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Integrated Pest Management (IPM) – A Constructive Utensil to Manage Plant Fatalities.

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Short Communication

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ABSTRACT

Insect pests are a serious menace to crops and inflict damage to plant leaves, stems, flowers, seeds and roots. For farmers in low input agricultural systems in developing countries like Pakistan, Integrated Pest Management (IPM) is potentially an effective tool of insect pests control. IPM is generally inexpensive, durable, non-polluting and locally improvable, which make it sustainable component of an integrated crop protection. Therefore, the present article deals with possibilities and suggestions for integrating pest control options to have additive or synergistic reduction of insect pest densities and protection of crop durability.

INTRODUCTION

At present, total worldwide food losses from pests are estimated to vary from 26 to 40% of the attainable yield in major food and cash crops [1]. Pre harvest losses alone, from insects, plant pathogens and weeds are estimated at about 30%. Additional post harvest losses from microorganisms, insects and rodents range from about 10 to 20% [2]. Surely this is a loss that we cannot afford as we face world food shortages and an ever-increasing world population. An alternative approach to the management of pest populations and on which holds great promise for reducing losses from pest attack has been to stress the integration of a multiplicity of methods into a flexible programme. This approach known as integrated pest management (IPM) may be described as a broad ecological attack, combining several tactics for the economic control and management of all pest populations. It 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 [3]. Recently, IPM is commonly referred to as a "crop protection/ pest management system" with implication for both methodological and disciplinary integration in the socioeconomic context of farming systems [4]. Integrated control practices rely on combinations of biological, chemical and cultural control methods, as well as the use of resistant or tolerant plant varieties [5]. IPM is a science-based decision-making process that identifies and reduces hazards from both pests and pest management-related strategies [6]. By bringing technology to farmers, IPM has been instrumental in increasing agricultural productivity and sustainability and reducing pesticide misuse in the developing world [7]. Knowledge of the interrelationships between pests, crops and the environment is needed in order to devise the best combination of techniques, which will give adequate control of the pest and produce minimum impact on non-target organisms and the environment. Management of the pests heavily depends exclusively on insecticides (4 to 10 sprays) which in due course of time have graduated from organochlorine to synthetic insecticides. Due to significantly assured success based on chemicals, research on natural enemies of pests and its field application received a back seat. Quest to harvest more and large scale farm mechanization led to adoption of modern farming systems which undoubtedly heavily rely on monocultures, zero tillage and on chemical pesticides, has added up new pest problems. Pretty *et al.* [8] have also shown that IPM technologies have affected a decline of 71% in pesticide use, while yields increased by 42%.

Pakistan being a diverse country, at this juncture both types of cultivation viz., monoculture as well as strip cropping is in practice. Pests' complex out breaks are more in monocropping than mixed cropping system and have led to indiscriminate application of chemical pesticides, which has been over simplified by tractor mounted spray equipments. Apart from causing temporary reduction in yield losses, it has created socio-economic problems. Although pesticides will continue to be a component of pest management, following their application, encourage frequent pest problems, resistance to pesticides, human health concerns and environmental hazards. The development of a strategy that may conserve and maximize the abundance as well as effectiveness of natural enemies will be crucial in the management of insect pests. There are many classical examples, which have shown that increased habitat diversity in crops can increase population densities of locally available predators to enhance biological control of pests. Predatory beetles (*Campoletis sonorensis*) have been reported to respond to volatile chemicals emanating from specific plant tissues and few (*Macrocenrus grandii*) are attracted to volatile chemicals from under managed plants. The search for the right habitat is imperative because like all living organisms, insect parasitoids and predators have requirements for resources, other than hosts. However, these other sources may or may not be found in the same habitat in which hosts are found. Optimal microclimatic conditions for a given parasitoid, nectar sources, and shelter may exist in some host habitats (crop systems) but not in others. One assumes that the habitats in which parasitoids find hosts also provide other needed requisites at optimum levels. There is little empirical or experimental data, to support this to be true, even for unmanaged eco-systems. The objective of this study is also to ensure that the occurrence of as many essential parasitoid resources and hosts coinciding with time and space. The conservation of natural enemies by the direct enhancement of vegetation diversity has been a subject of intense study for many years. Earlier, it was hypothesized that lower levels of herbivores in diverse agro ecosystems were a result of higher levels of natural enemies "enemies hypothesis". Much needed attention was given on the nature of the relationship between pest, crop and non-crop plants, and their physical environment. As a result habitat manipulation seeks to manage these relationships to enhance the impact of natural enemies on pest population. Indeed this approach is one of the key elements in the use of indigenous natural enemies in IPM. Conservation which involves protection and maintenance of natural enemy population has proved crucial for maintaining local/ native natural enemies in ecosystems. Review revealed that conservation involved modifying pesticide application practices so that they occur only when the pest population exceeds specified levels, however, conservation of natural enemies can also be achieved by changing the active ingredient, rates, formulations, timing, and location of pesticide applications or by maintaining refuges. It is probable that the most dramatic increase in the utilization of biological control in agricultural IPM systems could come through the judicious use of selective pesticides in conjunction with effective natural enemies in location specific cropping systems. While, knowledge of pesticide selectivity is available, it is inadequate to generally allow such precise usage. As long as key pests cannot be controlled biologically, culturally, or through host plant resistance, agricultural chemicals will be essentially needed to achieve goal of IPM [9].

In IPM our goal is to augment and foster the beneficial organisms to aid in keeping pest species below the economic threshold, thus lessening the reliance on chemicals. If insecticides must be used then if there is a choice, always choose the one that will do the least amount of harm to beneficial arthropods and microorganisms. Usually in the field there is an insect pest complex composed of several major and minor pests. For example, there can be three major field pests (thrips, mirids, and leaf beetles) and six or more minor pests which range from leaf-cutting ants to leaf-feeding caterpillars. Minor pests at times expand into major pests but usually for a limited time or over a confined area. Storage insect pests are more uniform throughout the world due to the international commerce system. Harvested grains often remain in storage for several months provided with ideal conditions of heat and humidity for a rapid build-up of pest populations. For IPM purposes, growth stage is the most important criterion because the relationship between insect injury and crop damage is dependent on the stage when the injury occurs. Researchers have determined that injury during the vegetative stages is usually not as detrimental to the plant as that during reproductive stages. The preferred index is based on whether the plant is in a vegetative or reproductive stage. The following is the system currently used, with representing vegetative stages and reproductive stages: Vegetative Stages- emergence, cotyledon + unfolding, unifoliate node, and trifoliate. Reproductive Stages- beginning bloom, full bloom, beginning pod, full pod, beginning seed, full seed, beginning maturity, and full maturity. Because crop response to insects is dependent upon the growth stage, economic thresholds vary with the stage. Thus, it is imperative that growers and IPM practitioners recognize these developmental stages.

Major Insect Fauna: The first step toward controlling the insect pests effectively is correct identification of the insects and other pests that attack plants. Major insect fauna associated with field cops are often grouped according to the injury they caused. The first group to consider is the defoliators, which consume leaf tissue (defoliator, beetle, caterpillar, bug complex, and looper). The second group of pests is the pod feeders (corn earworm *Helicoverpa zea* (Boddie), and bean beetle). The final group of insect pests is those that feed on or girdle the stem (stem feeder and girdler, hopper). Their injury can cause significant yield reductions, and lowering of seed quality because of entrance of seed pathogens via feeding scars. Numerous other insects can cause significant injury that requires therapeutic applications of insecticides; these problems are often on a state, regional, or local level. Notable pests in this group are two spotted spider mites, maggots, leafhoppers, grasshoppers and various slug species. Although not considered "major" pests, insects in this category nevertheless cause much concern to growers experiencing the problem, which dictates involvement by researchers, plant protection agents, and other IPM practitioners in their management.

Economic Injury Levels: A few comments on Economic Injury Levels (EIL) are appropriate because prior to the development of EILs for insects, applications of insecticides were often made at the mere sight of an insect population. With the calculation of EILs in the early 1970s based on knowledge of insect feeding and development, the plant's response to defoliation, economic costs associated with insecticide application and price of growers gained the knowledge that moderate insect populations could be tolerated without insecticides being needed. The use of insecticides in some states dropped dramatically after EILs became available. The most important aspect with the relationship between insect injury and crop response is that plant has a tremendous ability to compensate for low levels of defoliation or reduced plant stand. This natural tolerance allows growers to accept some injury knowing that yield losses will not occur. Although there is much work left in refining EILs, they are used in many crop-growing states. Because of local conditions, growers are always advised to contact local plant protection offices to obtain information for their given situation. Generally, insecticide treatments are not necessary until defoliation reaches >50% in the vegetative stages, 15-10% during the flowering, pod development, and pod fill stages, and >25% from pod fill to harvest in some crops. Some states use information on insect leaf-tissue consumption and present EILs as the number of insects per known unit, such as number of insects per linear foot, or number per sweeps.

Insect Injury: While research efforts in developing EILs usually have dealt with each insect as an individual pest, recent efforts have been directed towards developing a more comprehensive approach to how insects injure the plant. Since we are concerned with the plant, researchers are discussing the plant part that is injured; thus, insects are being grouped into leaf feeders, stem feeders, pod feeders. EILs based on insect guilds grouped according to the plant part injured attempt to present growers with useable levels based on the complex of insects that might be in their fields. However, this approach has a shortcoming because all insects might not produce comparable responses by the plant. For example, larvae consume large amounts of tissue; while beetle scrape the surfaces of the leaves. A more recent approach has been to categorize injury on how it impacts plant physiology. Thus, insects are being categorized as to the injury they cause, such as stand reduction, leaf mass removal, leaf photosynthetic-rate reduction, light reduction, seed or fruit destruction, to name a few. Injury to the plant leads to plant or crop damage, which is defined as a measurable reduction in plant growth, development or yield loss. By gaining a better understanding of these relationships, researchers hope to develop more useful EILs based on crop injury.

Detection of Problem: Much work has been occurred on sampling for insects and measurement of injury. When assessing an insect population, a sampling technique is used that is appropriate for the insect in question and the stage of the plant. Direct observation on the plant during the early stages of growth is considered the best option due to the plant's small size. As the plant reaches sufficient size, most IPM programs suggest the use of a ground or shake cloth, or a sweep net. A ground or shake cloth, while more cumbersome than a sweep net, often gives near absolute counts of insects such as caterpillars or other non-flying larvae (beetle). However, other insects are difficult to sample with a shake cloth because they tend to fly away when disturbed (beetle adults). For most insects, a sweep net is used where a net is swept through the plant canopy a given number of times and then the insects are counted. Sweep nets are also less cumbersome and time consuming to use, and allow for larger areas of the field to be sampled in a much shorter period of time. Although sweep nets provide insect counts that are considered at best relative to the size of the population and vary with size of the plants and the person doing the sweeping, they are usually considered the most appropriate insect-sampling technique in IPM programmes. Often the injury caused by the insect can be measured; for example, defoliation levels are estimated, percent pod injury is calculated, or percent stand reduction is determined. These measurements are quite useful in determining when an EIL is being reached. However, it is still advisable to confirm the presence of an insect pest before making any insecticide application. Most IPM guidelines suggest the frequency of sampling to allow for efficient use of time. Recommendations are often advised at least weekly sampling during the growing season. Examinations of plant injury combined with insect sampling will allow for the identification of a potential pest population. As an insect population develops, more frequent sampling is often recommended; numerous insects have the capacity to reach large, damaging populations very quickly and weekly sampling is often too long to go between field visits.

Management Tactics: When the EIL is reached, a therapeutic tactic is needed to prevent further injury to the plant; the only such tactic currently available is the use of an insecticide. However, it should be noted that past and current research has done much in lowering the amount of an insecticide's active ingredient (AI) that must be applied. During the 1960s and 1970s, rates of 1-2 lb. (AI)/acre for many insecticides were common; research got those rates down to levels of 0.5 to 0.75 lb. (AI)/acre. With the newer insecticides, we are seeing rates of 0.01 lb. (AI)/acre and lower. Much work has been done in developing preventive tactics, which are designed to lower the overall insect population or increase the carrying capacity of the plant. Although not always sufficient to maintain pests below economic levels, we realize the important contribution of natural enemies such as predators, parasitoids, and pathogens, in the biological control of insect pests, as we know that a naturally occurring pathogen can plays a major role in controlling outbreaks.

There are efforts underway to develop crops cultivars that are resistant to insects. Currently, only a few cultivars have been released to growers; however, numerous programs are active in developing adapted cultivars; numerous germplasm lines with high levels of resistance have been developed, but they are currently yielding lower than is necessary for release as cultivars. Numerous cultural tactics are being examined and recommended. Manipulating planting date is useful for the management of over wintering pests such as beetles and caterpillars. The adults of both insects leave their over wintering sites in mid-spring and tend to enter earlier planted fields. Thus, late planting is suggested as a management tactic for both these pests. Related to early planting is the use of trap crops, where a more preferred crop that attracts the pest could be planted near a field. Another preventive tactic being actively explored is planting cultivars of different maturity than would normally be grown in an area. When cultivars of differing maturities are present, insects will often prefer one cultivar to another. Thus, a grower attempts to pass through a susceptible crop-growth stage before an insect reaches damaging numbers. This idea is being examined to manage the bug complex. Although researchers have a good understanding of the current insect problems, they are ever aware of potential pests that might occur in the future as growers adopt new and different practices. A change in grower practices might cause different insects to become problems or alter insect-injury/plant relationships. For example, a practice-gaining acceptance is conservation tillage, which leaves over 30% crop residue remaining on the soil surface. These systems can significantly alter an insect's habitat and can cause changes in population dynamics of a pest. It should be noted that changes in these production practices might also affect the various natural enemies that are present. Another practice gaining wider acceptance is the use of narrow or solid-seed rows; rather than planting in broad rows, growers use a drill to plant in row of narrow widths. Although not appearing to have a direct impact on insect population dynamics, row width might have an impact on insect-injury/plant-response relationships, which might alter economic injury levels. Research on row widths and plant response to defoliation is currently being conducted. A grower philosophy that is gaining acceptance is alternative agriculture. Although not specific grower practices, alternative agriculture places a greater emphasis on preventive pest management tactics and away from reliance on insecticides. Preventive tactics will make more use of cover crops, trap crops, resistant cultivars, and other cultural practices, which the grower might employ specifically for pest management. Their use will demand a much better understanding of the biology and life history of insect pests. For organic agriculture neem is the general-purpose botanical pesticide of choice. Neem EC is widely used in several countries around the world today either singly in integrated pest management or in conjunction with synthetic pesticides. Amongst the other known botanical pesticides such as rotenone and pyrethrins, neem EC is superior due to reasons cited below: Research has shown that neem extracts can influence nearly 200 species of insects. It is significant that some of these pests are resistant to pesticides, or are inherently difficult to control with conventional pesticides (floral thrips, diamond back moth and several leaf miners). Neem EC belongs to the category of medium to broad-spectrum pesticides. Neem EC works by intervening at several stages of the life of an insect. Control of insect pests by disrupting their ecological status such as through the use of organisms' like predators, parasites and pathogens, is an environmentally sound and effective mean of mitigating or reducing pests and their effects [10]. The host plant resistance is a natural ability of plants to resist the attack of pests; this technique has long been considered a viable non-chemical and environmentally friendly strategy of controlling insect pests in crops [11]. During storage, the harvested grains suffer enormous damage from insect pests and use of resistant grain varieties is the cheapest, effective and ecologically safe method of protecting grains [12].

IPM philosophy suggests integration with other pest disciplines (diseases, weeds, and nematodes). A barrier to the full integration is the lack of an understanding of the plant responses to all types of injury. Determining that injury from an insect pest might possibly affect the physiology of the plant similar to a plant pathogen or weed would go far in development truly integrated approaches to pest management. As researchers begin to better understand the impact of injury from all pests on the plants' physiology, they then will be able to develop unified approaches to the management of pests. System of IPM has demonstrated high impact on crop productivity and great adaptability in their application.

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