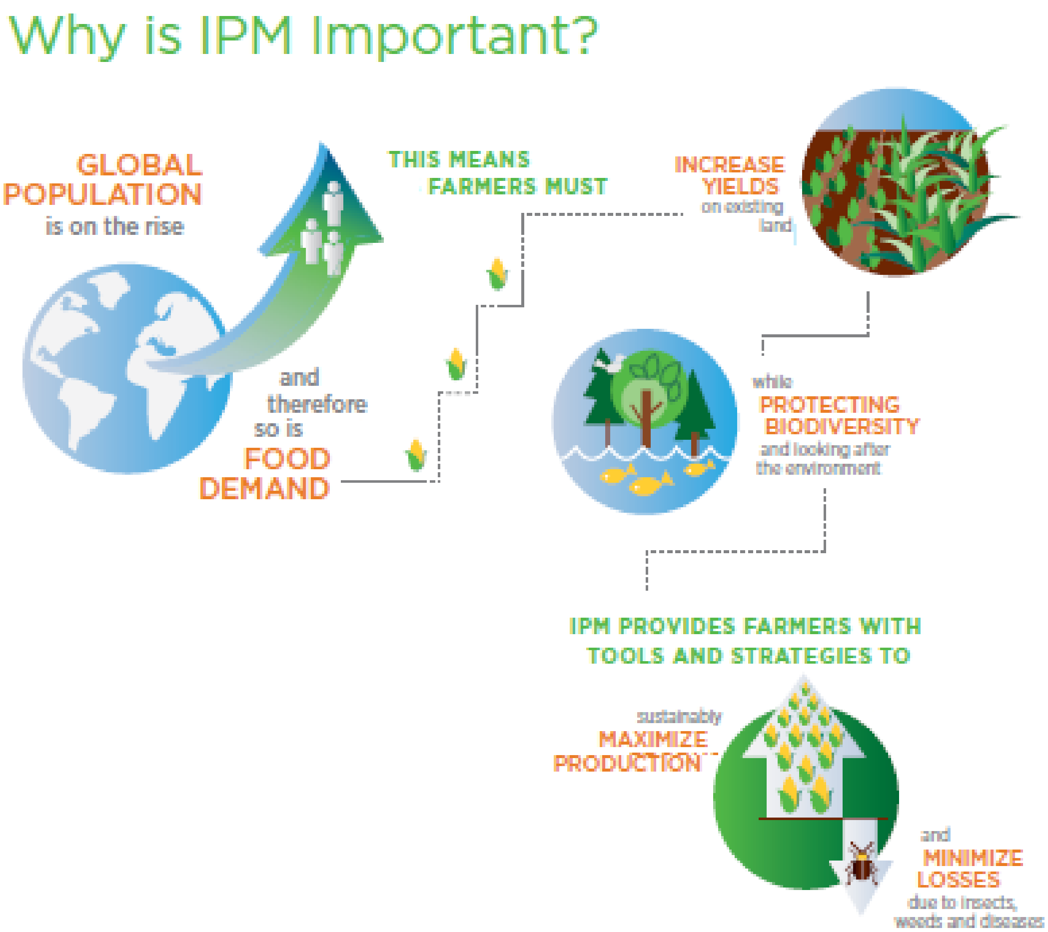
IPM programs use current, comprehensive information on the life cycles of pests and their interaction with the environment. This information, in combination with available pest control methods, is used to manage pest damage by the most economical means, and with the least possible hazard to people, property, and the environment. The IPM approach can be applied to both agricultural and non-agricultural settings, such as the home, garden, and workplace. IPM takes advantage of all appropriate pest management options including, the judicious use of pesticides.

In the developing countries, it was realized that IPM should be promoted among farmers by involving the agricultural stakeholders. In this regard, private sector was directed by the Government of Pakistan (1988) to provide the total package of plant protection advisory services, consisting of guidance on agronomic, biological and chemical protection practices, in addition to selling the products of their respective companies. It is need of the hour to take advantage of all appropriate, pest management options i.e. IPM, including but not limited to the judicious use of pesticides (Ofuoku *et al.* 2008). The farmers are now also using cultural, mechanical, physical, biological control in addition to chemical methods of pest control in Pakistan (Khaliq, 2005).

Why IPM Is Important?

The demands of a growing world population for food and fiber require farmers to produce more crops on existing farmland. To increase these yields requires continuous improvement of agricultural technologies to minimize crop losses. The challenge is to do this, while protecting the environment.

IPM is a big part of the solution. Increasingly it is being adopted in both developed and developing countries for long-term, sustainable agriculture that achieves adequate, safe and quality food production, improves farmer livelihoods and conserves non-renewable resource.



2. IPM – A PHILOSOPHY

2.1 Pest Management Strategy

Integrated Pest Management (IPM) is a philosophy that involves the management of a pest instead of controlling or eradicating a pest. It requires a greater knowledge of the pest, crop and the environment. Therefore, its strategy focuses on harnessing inherent strengths within ecosystems and directing the pest populations into acceptable bounds rather than toward eliminating them. This strategy avoids undesirable short term and long term ripple effects and will ensure a sustainable future (Lewis et al., 1997). IPM programs should be operated with “pest management objectives” rather than “pesticide management objectives”.

The foundation for pest management in agricultural systems should be an understanding and shoring up of the full composite of inherent plant defenses, plant mixtures, soil, natural enemies, and other components of the system. The use of pesticides and other “treat-the-symptoms” approaches are unsustainable and should be the last option rather than the first line of defense. A pest management strategy should always start with the question “Why is the pest a pest?”.

2.2. An integrated Process

Integration or compatibility among pest management tactics is central to Integrated Pest Management. Simply mixing different management tactics does not constitute IPM. Mixing the tactics arbitrarily may actually aggravate pest problems or produce other unintended effects. IPM recognizes that there is no “cure-all” in pest control (dependence on any one pest management method will have undesirable effects). Reliance on a single tactic will favor pests that are resistant to that practice. In IPM, integrated control seeks to identify the best mix of chemical and biological controls for a given insect pest.

2.3 Understanding Pest Biology and Ecology

The determination of the correct cause of pest problem and ecology is essential in manipulating the environment to the crop’s advantage and to the detriment of the pest.

2.4 Acceptable Pest Levels (Economic Threshold Levels)

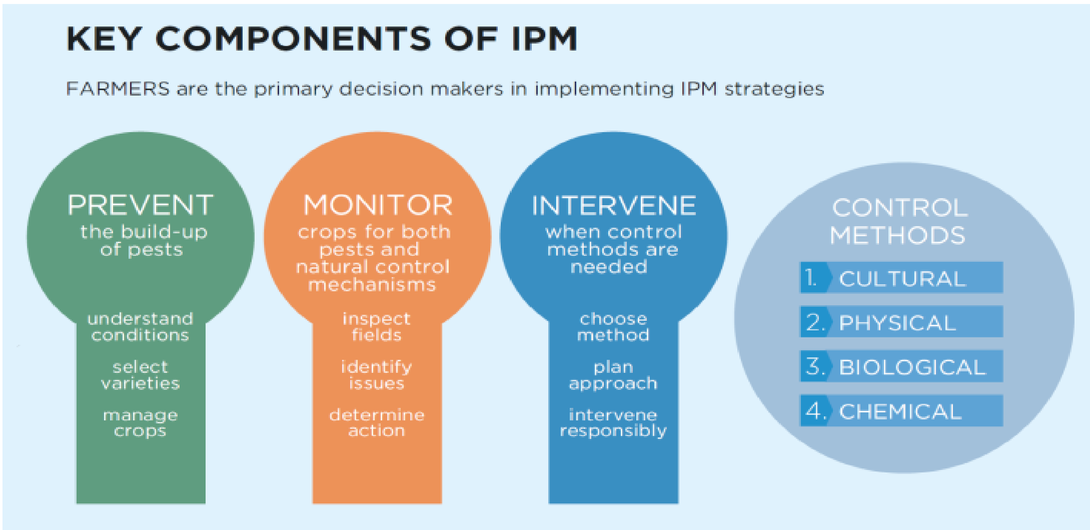
IPM recognizes that eradication of a pest is seldom necessary or even desirable, and generally not possible. The primary objective in pest management is not to eliminate a pest organism but to bring it into acceptable bounds (Lawal et al., 1997). IPM holds that wiping out an entire pest population is often impossible, and the attempt can be expensive and environmentally unsafe. IPM programmes initial task is to establish acceptable pest levels, called action thresholds, and apply controls where the thresholds are crossed. These thresholds are pest and site specific, i.e. it may be acceptable at one site to have for instance a weed such as white clover, but at another site it may not be acceptable.

2.5 IPM a Continuum, not an end

Agriculture is a dynamic system that continually changes to changing crop production practices. IPM must continually change to meet pest management challenges. IPM is a continuum that will change with time. Every farmer practices some type of IPM, as long as they make progress to better its management. As new pest control techniques are discovered, the producer and crop advisor must adapt their pest control program to reflect these changes.

3. IPM COMPONENTS

IPM requires competence in three areas: prevention, monitoring and intervention.



3.1 Prevention

Many aspects of crop management are designed to prevent initial outbreaks of insects, diseases or weeds. Practical strategies can be combined and optimized for an IPM program. The goal is to prevent pest populations from building up to economically damaging levels/Economic thresh hold level.

3.2 Monitoring

Observing crops determines if, when and what action should be taken to maximize crop production and quality. Decision-making tools range from pegboards to computers and trained local experts to remote-sensing technologies. Getting real-time information on what is happening in the field is ideal management of any crop which requires routine inspections to assess how well plants are growing and what actions need to be taken from seeding to harvest. Walking through a field involves scouting for pests and distinguishing them from non-pests and beneficial insects. Tools like pheromone traps, diagnostics and forecasting systems can assist with such monitoring in a timely and accurate way. IPM often requires collaborative decisions within a specific geography to provide effective control of pests. Some of these decisions need to be taken by national governments in relation to quarantine regulations and legislation, provision and training of advisory services and strategies for control of highly mobile pests like locusts.

3.3 Intervention

Reducing economically damaging pests to acceptable levels may involve cultural, physical, biological and chemical control measures individually or in combination. Costs, benefits, timing, labor force and equipment as well as economic, environmental and social impacts all have to be taken into consideration.

3.4 Agronomic Components in IPM

Agronomic adjustments like alteration in micro climate of plants, changes in sowing time, plant population are necessary for higher yield and preventing mass multiplication and spread of pest, diseases and weeds by modifying the crop micro climate, following are the important Agronomic components of IPM.

a. Land Preparation

Tillage can be beneficial because it disrupts the life cycle of insect pests and can expose pests to predators and the elements. Fall tillage can destroy crop debris that serves as over wintering sites for flea beetles, corn borers, squash bugs, and other insect pests. However, excessive tillage can accelerate the decomposition of soil organic matter and deplete the food source that soil microorganisms depend on, decreasing their ability to disrupt pests. Excessive and untimely tillage can also contribute to soil erosion.

b. Cultivars Selection

Cultivars with high yield potential and quality without resistances to pest and disease cannot reach at their potential. Therefore, selection of cultivars having resistance against pest and disease can bring down the pest and disease incident considerably.

c. Time of Sowing

As weather influences developmental of plants as well growth and survival old pest and disease, serious setback occurs when the weather condition are favorable to coincidence of the susceptible crops stages with highest incidence of pests and disease. Therefore, adjustments in sowing time is often restored to an agronomic strategy to escape the crop loss. In general early sowing in the season concidерly reduces the pest and disease attack.

d. Plant Population

Plant population per unit area influences crop microclimate. Dance population of plants restricts wind movement within plant canopy leading to high humidity. This creates congenial condition for pest and disease multiplication. Keeping the plant population constant, inter and intra row plant population can be adjusted to minimize the humidity buildup within the crop canopy.

e. Intercultivation

Mechanical or manual Intercultivation suppresses the pest, diseases and weeds. Weeds that serve as alternate host to insect and pathogen can be efficiently controlled with Intercultivation. Microclimate conductive to pest and disease buildup is also distributed by Intercultivation.

f. Manures and Fertilizers

Excessive nitrogen application increases susceptibility of crop to sucking and leaf eating pests because of the succulence to the crop conferred by nitrogen. High rates of nitrogen than the recommended rate to hybrids without corresponding increase in phosphorous and potassium is the main factor for heavy pest and disease incidence. It is know that balance fertilizer application helps the crop to tolerate pest and diseases considerably.

g. Irrigation and Drainage

Modification of natural water supply changes the biological equilibrium between crop and its pest and disease. Irrigation can reduce the soil inhabiting pests by suffocation or expositing them to soil surface to be preyed upon by birds. Granular insecticide and herbicide applied in the soil do not become available until dissolved in the water. Systemic chemical are not absorbed by plants in the absence of adequate soil moisture. Water logged or saturated soils create microclimate on the crop productive to building pest and disease.

h. Crop Rotation

Advantages of crop rotation have been well known to us. It serves the purpose of plant protection by reducing the nutrition of pests in every subsequent year or season or totally deprives them of food. It reduces the amount of initial infection by diseases and ensure unfavorable stratum for its development.

i. Mulches

Mulches, both organic and synthetic, can help reduce insect pest problems. Plastic mulch is often used to speed early season crop growth that makes plants better able to tolerate insect feeding. Reflective mulch repels thrips and aphids and can reduce the incidence of insect transmitted virus diseases in vegetable crops

4. IPM PROCESS

IPM is applicable to all types of agriculture and sites such as residential and commercial structures, lawn and turf areas, and home and community gardens. The process includes:

4.1 Proper Identification of Pest Damage and Responsible Pests

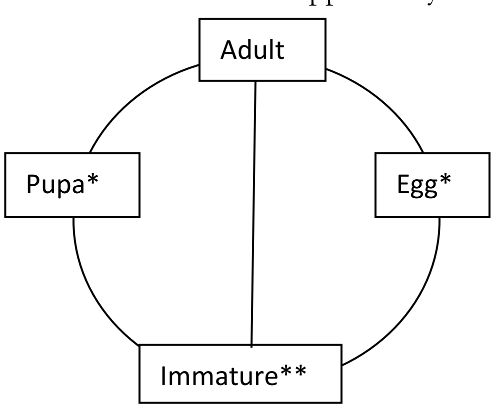
Identification of pest must be the first objective of an IPM program. When the identity of a pest is unknown, then, a strategy built to control the pest cannot be developed, primarily, because pest species or strain (biotype) might behave differently. Thus, a solid foundation must be built on systematic, taxonomy, etiology, and spatial distribution (Irwin, 1999). Cases of mistaken identity may result in ineffective actions.

4.2 Pest and Host Life Cycles Biology

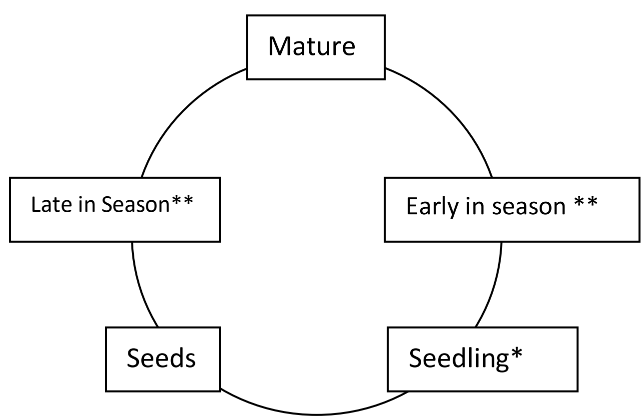
The interactions between crop and pest (as well as the environment) are very important. To develop an efficient IPM programme, literature and other data sources about the pest, pest's life cycle, host range, distribution, movement, and basic biology should need to be researched and understood.

Most pests have certain weak points or "windows of opportunity" during their life cycle when they are the most vulnerable to control. For insects, these windows are immature life stages. Weeds are typically easiest to control during their seedling stage, early in the season when they are just beginning to grow (annuals) or late in the season when they are preparing for dormancy (perennials). Diseases are often easiest to control by using preventive or early intervention tactics before the disease begins developing or becomes established. To optimize management of a pest, control tactics should be targeted for these weak points.

Insect Life Cycle
"Windows of Opportunity"



Weed Life Cycle
"Windows of Opportunity"



Insects and weed life cycles.

*Indicates weak points in pest life cycles that should be targeted for control,

** indicates the general level of weakness

4.3 Monitor or Sample the Environment for Pest Populations

After correct identification of pest, monitoring must be done before it becomes a problem. Sampling and monitoring methodologies must be designed and tested to provide the ability for assessing instantaneous and dynamic aspects of the pest's density, activity, or incidence (Irwin, 1999). During sampling and monitoring, understanding of environmental effects on pest and crop development are very important. These interactions allow crop advisors to develop a strategy on basis of changing conditions of climate. Environmental influences like drought stress influences pest management recommendations.

4.4 Choose an Appropriate Combination of Management Tactics

The word 'integrated' in IPM referred to the simultaneous use or integration of any number of tactics in combination, with focus on maintaining a single pest species below its economic injury level. Several of the tactics are compatible, but some are not. Certainly the tactics of biological control, habitat manipulation, and legal control go alongside. The tactic of host resistance can stand alone or be combined with the other tactics.

4.5 Evaluate and Record Results

Evaluation is often one of the most important steps in Integrated Pest Management (Bennett *et al.*, 2005). It is the process of reviewing an IPM program and recording of results.

5 ADVANTAGES AND DRAWBACKS

The benefits of Integrated Pest Management are immense directly to farming and indirectly to society.

- **a.** Integrated Pest Management (IPM) protects environment through elimination of unnecessary pesticide applications. In IPM, pesticides are used at the smallest effective dose when other methods of pest control have failed. Also, they are used in bringing a pest organism to acceptable bounds with as little ecological disruption as possible.
- **b.** IPM improves profitability of the growers. Since IPM programme applies the most economical management pest tactics, profitability is ensured for the grower or farmer.
- **c.** It reduces risk of crop loss by a pest. Applying pest management and monitoring tactics will also ensure the reduction of crop loss or damage by pests.
- **d.** Long term sociological benefits of IPM would also emerge in areas of employment, public health, and well being of persons associated with agriculture.

In spite of many benefits of IPM stated so far, there are also some drawbacks of it:

- a. An IPM program requires a higher degree of management
- b. Making the decision not to use pesticides on a routine or regular basis requires advanced planning and higher degree of management. This planning includes

attention to field histories to anticipate what the pest problems might be, selecting crop varieties which are resistant or tolerant to pest damage, choosing tillage systems that will suppress anticipated pest damage while giving the crop the greatest yield potential.

6 GENERAL PEST MANAGEMENT TACTICS

The easiest, lowest cost and often most reliable way to avoid many pest problems is to provide a healthy environment that discourages pest activities and/or reduces the host's (plant, animal, or ecosystem) susceptibility to damage.

Examples of some general pest management tactics:

6.1. Cultural Controls

a. Land/Water Management: Maintain the ecosystem in a healthy state to minimize the competitiveness of pests. In some situations water levels can be regulated to reduce pest problems (e.g., mosquitoes, aquatic weeds, etc.). Avoid over or under-watering plants to minimize stress.

b. Sanitation: Remove (prune, gather, burn) plant parts and debris that can serve as protective or over wintering sites for many pests.

c. Habitat diversification: In monoculture situations (e.g., agricultural fields, orchards, landscapes, etc.), diversification of vegetation in the habitat may subsequently increase the diversity of animal life in the habitat. Such diversification may attract beneficial and pest organisms, the specific approach should be tailored to the specific situation.

d. Tolerant / Resident Species and Cultivars: Select insect and disease resistant species and cultivars of plants whenever they are available. For perennial plants, select species and cultivars that are cold hardy (for cold climates).

e. Soils and Nutrition: Although you cannot change the soil type in an area, there are some practices you can follow to improve growing conditions for plants. Proper fertilization is important, but over-fertilization can lead to excessive, lush growth that can be attractive to aphids and other foliage pests. Increasing organic matter of soil where it is low can improve the growth and health of plants.

6.2. Mechanical Controls

a. Hand Removal: Hand-pulling of weeds or other pests physically removes them from the situation.

b. Removing Weeds: Mowing down weeds, especially before they produce seeds, can be a very effective management tool.

c. Traps: Attractive traps can be used to mass trap and remove pests from the environment or to monitor their activity so that control actions can be appropriately timed. Traps are primarily used for insect and vertebrate pests, and for some disease pests. Attractive traps typically use visual cues (color) and/or odors (pheromones, food baits) to attract pests to them. Passive traps may be placed in areas of common pest activity or use wind currents to catch pests.

d. Physical Barriers: There are many types of physical barriers that can be used to block or disrupt the movement of pests. For example, sticky bands placed around the trunks of trees can prevent some mite and insect pests from crawling up into trees.

6.3. Biological Controls

In the simplest terms, biological control is the reduction of pest populations brought about through the actions of other living organisms, often collectively referred to as natural enemies or beneficial species. Virtually all insect and mite pests have some natural enemies, although not all are effective in suppressing pest populations. Learning to recognize, manage, and conserve natural enemies can help reduce pest populations and maintain them below economic levels, thus reducing crop losses and the need for more costly control measures that may also have undesirable environmental side-effects. Biological control is often most effective when coupled with other pest control tactics in an integrated pest management (IPM) program. Practices that are often compatible with biological control include cultural controls, crop rotation, planting pest-resistant varieties, using insecticides with selective modes of action, or spot treatments that leave untreated areas to serve as refuges for natural enemies.

Effective biological control often requires a good understanding of the biology of the pest and its natural enemies, as well as the ability to identify various life stages of relevant insects in the field.

6.4. Chemical Controls

- **Synthetic Pesticides:** Human-made in the laboratory; chemically joined compounds or elements (e.g., most herbicides, diazinon, malathion, carbaryl, benomyl, streptomycin, etc.)
- **Organic Pesticides:** Derived from plant, animal, or naturally occurring rock or petroleum oil sources (e.g., rotenone, sabadilla, ryania, nicotine sulfate, pyrethrum, soaps, oils, microbial agents, lime sulfur, copper, etc.)
- **Biological Pesticides:** A subset of organics that specifically refer to products developed from naturally occurring microbial agents such as bacteria, viruses, and fungi (e.g., *Bacillus thuringiensis*, a bacterial pathogen of many insects.)
- **Insect Growth Regulators (IGRs):** Kill insects by interfering with the normal processes of juvenile development; common IGRs disrupt either the insect's hormonal process or exoskeleton development.

7. Drone Technology in Agriculture

The progressive automation of agricultural processes has significantly improved the productivity of agriculture labour, shifting masses of workers into other productive industrial areas. Since then, scientific advances in chemistry, genetics, robotics and many other applied sciences have fuelled the accelerated development of agricultural technology. In effect, in recent years agricultural production has increased substantially.

One of the latest developments in the agriculture sector, is the increase in the use of small, Unmanned Aerial Vehicles (UAVs), commonly known as drones, for agriculture. Drones are remote controlled aircraft with no human pilot on-board. These have a huge potential in agriculture in supporting evidence-based planning and in spatial data collection. Drones are used in various fields ranging from the military, humanitarian relief, disaster management to agriculture.

There are a number of applications of drone technology convergence with advanced image data analytics that can be utilized in the agriculture industry. The use of drones in agriculture is extending at a brisk pace in crop production, early warning systems, disaster risk reduction, forestry, fisheries, as well as in wildlife conservation, for example. UAVs can be used in livestock management, fisheries, in surveying, land tenure, land use planning, stockpile estimation, crop damage assessment, scientific research, inspection of fixed and mobile assessment etc., real estate and tourism marketing, media production, small cargo delivery, and more.

Drones are used to gather a variety of image-based data about the condition of crops, fields and livestock – including:

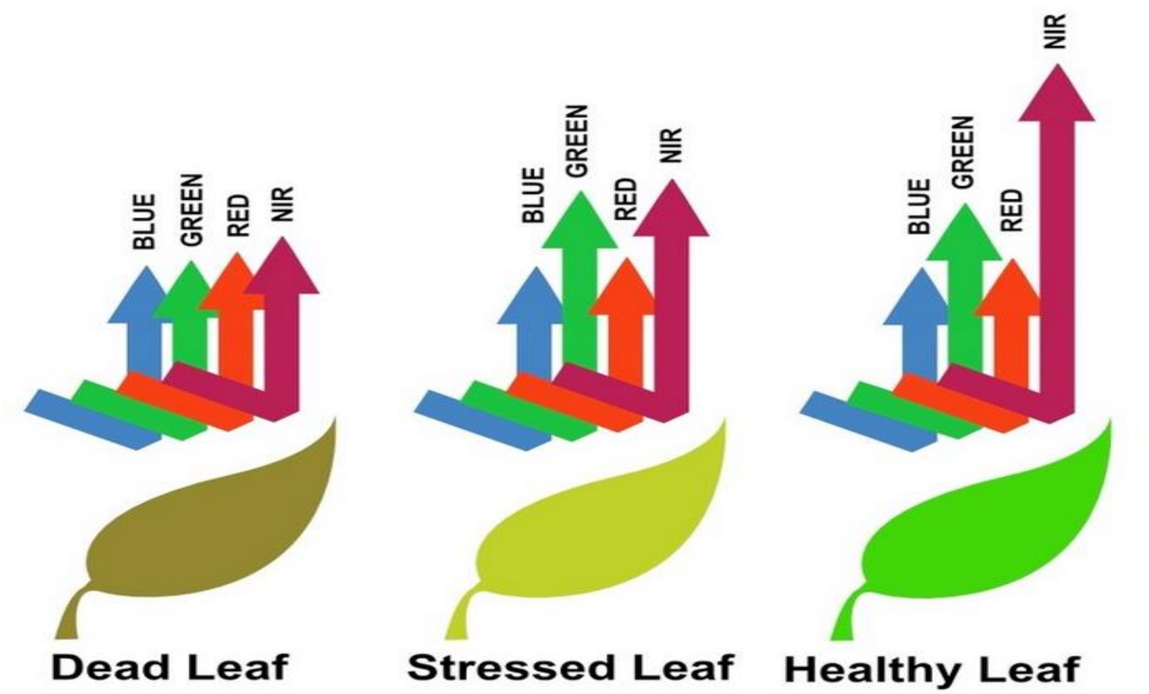
- Plant height
- Plant count
- Plant health
- Presence of nutrients
- Presence of disease
- Presence of weeds
- Relative biomass estimates
- 3D / volumetric data (piles, patches, holes and hills)

For livestock operations, drones can be used to monitor the location, status and movement of animals over time with more frequency and at a lower cost than other means.

How Flying Cameras Measure Crop Health?

Most agriculture drones depend on multi-spectral imaging to spot problems with a crop's health; specifically, they look at changes over time in visible light (VIS) and near-infrared (NIR) light reflected by crops. These images are taken over time by drones, manned aircraft or satellites. It is possible to detect plant health from these images because plants reflect different amounts of visible green and NIR light, depending on how healthy they are. By measuring the changes in visible and NIR light reflected from a crop, we can spot potential health issues.

This image explains the general idea:



7.1 Applications of Drone Technology

The majority of applications are based of drones as a mobile, aerial platform for advanced image data acquisition. The most established application based on drone-acquired image data is to assess the health of crop vegetation. This unmanned airborne platform is equipped with infrared cameras which can develop the Normalized Difference Vegetation Index (NDVI). The NDVI is a view of solar radiation absorption intensity made by plants of certain area. This method has been widely used for decades based on satellite or plane-borne cameras, but the resolution of the resulting products has been insufficient to map fields, precisely, not to mention specific plants.

However, drone technology as a platform for image data acquisition has brought the NDVI mapping capabilities to a completely new level of accuracy making it possible to monitor the condition of not only plants, but also specific parts of plants. This level of information enables early identification of pests, diseases and pests. The precisely mapped and identified issues within a certain area can be addressed with precise applications of fertilizers, pesticides or herbicides. Drones such as the DJI Agras MG-1 (DJI, 2017) are designed for precision variable rate application of liquid pesticides, fertilizers and herbicides.

The fusion of advanced aerial information acquired with the help of drones with data from other sources such as weather forecasts and soil maps can help to refine the final information and enable the farmer to take full advantage of the farm and maximize the yields to their natural limits. Nowadays, drone technology is more and more often employed in insurance, with agriculture claims management being one of the key applications.

Crop Spraying

Another application of drone technology in agriculture is crop spraying. The technology was first implemented in Japan in the 1980s when unmanned helicopters equipped with spraying equipment and pesticides tanks were used to spray crop fields. Typical modern day spraying drones have tank capacity of over ten liters of liquid pesticide with discharge rate of over a liter a minute, allowing them to cover a hectare in ten minutes. However, to leverage drone technology fully as a spraying platform, the spraying needs to be paired and synchronized with the above-mentioned imaging, processing and automated analytics capabilities in order to address the affected areas or plants with precision. Such an approach would lead not only to the improvement of dosage in the affected areas, but also to a reduction in the overall use of chemicals within the area.

Soil and Field Analysis

Drone technology can be used to assess soil condition and thus potential yields. The key application in assessing soil condition is actual 3D mapping of the terrain with precise soil color coverage. This helps to assess the soil quality as well as the moisture and water flow precisely. This mapping also helps in seed sowing, irrigation management and nutrient management. During the vegetation period, cyclical flights can be employed to monitor crops and the agriculture process and swiftly react if issues are observed. This can instantly be done by automated drones equipped with spraying capabilities.

Irrigation:

Drones with hyper-spectral, multispectral, or thermal sensors can identify which parts of a field are dry or need improvements. Additionally, once the crop is growing, drones allow the calculation of the vegetation index, which describes the relative density and health of the crop, and show the heat signature.

Forestry:

Drone technology can be used in forest management operations like monitoring of illegal activities and encroachment. It also assist in collecting various forest metrics such as carbon sequestration, tree canopy analysis, conservation features, tracking native species monitoring biodiversity and ecological landscape features. For example, Novadrone (Novadrone, 2017) uses drone technology to improve forest management and operational planning, including the monitoring of illegal activities and encroachment.

Fisheries:

In the fisheries sectors, the governments of a number of nations including the Republic of Palau, Belize, Jamaica, and the Republic of Costa Rica are now using drones to detect illegal fishing and aid in prosecution of offenders. The government of Belize is using drones to enforce fishing regulations over the Glover's Reef Marine Reserve and other marine protected areas in the waters off Belize (Howard, 2016).

7.2 Advantages

There are three main advantages in using an Unmanned Air System UAS for disease and stress detection.

1. The first advantage is cost. Collecting images and data are less costly by UAS than by satellite or manned airplane.
2. The second advantage is timeliness. UAS have the ability to fly and capture images on short notice or during small windows of opportunity. This is particularly important for applications in agriculture in which timeliness in collecting images is often critical.
3. The third advantage is the ability to collect high-resolution aerial images by flying at a lower altitude, which results in much clearer data and images. For some diseases, it is necessary to see an individual leaf on a tree.

8. IPM IN PAKISTAN

In Pakistan, research and development on IPM was initiated in 1971 by PARC-IIBC station, Rawalpindi (now CASI Biosciences Regional Center Pakistan). A seven years project on cotton bollworms, a three year project on cotton whitefly and an institutional three year support project on IPM, funded by Asian Development Bank, where the first IPM project. Similarly other IPM activities like introduction of natural enemies of sugarcane pyrilla in Sindh and KP, cultural control of Gurdarspur borer in sugarcane, pheromones (methyl eugenol) to control fruit fly and effective environment friendly use pesticides against cotton pests were successfully carried out on large scale by various researches.

To overcome/reduce the misuse of pesticides and their negative impacts on the society IPM has been identified as a key element for sustainable agriculture development in its policy and strategy on agriculture by the Government of Pakistan. In this regard, a consultative process among potential stakeholders was started;

which launched the National Integrated Pest Management Programs (Nat-IPM) in December 2000. These Nat-IPM programs were dealt by Department of Plant and Environment Protection (DPEP), NARC Islamabad in past. However, no updated data is available yet on the achievement of the targets and outcomes of the Nat-IPM.

8.1 National Integrated Pest Management Programs

According to Pakistan Agriculture Research Council (PARC), two projects were implemented under National IPM Program through Farmers Field School approach (FFs):

1. "Management of Cotton Leaf Curl Virus (CLCuV) disease through Integrated Pest Management (IPM) Techniques by adopting Farmers Field School (FFS) approach"
2. Management of CLCUV Disease Through Integrated Pest Management (IPM) Techniques by Adopting Farmers Field School (FFS) Approach" ICARDA-USDA Project 2011-2015

Achievements

- Farmers' income was increased up to Rs. 100,000 by the adopting improved technology include pruning and canopy management trials.
- A colourd guide was developed and distributed to more than 5,000 growers to identify and manage mango fruit sudden death.
- Almost 400 growers from both Punjab and Sindh provinces got benefits from training at 41 demo Orchards.
- More than 487 growers, 150 Field Assistants and 150 Agriculture Extension Officers were given training on canopy management, budding and grafting and identification of field diseases of mango.
- Creation and improvement in knowledge and awareness as well as capacity building of cotton growers regarding integrated management of CLCuV through establishing 321 Farmer Field School (FFS) and 279 Participatory Learning Groups (PLGs).
- Major and successful CLCuV management obtained by the use of macro and micronutrients (foliar application).

8.2 Current Research Activities of National Agriculture Research Center (NARC) in Respect of IPM

- Induction of Host Plant Resistance
- Control of Insect Pest through biological measures
- Management of Stored Grain Insect Pests
- Integrated Management Strategies for Fruit fly

Host plant resistance

- Established laboratory for mass rearing of maize stem borer (MSB) for screening of maize lines/varieties/hybrids under artificial infestation against MSB.
- Evaluated maize different maize lines hybrids and OPVs for resistance susceptibility against MSB.
- Evaluated wheat varieties/advanced lines for resistance under artificial infestation in the lab and under natural conditions in the fields.

Biological control of insect pest

- Establishment of an Insectary-Biological control lab to facilities research and development of biological control of insect pest at NARC University Campus
- Developed mass rearing techniques of nymphal parasitoids, *Encarcia cibensis* and its host, white fly (*Bemicia tabaci*)
- Provided technical assistance and feasibility for Establishment of biological control labs for Mass production of egg parasitoids of sugarcane borers, *Trichgrama spp.* in Private sectors (5 sugar mills 3 institutions)
- More than 15 laboratory technicians from Sugar Industry Research institutes were trained in rearing technique of insect bio-control agents and their host

Management of stored grain insect pests

- Establishment of laboratory for culture development of 04 different stored grain insect pests
- Screening of different stored grain commodities against different stored grain insect pests

Future Plans

- To develop IPM strategy for the control of insect pests of fruits, vegetables and cereal crops
- Efficient and quality rearing of insect biological control agents (parasitoids & predators)
- Screening of different genetic lines/varieties of field crops against their insect pests
- Control strategies for stored grain pests to reduce the storage losses in public and private sector
- Testing of bioactivity of plants against insect pests
- Transfer of generated knowledge to the stakeholders

8.3. Current Projects of Punjab Agriculture Department

1. A project on "**Management of fruit fly with reference to non-conventional methods**" was in practice from FY 2014-15 to 2017-18 with an amount of Rs. 227.610 Millions. The objective of the project was given below:

    - To introduce and promote integrated plant protection management (IPPM) techniques against fruit fly
    - To reduce fruit-fly management cost and increase income in natural eco-system (Mango, Citrus & Guava etc.).
    - Provision of Methyl Eugenol, traps and Protein Hydrolysate at subsidized cost to the farmers in a transparent manner
    - To comply Sanitary and Phyto-sanitary measures of WTO linked with Mango, Citrus and Guava Trade
    - To strengthen Biological Laboratories for rearing of fruit fly predators and releases in the orchards.
    - Capacity Building of extension and farmers on Biological, Cultural, Mechanical and Chemical control of Fruit Fly
    - Collection for identification of citrus & Mango fruit fly species
    - Development of Bio-rational modules for the management of fruit fly

2. A project of **"Community Based integrated Management of Pink Bollworm (PBW) and Provision of missing facilities to Pest Warning Wing** was started from 2016-17 to 2018-19 with the cost of Rs. 96.232 Million. The objectives of the study are given below:
    - Demonstration for management of pink bollworm to farmers through Gossyplure (Ropes) and Sex-Pheromone traps installation
    - Field demonstrations to promote a viable component of IPM techniques for effective PBW control and conservation of natural enemies.
    - Communication with mobile alerts to farmers and policy makers about the hot spots identified manually as well as on the basis of eco-biological prediction models.
    - Increased farmers income through increased crop productivity, diversified agricultural practices.
3. Another project of "**Development of Integrated Management of Citrus Orchards to Enhance the Yield and Improvement of Fruit Quality**" was started from 2016-17 to 2018-19 with the cost of Rs. 28.429 million. The objective of this experiment are given below:

    - Enhancement of citrus yield.
    - Improvement of quality of citrus fruit (Kinnow) overcoming the disease.
    - Integrated management of citrus orchards.
    - Field demonstration of trials at farmer orchards to disseminate developed management

8.4 Current IPM Programs of Sindh Government

To achieve the goal, the Agriculture Extension Worker are performing their duties to disseminate the timely seasonal information amongst the growers for cultural practices; proper seed requirement, timely sowing, balanced and efficient use of fertilizer, efficient/judicious use of irrigation water, pesticide use, effective crop management, harvesting, threshing and storage / marketing etc.

Some activities related to IPM in sindh are given below:

- An Integrated Pest Management (IPM) program has been launched in cotton, wheat, Rice, Sugarcane, Fruits and Vegetable crops growing areas to rationalize the use of pesticides in the province.
- Pest scouting program launched in cotton and rice growing districts.
- New technologies, compost Mannuring, Effective Microorganism (EM) technology, integrated pest management, laser leveling, cultivation on ridges, bed and furrows etc. are being disseminated among farmers.
- Pest scouting program is launched in cotton and rice growing districts.
- Integrated Plant Nutrient & Soil Management technology is being disseminated in the area of Water Boards under World Bank Assisted Project Sindh on Farm Water Management Project.
- To minimize the use of pesticides; with the collaboration of PARC, an IPM programme has been launched in cotton, mango, vegetables and rice crops with the collaboration of PARC to minimize the use of pesticides.
- Integrated Plant Nutrition Management technology is being disseminated through demonstration plots in district Khairpur, Naushehroferoze, Shaheed Benazirabad, Sanghar, Matiari, Thatta, Badin and Mirpurkhas.

9. CASE STUDIES

- Mallah G. H and Akram K.K, (2007) did an experiment on establishment of integrated pest management (IPM) in cotton through farmer field school (FFS) in sakrand, Sindh, Pakistan. The aim of this research was to compare the farmers' practices versus IPM techniques and to motivate growers towards the implementation of the Integrated Pest Management (IPM) approach. They utilized NIAB 78 seeds and trial was sown on 25-5-2003. To record pest and their natural enemies, observations were recorded at weekly intervals. Common stick sample method was used and 4 samples per plot were taken.

  From this experiment they concluded that Farmers Field School is the best approach to transfer technology to farmers about IPM. Results showed that showed 65% improvement regarding pesticides hazards, 50% improvement about selection of good quality seed, 65% improvement in identification of insect pests of cotton, 50% improvement about identification of natural enemies and about cotton contamination 75% improvements observed. IPM plot provided (25%) more yield and (38.03%) profit increase over growers plot. The IPM approach has many more long-term advantages/benefits than only relying on chemical control method.

Which do not only enhance the cost of production but the indiscriminate use of pesticides creates many other problems like, degradation of environment, enhancement in pollution, resistance to pesticides, outbreak of secondary pests etc.

- Khan A., et al (2007) applied an IPM program on cotton producing areas of Sindh with the objective to make assessment of change in knowledge and practices of farmers on plant protection measures, number and doses of chemicals used, toxicity of pesticide use, estimation and attitude towards environment. Additionally, improvement in biodiversity, preservation of soil health and water quality, human and animal health gains, empowerment of farmers in decision-making on plant protection measures was also assessed during post-FFS impact assessment study. In the first phase of the survey, they collected data from Khairpur district. At second stage four FFS villages planned in sukkur district.

  They found that Human and animal health hazards and treatment cost was reduced due to less use of less toxic chemicals. The health precaution score for pesticide spraying workers and cotton pickers improved slightly and needs special consideration during FFS-follow up activities and ToF trainings. Attitude towards environment, soil fertility management and biodiversity has improved considerably. These changes in farmers' perception directly benefited the communities through cost reduction and health and environmental improvements. Green manuring and compost making practices would help in improving village level sanitation through recycling agricultural waste and its utilization to manage fertility for sustainable production.

- A study sustainable cotton initiative (SCI) had been started in major cotton producing areas of Pakistan for sustainable production of cotton with minimum use of chemicals against cotton pests. This study was conducted at Institute of Agricultural Extension and Rural Development, University of Agriculture, Faisalabad, Pakistan during 2014-15 to analyze the impact of SCI on farmers' attitude regarding insect/pests risk management. In all 400 respondents (registered SCI cotton growers) were selected randomly from two cotton producing districts of the Punjab province (Toba Tek Singh and Bahawalpur). The results revealed significant impact of training regarding insect/pests risk management. Majority (70.5%) of respondents thought that skill about insect pest control had changed and only small number (18%, 17.75%) of the respondents perceived that knowledge about insect pest control and sustainable cotton production had changed to some extent because of SCI trainings. Famers were found better knowledgeable in recognition of insect/pests (harmful and beneficial) and were applying better strategies for pest control. Decrease in pesticide consumption is indeed a significant achievement providing security to crops and human health as well.

- An assessment on Impacts of Farmer Field School (FFS) approach on IPM practiced in cotton zone of Punjab and Sindh on livelihoods of cotton growers were made at University of Agriculture, Faisalabad during the year 2014. Four districts Vehari, Lodhran, D.G Khan and Bahawalpur were selected through stratified sampling technique. Data were collected through structured interview schedule and analyzed through Statistical Package for Social Sciences (SPSS). Results showed that in the treatment group majority of the farmers (24.6%) had primary education. Similar trend was also found in exposed group where majority (23.8%) of the farmers had primary educational level. But in the control group majority (27.5%) of the farmers had matriculation. This showed that educational status of control was better than the other two groups. Majority (>50.0%) of the respondents had land up to 20 acres in all the three categories. It was also concluded that majority of the respondents (about 50.0%) grow cotton on their fields but difference was recorded in the agronomic practices adopted by them. This showed that FFS approach had impact on the knowledge of the cotton growers in variety of cotton cultivation practices. This entails the FFS based IPM program which helped farmers understand the concepts behind the program.

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