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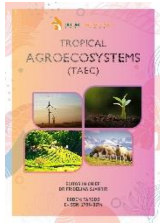

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RESEARCH ARTICLE

A REVIEW ON CULTURAL PRACTICE AS AN EFFECTIVE PEST MANAGEMENT APPROACH UNDER INTEGRATED PEST MANAGEMENT

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ABSTRACT

Integrated Pest Management is a sustainable and holistic approach based on ecological, biological, physical and chemical tactics for controlling pests in the field that, in any way, minimizes risk towards the health and environment. IPM methods involve identifying and knowing the characters of possible pests, making efforts to prevent prevalence, judgment of severity of pest-disease infestation through scouting and monitoring techniques. This paper highlights some of the already practiced strategies and experiments with interpretation of results obtained in various field conditions suggesting wider implications of IPM for managing pests in our fields. The review collects and studies some of the basic and commonly adopted cultural practices like clean and healthy crop growth, trap crop plantation, crop rotation, crop combinations etc. Cost effectiveness, ease of execution, instantly observable results etc are some unattainable aspects affecting IPM adoptions yet farmers seem somewhat encouraged towards sustainable and healthy production in recent years. It is necessary to know about crop and pest biology, ecology, phenology and their links/interaction to successfully implement cultural practices.

KEYWORDS

Biocontrol Agents, Farmer, Natural Enemies, Pesticides

1. Introduction

Insects cause significant damage to cultivated crops resulting in heavy losses in farming. Besides disease-causing pathogens, production obstacles in crops are created due to insects of different orders– coleoptera, lepidoptera, orthoptera and diptera (Babu et al., 2019). Cucurbit fruit fly, epilachna beetle, red pumpkin beetle, aphids, bugs, whitefly etc. in cucurbits; lepidopterans like *Thysanoplusia orichalcea*, *Pieris brassicae*, *Pieris rapae*, *Plutella xylostella*, *Agrotis ipsilon* and *Helicoverpa armigera* in cole crops; and aphid, whitefly, and hoppers in okra are some of the examples, out of many insects, affecting crops and their products in various ways (Pessarakli 2016; Bhat 2018; Rawat, Karnatak, and Srivastava 2020). A group researchers have reviewed that around one-third of the total production has been reduced due to pests, diseases, and viruses, among which arthropods account for about 18-20% damage (Sharma et al., 2017).

Losses are found to be considerably higher in densely populated countries of Asia and Africa with major reliance on agriculture production, especially in the post-revolution period. Damage to the crop depends upon the type of insects affecting the crop, for example, the larvae of leafminer i.e *Liriomyza sativa* cause damage in leaves, loss of vigor and reduces the photosynthetic capacity of plants (Johnson et al., 1983). Likewise, cutworms (*Agrotis ipsilon*) are known to cut the basal stem of vegetables and damage the roots and tubers (Rings et al., 1975). Insecticides might be found effective in limiting the spread of insects and ultimately, the persistently and non-persistently transmitted viruses but their excessive use harm naturally occurring biocontrol agents, cause water pollution and eutrophication, and many health effects like birth defects, nerve damage and cancer. Yearly variation in pest occurrence and pressure in different countries suggests a direct correlation with the use of pesticides reflecting the concern of farmers about yield loss as well as the differences in climatic conditions, pesticide prices, policies, and extension-based services (Jorgensen et al., 2014).

With the increased economic and ecological pressure in the commercial agriculture system and the availability of sophisticated evaluation systems, the concept of Integrated Pest Management (IPM) has been developed to achieve the goal of designing economically and ecologically sustainable agro-ecosystem. Many countries now have major scientific and extension service activities to support recommendations on crop protection issues and minimize losses from insects and diseases. IPM methods involve identifying and knowing the characters of possible pests, making efforts to prevent prevalence, judgment of severity of pest-disease infestation through scouting and monitoring techniques, and integrated, judicial and need-based management of all pests and diseases for reducing pests to tolerable levels in a wide area basis (Matthews 1996; Alston 2011). These activities imply the development of damage thresholds for control measures and more use of comprehensive decision support systems (DSS). Some trained IPM favoring farmers seem to be interested in knowing about alternatives for pest management while most commercial farmers still rely completely on chemical pesticides, either not knowing or ignoring the health hazards (Hashemi and Damalas, 2010).

2. Materials and Methods

The methodology used in preparing this article was the collection of information from different searching sites like google, google scholar, academia, springer etc., research articles published in various national and international journals and their compilation under different headings. The

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article makes an attempt to emphasize the considerable works and efforts of many IPM experts/agri-scientists so that this article could do justice to present their significant works in the field of IPM. The need and situation based methods of integrated pest management includes physical, cultural, biological, legislative as well as chemical measures. Here in this article, we would specifically focus on cultural practices that can either prevent or control insect pests.

2.1 Cultural Methods

Cultural method of pest control is one of the oldest and most effective methods deployed for pest control by farmers in their crop fields. These methods promote natural pest control by making the environment less favorable for their growth and enhancing the competing ability of the crops grown (Hill, 1987). Simply, it refers to the application of cultural practices or manipulation of cropping systems for the control of pests (Walgenbach, 2018). The goal of cultural control lies in making the environment less favorable for the survival and reproduction of insects (Gibb, 2015). Practices such as crop rotation, healthy crop growth, altered timing of cropping, different crop combinations that come under cultural control are solely related to crop ecology (Bajwa and Kogan, 2004). These practices may range from simple intercropping and adjusting planting dates to complex approaches including temporal and spatial arrangement of agro-ecosystem for managing the crop pest (Walgenbach, 2018). Prevention, avoidance and suppression are the 3 main categories under cultural control of pests which enhance crop competing ability against pests as well as create a favorable environment for pest natural enemies and less suitable conditions for pest outbreaks (Bajwa and Kogan, 2004).

2.2 Healthy Crop

To avoid the pest incidence right from the start, use of clean seed material is very critical (Dara, 2019). Besides using certified seeds or treated seeds to make them free from soil or seed-borne pathogens, one should equally focus on using optimal fertilizer dose and clean irrigation water for healthy crop production (Cook, 2000). Enhanced soil fertility through fertilizers, cover crops, green manure, mulching, compost, rotation, and enhanced pest regulation through crop diversity, cultural practices, pesticides, and habitat modification create synergism between soil fertility management and IPM to produce healthy crops (Altieri and Nicholls, 2003). Use of resistant plants can also be an effective practice to reduce pest infestation. Higher grain yield and lesser number of aphids per plant were observed in genotypes ILL 9924, Rl 83, ILL 10856, ILL 6458 and RL 67 of lentil provided by Grain Legume Research Program, Khajura, Banke of Nepal (Neupane et al., 2020).

2.3 Sowing Date and Altered Timings

By adjusting planting dates, insects that follow a particular seasonal pattern can be controlled (Dara, 2019). The synchronized crop-pest association can be disrupted by enabling the plants to escape the pest damage during the susceptible stage which can be obtained by altering the planting dates. Delayed sowing can either reduce or encourage the risk from several pests but in cases, a significant delay in sowing also will have a significant negative impact on yield. Farmers in the highlands of Chiapas, Mexico plant their corn as early as possible to avoid the seedling damage done by white grub. The early sown corn plants get older when the white grub population is at peak thereby reducing its infestation but according to early sowing of maize resulted in severe infestation by the Maize stem borer (*Chilo partellus*) (Morales 2002; Anwar et al., 2010).

Approaches propose delay sowing in rabi crops integrated with deep plowing and solarization in summer, organic amendment in monsoon and seed treatment and residue destruction in kharif season for effective nematode pest management (Trivedi, 2003). In an experiment carried out in Uganda, reduced infestation of aphids, pod bugs and thrips in cowpea cultivation was found during early planting. Aphid population was also found lower when early planting was combined with high-density planting (Karungi et al., 2000). Experiment done has shown that mid-season sowing of mungbean faced lesser infestation from pests than both early and late season sown; suggesting that prevailing climate conditions are highly responsible for pest incidences (Hossain et al., 2009). Difference in per plant population of *M. persicae, S. exigua, H. armigera and B. tabaci, B. brassicae and L. erysimi* was observed with different sowing dates of canola but no difference in time of incidence of those insect pests in crops with different sowing dates was recorded in an experimental study done in Punjab (Abid and Razaq, 2014). Similarly, significant differences in number and percentage of onion thrips, aphids, whitefly and leafhopper was observed in onions planted at different dates in Egypt (Awadalla et al., 2017).

Not only altered planting dates but also the adjustment of harvesting time can reduce the pest infestation (Dhawan and Peshin, 2009). The effects of harvesting depend on its timing and the natural enemy population may be affected by the change in microclimate of the agro-ecosystem brought by harvesting (Rusch et al., 2010). Riechert and Lockley stated that spider populations are affected by harvesting greatly rather than due to the effect of pesticides (Riechert and Lockley, 1984).

2.4 Soil and Fertilizer Management

The physical, chemical, and mainly biological properties of soils affect the ability of a plant to resist or tolerate the pests (Altieri and Nicholls, 2003). A fertile and healthy soil gives rise to healthy plants and enhances its ability to resist diseases. Soil rich in organic matter exhibits a complex food web, a large number of beneficial organisms that suppress other harmful microorganism growth thereby making soil healthy. In Japan, the density of the planthopper species *Sogatella furcifera* was significantly lower and the settling rate of female adults was generally lower in organically framed fields compared to conventional rice fields (Kajimura et al., 1995). In an experiment with cage treatment of vermicompost mixed at different levels with soil-less bedding medium, availability of Nitrogen and required micronutrient and the production of phenols were supposed to be the possible mechanism behind repulsion of aphids and mealy bugs by vermicompost in cucumber and tomato (Arancon et al., 2007).

On a study, soil application of humic acid and vermicompost induced systemic bottom-up defence mechanism in cruciferous plants against *Plutella xylostella* with significantly lower longevity, oviposition period and fecundity (Jafary-Jahed et al., 2020). However, a group researchers have explored that the organic matter and legume crops, if not completely decomposed before applying to the field, can increase oviposition of soil insect pests leading to crop damage (Nyamwasa et al., 2020). Combination of nitrogen and phosphorus based fertilizer application was found more effective in managing aphid population of barley as compared to single fertilizers viz. Urea and DAP (Wagan et al., 2020). Similarly, integration of inorganic fertilizers at 75% recommended dose with organic fertilizers - neem cake significantly reduced the population of jassid, mite, white fly and fruit borer in addition to higher yield (Mishra et al., 2020).

A group researchers showed that the application of growth regulators and micronutrients in cotton neither increased nor decreased the multiplication and infestation of insects like jassid, thrips and bollworms (Abro et al., 2004). Foliar spray of Silicon fertilizer on wheat enhanced the activity of defense enzymes and increased the concentration of secondary metabolites to decrease the reproductive rate and increase population doubling time of aphids (Qi et al., 2020). Likewise, the foliar application of micronutrients, including nitrogen and sulfur along with the release of common green lacewing in sugarbeet made a significant influence in reducing the population of aphids followed by sugar beet moths, leafhoppers and sugarbeet flies (Yousuf and Dar, 2016).

Fertilizers do provide the best conditions for crop plants to express their yield potential by affecting the physiology of plants, altering plant tissue nutrient levels, and bringing changes in the nutritional content of crops. But it is also evident that soil manuring and fertilization input increased fecundity and developmental rates of different insects like green peach aphid, *Myzus persicae*, which were highly correlated to increased levels of soluble N in leaf tissue (Emden, 1966). A group researchers reported higher infestation of jassid and red cotton bugs in okra crops with an increase in the amount of Nitrogen fertilizer (Belbase et al., 2020). Excessive Nitrogen application in the rice field decreased the searching ability of *Anagrus flaveolus*, an egg parasitoid of brown plant hopper, as indicated by long development period and decreased fecundity (Zhu et al., 2020).

2.5 Clean Cultures

Habitat alteration techniques like region-wide sanitation (removal of weed, infested fruits, clipping infested leaves, insects), use of virus and insect-free transplants and propagative stocks, resistant varieties, weed management and implementation of the host-free period, destruction of crop refuse etc. come under clean culture. Some of the sanitary practices like regular cleaning of field implements, destruction of crop residues, avoiding contamination of healthy fields by human activity, removal of infested plant parts play an important role in preventing pest spread (Dara, 2019).

Starting from the primary stage of crop growth, if the practice of clean culture is given continuity, much pest infestation can be reduced (Kabir and Rainis, 2015). Reduction in yield was accompanied with higher pest incidence in non-weeded okra fields as compared to those in which hoe weeding was carried out in continuous intervals (Iledun et al., 2020). Destruction of stubbles and off-season sprouts was found to bring a significant impact on the production of Rice, sugarcane, and maize; directly by reducing crop-weed competition and indirectly by breaking the life cycle of insects (Bajwa 1988; Capinera 2001). In the case of Apple maggot, collecting the fallen fruits and destroying them interrupted their life cycle thereby reducing their population in the apple orchard (Dowell, 1990).

2.6 Tillage

Tillage practices expose the various life stages of insects and destroy them by exposure to predators or adverse environmental conditions or these practices may change the soil microclimatic conditions. Soil depth and timing of tillage are necessary points to be considered for managing soil pests. The immobile stage of pests determines the timing of tillage while their location in the soil determines the depth up to which tillage has to be done (Bajwa and Kogan, 2004).

Either to kill weeds or to control pest/pathogens, tillage practice has been considered as the best sanitary tool (Cook, 2000). Conventional tillage is supposed to expose pupa and larvae of insects hiding at a certain depth which may be killed by the heat of the sun. Field scouting with pest injury detection was carried out at early and mid-season for black cutworm, stalk borer, army worm, slug problems and European corn borer which revealed that no tillage reduced stand injury of the European corn borer but higher level of stand injury for other insects were exhibited (Willson and Eisley, 1992).

On the other hand, predatory carabidae, which feed on soft-bodied caterpillars and aphids, were more abundant in conservation tilled compared to conventionally tilled crops showing that conservation tillage assists in maintaining populations of beneficial insects (Horne and Edward, 2007). Weed seeds are devoid of scarification and disturbance for germination with conservation tillage which ultimately reduces the pest harbored by weeds (Shrestha et al., 2006). A group researchers argue that intensive pest spread and development occurs via plant residues accompanied with conservation tillage at shallow depth (Prymak et al., 2020).

2.7 Planting Density

Spacing between plants has a paramount influence on vigorous growth of crop with provision of suitable microclimate while it also affects the incidence of many insect pests. High planting density resulted in more seeds and pod damage by pod sucking bugs in pigeonpea while higher planting density is favored in rice with respect to lower larva density and the damage by stem borer (dead heart and white head) in rice (Dialoke et al., 2018; January et al., 2020).

However, some researchers donot find planting density as a measure for pest control with significant results. A group researchers reported no significant difference in pest population of cotton in high density planting and normally spaced crops while validating the effectiveness of IPM modules viz. seed treatment, trap cropping, use of pheromone traps and application of neem based insecticides (Harshana et al., 2017). A group researchers also suggested that plant spacing cannot be a measure for pest control in cowpea with the insignificant differences found in pest population and damage caused by them (Ajao et al., 2016).

2.8 Mulching

Soil surface mulch can considerably reduce surface runoff, conserve moisture, increase infiltration capacity, and slows down hazards of soil erosion (Jenkins, 2004). Besides, mulching can be used to control a significant amount of pest attacks in the fields. Organic mulch of fresh or dried materials of plants like cypress, eucalyptus and Lucerne help to reduce the attack by weevils on storage roots of sweet potato by reducing cracks on dry period and repelling and reducing their movement (Rehman et al., 2019). Use of *Azadirachta indica* as mulch material was found to be the most effective mulch material in controlling flea beetles in okra (Norman et al., 2020). Crop diversification strategies like maize-soybean intercrop and maize-desmodium intercrop integrated with the use of maize stover as mulch reduced damage caused by termites in maize (G et al., 2019).

In comparison with bare soil, jassid population was significantly lower in silver mulch, black plastic mulch as well as wheat straw mulch on a research carried out in Chitwan district of Nepal (Dahal et al., 2020). In a 2 years study on the integrated impact of reflective mulches, plant resistance and insecticide use, lower number of whitefly eggs, nymphs and adults were observed in reflective silver mulch treatment in comparison with organic straw mulch and no-mulch treatments (Nasruddin et al., 2020). The use of red and white color mulches showed a significantly lower population of insect pests like whitefly, thrips and spider mites followed by blue, no-mulch, yellow and green color mulches in cucumber plants (Ammar and Abolmaaty, 2016). A group researchers suggested the efficacy of metalized mulch against Thrips palmi at low population density and at an early stage of crop growth in snap bean, cucumber, tomato, eggplant and pepper (Razzak et al., 2019).

2.9 Irrigation/Water Management

Rain or sprinkler irrigation dislodge the eggs and larvae of small insects (Jijabrao, 1995). But sprinkler irrigation decreased the effectiveness of pheromone traps for potato tuber moths as compared to furrow irrigation (Mohamadi et al., 2020). When mustard field was irrigated two times, aphid population was the lowest among non-irrigated and once-irrigated fields while yield was also affected simultaneously (Mannan and Tarannum, 2016).

Higher Nitrogen uptake in irrigated conditions in dry years might favor more damage from larval feeding of European Corn Borer but these information need further research studies (Sarajlic et al., 2020). Thrips, the major production limiting factor of Dolichus lablab in Kenya, was found to be more infesting in irrigated conditions than rainfed farming (Nahashon et al., 2016). Stalk-eyed fly and African rice gall midge were recorded to be highest in continuously flooded rice fields compared to alternate wetting and drying and continuous dry field situations (T. et al., 2016).

2.10 Tritrophic Interaction

The factors which affect the potentiality of pest proliferation or complementation and the subsequent suppression by their natural enemies depends upon crop ecology, thus creating a tritrophic interaction. The reproductive capacity of parasitoid, *Eretmocus mundus Mercet*, was found to be higher with an increase in Nitrogen fertilization indirectly through increase in weight of whitefly nymph (Pekas and Wäckers, 2020). Ecological interaction among the 3 components is influenced by herbivore ontogeny and Herbivore Induced Plant Volatiles (HIPVs) (Boege et al., 2019; Aartsma et al., 2017). A review by suggests that Integrated Pest Management Strategies should be directed towards the exploitation of tritrophic interaction by incorporating cultural practices like fertilization, irrigation and host plant resistance (Han et al., 2019).

2.11 Intercropping

Growing two or more crops simultaneously in a field is known as intercropping (Vandermeer, 1989). Mixed intercropping, row intercropping, strip intercropping are some spatial combinations under intercropping of crops in the field (Liburd, 2018). The associated plant in intercrop control the pest or lead to escape of pest attack either by making hosts less good for the pest or by changing the environment in favor of natural enemies of the pest or by interfering directly with the activities of the pest. All these methods involve lowering the population growth rate of attacking pests to the main crop (Trenbath, 1993). How an insect will react to a given crop mixture depends upon the host range and host finding aspect of insect behavior (Liburd, 2018). Among two hypotheses which explains about reduction of pests in intercropped systems, "Enemies hypothesis" is one of them.

It explains that pest reduction in the intercropping system predicts that the polyculture system has a favorable environment for predators and parasitoids leading to their greater number which in turn control the pest population (Risch, 1983). While the other hypothesis of "resource concentration" explains that the herbivore abundance is seen if the resources it needs to live and reproduce are concentrated which is greater in monoculture than in polyculture where resources are diluted with non-host plants (Liburd, 2018; Risch, 1983). It is important to focus attention on all sympatric pest species along with the maintenance of species diversity whereby prey and natural enemies are maintained below economic injury level and at functional response level through a deep understanding of community structure and habitat management (Kogan and Hilton, 2009).

Sorghum and cowpea was identified as the best crop combination in a 10-years intercropping study conducted by the International Centre of Insect Physiology and Ecology (Omolo et al. 1993) (Appendix 1). Rai (n.d.) has observed that the combination of cabbage and carrot helps in managing Diamondback moth, Coriander/Fennel help in reducing Shoot and Fruit borer in brinjal while fruit fly seem to be managed to some extent when maize is intercropped with bitter gourd. Minimum tuber damage was observed when potatoes were intercropped with onions and garlic compared to radish, coriander and tomato (Kahar, 2020). In contrast, combination of crops with weed species or the alternate host of different insects proves to be more damaging. In mature and unmanaged orchards of apple, insect species associated with diverse habitat patches reach a climax community characterised by fruit spurring, lack of foliar growth and presence of dead and dying limbs (Knisley and Swift, 1972).

Table 1: List of Some Crop Combinations Effective Against Major Insect Pests.

Major Crop	Crop Combination	Remarks	Reference
Maize	Bitter Gourd	for managing fruit fly	(Rai n.d.)
	Napier Grass	oviposition preference by gramineous stem borer, *Chilo partellus*	(Van den Berg 2006)
Cabbage	Carrot	for managing Diamondback moth	(Rai n.d.)
	Clover	Better quality harvest due to less insect damage	(Theunissen, Booij, and Lotz 1995)
Brinjal	Coriander, Fennel	for reducing Shoot and Fruit borer in brinjal	(Rai n.d.)
Tomato	Marigold	Effective in increasing the population of coccinellid predators for the control of *Helicoverpa armigera*	(Singh and Tripathi 2017)
Cucumber	Marigold	increased fruit yield and reduced insect pest severity	(Adewoyin 2018)
Potato	Brinjal, Litchi Tomato	trap crop for controlling potato cyst nematode	(Scholte and Vos 2000)
	Pea (More Effective), Wheat, Oilseed Radish	trap crop to control wireworm in potato field	(Landl and Glauninger 2013)
Chickpea	Coriander	Increase in natural enemy activity against *Helicoverpa armigera*	(Pimbert 1991)
Tomato, Tobacco	Cabbage	Feeding inhibition on Flea beetles (*Phyllotreta cruciferae*) due to odours from non-host plants	(Pimbert 1991)

2.12 Trap Crops

The vegetative diversification that is created to divert, attract, manipulate or retain the pest for feeding, oviposition and as a sink for pathogens in order to protect the main crops is defined as trap cropping. Trap crops are used as an IPM strategy based on the concept that immigrating insects would feed first on the border crops and they will probably release their inoculum before moving to the main field. The crops which are naturally more attractive to a pest for oviposition and feeding serve as a sink for insects or pathogens. From an experimental study carried out by for a trap crop to be effective, its retention rate to hold the pest should be pronounced enough to prevent the insect from going to the main crop along with their spatial distribution in the field (Holden et al., 2012). Attractiveness of the trap crop is more significant when the trap has high retention capacity for the pest. Their successful deployment is dependent on insect stage targeted by the trap crop and the insect's ability to direct its movement, its migratory and host-seeking behavior (Shelton and Badenes-Perez, 2005). Within a landscape, it depends on the inherent, spatial and temporal characteristics of the trap crop and the higher value crop and the agronomic and economic requirements of the production system. Border trap cropping, simultaneous multiple cropping, push-pull trap cropping a combination of a trap crop (pull component) with a repellent intercrop (push component) and planting of dead-end traps like Sunhemp for bean pod borer, *Maruca testulalis* can be practiced under this strategy. Push Pull strategy was applied in cotton by planting okra and pigeonpea as trap crop with restricted application of Nuclear Polyhedrosis Virus and diversifying pests with restricted application of Neem Seed Kernel Extract for reducing the infestation of *Helicoverpa armigera* (Duraimurugan and Regupathy, 1042). Cultivation of marigold as trap crop has been found effective in increasing the population of coccinellid predators for the control of *Helicoverpa armigera* (Singh and Tripathi, 2017).

2.13 Crop Rotation

The practice of cultivating different sequences of crops in the same piece of land for exploiting the beneficial role in soil conversion, improving soil structure and fertility along with controlling pests and weeds can be defined as crop rotation (Degu et al., 2019). Most of the commercial farming landscapes are characterized by homogenous planting with frequent disruptions due to harvest and fallow cycles, and the use of non-selective insecticides causing lack of shelter to natural enemies. Increased vegetational diversity may reduce pest infestation by making crop plants more difficult for insects like *N. viridula* to locate the host and together, attracting more natural enemies (Buntin et al., 1995). When spring-summer and winter crops are altered, it will break the life cycle of many pests. Specially in case of vegetable pests, rotation of plants from different families is recommended (Barzman et al., 2015). The crops planted for crop rotation should differ in pest complexes and have different planting patterns (Dhawan and Peshin, 2009). Pairs of rotated and unrotated fields, both located on the same farm, were monitored weekly for the density of different stages of Colorado beetle and defoliation levels which showed low early-season adult densities in both but more egg masses, high defoliation level, and need of insecticide use in non-rotated fields (Wright, 1984). In a research carried out, it was found that crop rotation of corn with other crops significantly reduced the incidence of the western corn rootworm which had been resistant to genetically engineered Bt corn plants (Carrière et al., 2020). Also, the corn fields were found free from corn rootworm larvae when crop rotation was practiced. Crop rotation practice was found effective in controlling wireworm in wheat fields. When the cropping pattern was switched from continuous spring wheat cropping to no-till summer fallow and winter wheat cultivation as IPM strategy, the population of *Limonius californicus* and *Limonius infuscatus* were greatly reduced (Esser et al., 2015).

2.14 Challenges

Pest becomes part of the environment once they get established and their life cycle is affected by the different practices occurring in their environment. Cultural control practice is an approach to control pests by changing their living habitat or environment. Eradication, Suppression, Containment and Prevention are four pillars of IPM strategy which work collaboratively for long term monitoring and maintenance systems. Cultural methods are mainly preventive rather than curative because of which their results are seen on long term only. IPM programs lack a mechanism for extension and refinement at the farm level across a larger smallholder community. Farmers feel reluctant to change their traditional way of practicing farm works, low technical standards used in most of the training derail farmers from taking training and they feel that their knowledge is self-sufficient to grow crops. The approach of Integrated Pest Management assumes active diffusion of methods between trained and untrained farmers, without specific extension intervention.

3. Conclusion

For better effectiveness, long term planning and careful timing is required. It is necessary to know about crop and pest biology, ecology, phenology and their links/interaction to successfully implement cultural practices. The involvement of all stakeholders and most progressive growers with good teaching material, pest management guidance, and biological control agents should be assured for the successful implementation of IPM programs. It has become a prime necessity of all the associated stakeholders to give attention to research on IPM methodologies at local environmental conditions and its subsequent application in the farmer's field level. This article opens up the scope of research on cultural methods under Integrated Pest Management in different field situations and augments the need of detailed and specific articles on each strategy.

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Declaration of Interest

We hereby clarify that all 3 authors have contributed to our best level to prepare this article and are highly interested to have this article published in the International Journal of Pest management. All the co-authors confirm agreement with the final statement as included in the author guidelines of the journal.

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