Good agricultural practices in insect pest management of field crops

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With the increasing demand for food and improvement in the disposable income of the consumers, the concepts like food safety and nutritional security, natural resource degradation and environmental sustainability etc., started gaining more attention from health and trade perspectives. Consumers' understanding of food safety has recently increased and the agriculture industry must adjust to the changing demand. To achieve this, strategies must be modified along the entire value chain, from the fields to the customers. Globally, Good Agricultural Practices (GAP) have become a crucial strategy in this direction. Several nations have included GAP in their future plans of action, making its acceptance and promotion through legislative measures necessary (Rodrigues et al., 2004). Good Agricultural Practices GAPs are a set of guidelines for growing and handling agricultural products including cereals, pulses fruits, vegetables and other agricultural produce. Food and Agriculture Organization defined GAP as practices that address environmental, economic and social sustainability for on-farm processes, and result in safe and quality food and non-food agricultural product. These guidelines help to ensure that the food produced is safe, of high quality, and grown in an environmentally sustainable manner. GAPs cover a wide range of topics including: crop management, water and soil management, pest management, worker safety and training and food safety. Implementing GAPs can help farmers to reduce risks associated with food safety, improve yields, and increase the marketability of their products. GAPs can be voluntary or mandatory, and are often required by retailers and food service providers as a condition of doing business with them.

The criteria/requirements for GAPs have been categorized, based on their importance, as critical, major or minor;

1. Critical: They are necessary to preserve the quality of the produce, and failure to follow them could result in significant food safety issues leading to product integrity (100 per cent compliance shall be compulsory)
2. Major: these are mandatory and must be followed (90 percent compliance shall be compulsory)
3. Minor: These are important but may not be essential depending upon the produce category (50 per cent compliance shall be compulsory)

According to FAO, to minimize the harmful effects of production and post-production practices, good agricultural practices for controlling food safety hazards are grouped into eleven elements.

The pertinent Food Security Modules (FSMs) are:

- Site history and management
- Planting material
- Genetically modified organisms
- Fertilizers and soil additives
- Chemicals (Plant protection products or other agro and non-agrochemicals)
- Water (Irrigation/Fertigation)
- Harvesting and handling produce
- Traceability and recall
- Training

- Documents and records and
- Review of practices (FAO, 2016)

One important aspect of GAPs is the management of insect pests in field crops. Insect pests are a major problem for farmers as they can cause significant damage to crops and reduce yields. In order to effectively manage insect pests, farmers must adopt a holistic approach that incorporates various techniques and strategies. Among the 11 Food Safety Measures listed by FAO; site history and management, planting material, genetically modified organisms, chemicals, and harvesting and handling produce are relevant in plant protection perspectives of all crops, including field crops.

1. Site history and management: Site history shall be assessed to identify the risks of contamination to crops grown, from the previous use of chemical and/ or biological hazards on the site or adjoining sites, and the risks shall be documented.

2. Planting material: One important aspect of GAP is the use of high-quality planting material. High-quality planting material is more likely to be free from pests and diseases. Crops grown from high-quality planting material are less likely to be affected by infestations or outbreaks of pests and diseases, which can cause significant damage to crops and lead to economic losses for farmers. High-quality planting material is more likely to have the right genetic makeup and characteristics to thrive in the specific growing conditions of the farm. This results in crops that are more resistant to environmental stresses, such as drought or extreme temperatures, and biotic stresses like pests and diseases and thus reduces the need for chemical inputs. Moreover, high-quality planting material also reduces the risk of chemical residue in the products, making it safer for consumption (Adhikari and Thapa, 2023).

3. Genetically modified organisms (GMOs): Genetically modified organisms (GMOs) can revolutionize agriculture by increasing crop yields and reducing the use of pesticides and herbicides. However, the success of GMOs depends on the implementation of good agricultural practices. Good agricultural practices (GAPs) refer to the methods and techniques used to grow crops and raise animals sustainably and responsibly. GAPs include crop rotation, soil conservation, and appropriate fertilizers and pesticides. When these practices are implemented, they can lead to increased yields, improved soil health, and reduced environmental impacts (FAO, 2016). In the case of GMOs, GAPs are particularly important because they can help to mitigate the potential negative impacts of these crops on the environment and human health. For example, genetically modified crops are grown in monoculture, they can lead to the destruction of natural habitats and the loss of biodiversity (Dale et al., 2002). However, if GAPs such as crop rotation and soil conservation are used, the negative impacts of GMOs can be minimized. Furthermore, GAPs can also help to ensure that GMOs are grown safely and responsibly. For example, using appropriate pesticides and herbicides can help prevent the development of resistance in pests and weeds, which can lead to increased use of these chemicals in the long run. Farmers, policymakers, and researchers need to work together to promote and implement GAPs for GMOs. Planting or trials with GM crops shall be done if permitted by the applicable legislation in the country. This shall be documented if a producer is growing GM crops, as permitted by the country's legislation.

Even though growing genetically modified crops is a controversial issue, these have been adopted in several countries worldwide. The most widely grown genetically modified crops are; soybean, corn, cotton, canola, alfalfa, sugar beet, papaya, squash, tomato and potato. These crops have been genetically modified for traits such as pest resistance, herbicide tolerance, improved nutritional content, and drought tolerance. The cultivation of GM crops varies widely by country, with the majority being grown in the United States, Brazil, Argentina, India, and Canada.

In developing countries, GMCs are promoted as a means of increasing food security, although their adoption is still limited due to concerns about their impact on human health and the environment.

4. Chemicals (Plant protection products or other agro and non-agrochemicals): Chemicals used on the farm can be categorized as agrochemicals that are applied on the farm or produce such as fertilizers, pesticides, seed treatment material, plant growth regulators and additives, and non-agrochemicals such as grease, fuels, and oils that are required for other purposes. Pesticides for managing insect pests are important in GAP in insect pest management. The critical requirement here is the use of pesticides permitted under a country's regulations. Some major regulations are; purchase of chemicals from registered/licensed suppliers; the dosage as recommended by competent authorities; disposal of surplus chemicals to avoid contamination of the produce; maintaining pre-harvest interval mentioned on the label claim of the pesticide; proper maintenance of plant protection equipments; proper disposal of equipment washed water to avoid contamination to produce; storage of chemicals in the original container with a legible label and according to label directions; avoid reusing empty chemical containers and should be properly disposed of according to the country's regulations and in a manner to avoid contamination of produce and the environment; Obsolete or expired chemicals shall be clearly identified and kept in a secure place till disposal. A record of application for each crop shall be maintained giving details of chemical, reason for application, treatment location, dosage, method, date of application and name of operator; A record of chemicals held in storage shall be maintained detailing chemical name, date and quantities procured and date of complete use or disposal; If chemical residues in excess of maximum residue limits (MRL) are detected in the market where the product is traded or exported, the marketing of the product shall cease and the cause of contamination shall be investigated (FAO, 2016). Corrective actions shall be taken to prevent recurrence and a record kept of the incident and the actions taken; Non-agrochemicals shall be handled, stored and disposed of in a manner to avoid any risks to food safety; Integrated Pest Management (IPM), if implemented, shall require careful consideration of available pest control techniques and the subsequent integration of appropriate measures to discourage the development of pest populations, while keeping the use of plant protection chemicals at minimal level.
Minor requirements are, mixing of two or more chemicals should not be done, unless recommended by technically competent personnel/institutions/ authorities; chemicals should be stored in a well-lit, sound and secure structure, which is located and constructed to minimize the risk of contaminating produce and equipped with notices and emergency facilities in the event of a chemical spill; A record of chemicals obtained should be maintained, detailing the chemicals used, name of the supplier, date and quantity obtained, date of manufacture and expiry.

5. Integrated pest management:

Integrated pest management (IPM) is an effective GAP for insect pest management. IPM is a holistic approach that combines multiple techniques and strategies to manage pest populations. IPM aims to reduce pest populations to a level that does not cause economic damage to crops. This is achieved by using a combination of cultural, biological, and chemical control methods. By using IPM, farmers can reduce the need for chemical insecticides, which can help to protect the environment and maintain biodiversity. Effective insect pest management in field crops is essential for achieving sustainable and high-yielding agriculture.
One of the most important GAPs for insect pest management is crop rotation. Crop rotation is the practice of growing different types of crops in a specific field in a recurring sequence. By rotating crops, farmers can disrupt the life cycle of pests and make it more difficult for them to establish populations in a field. For example, if a farmer grows corn in a field one year, and then switches to soybeans the next

year, the insect pests that are specific to corn will have a difficult time finding a suitable host plant. This can reduce the overall pest pressure on the soybeans, and increase the chances of a successful crop (Nain et al., 2020).

Another GAP for insect pest management is the use of cultural control methods. Cultural control methods are practices that farmers can use to create an environment that is less conducive to pest outbreaks. These methods include things like proper irrigation, fertilization, and soil management. By providing crops with the right amount of water and nutrients, farmers can help keep them healthy and strong, making them more resistant to pest damage.

Biological control is another effective GAP for insect pest management. Biological control involves the use of beneficial organisms, such as predators, parasites, and pathogens, to control pest populations (Jeffers and Chong, 2021). These organisms can be either naturally occurring or introduced. For example, ladybugs and lacewings are beneficial insects that feed on a wide range of pest insects, and can help to keep populations in check. By rotating crops that attract these beneficial insects into a field, farmers can create a more balanced ecosystem that is less conducive to pest outbreaks.

Another GAP for insect pest management is the use of insecticides. Insecticides are chemicals that are used to kill or control pest populations. While insecticides can be effective in controlling pest populations, they also have the potential to harm beneficial organisms and the environment. Therefore, farmers should use only insecticides when necessary and choose the least toxic option. They should also follow the label instructions and safety precautions when applying insecticides.

6. Harvesting and handling produce

Post-harvest insect pest management is crucial to ensuring the quality and safety of stored agricultural products. Insects are major pests that can cause significant damage to stored grains, fruits, and vegetables, leading to economic losses for farmers and reduced food security for consumers. The key to effective post-harvest insect pest management is understanding the biology and behavior of the pests, as well as the characteristics of the products being stored. post-harvest insect pest management is essential for ensuring the quality and safety of stored agricultural products (FAO, 2016). By understanding the biology and behavior of pests, properly cleaning and preparing storage facilities, monitoring for pests, and using a combination of chemical and non-chemical control methods, farmers and storage operators can effectively manage insect pests and reduce the risk of economic losses and food insecurity. One important step in post-harvest insect pest management is to properly clean and prepare storage facilities before use. This includes removing any debris or old stored products that may harbor pests, as well as thoroughly cleaning and sanitizing the facility. This can help to reduce the number of pests that are present in the facility and make it less attractive to new pests. Another cultural control method is to use good agricultural practices (GAP) for crop production. This includes regular monitoring of crop growth, identifying and removing pests, and using pest resistant varieties of crops. GAP also includes proper crop rotation, and maintaining field sanitation to reduce the risk of pest infestation.

Conclusion

We need defining certain minimum standards with a well-defined certification and accreditation mechanism for effective GAP. Agriculture being subjected to so much diversity in crop, soil, water, climate, etc. across the country, this does not easily render itself to regulation in order to implement specified Standards. Therefore, there is a need to have a voluntary certification scheme for implementing Standards for GAP. GAPs such as crop rotation, cultural control methods, biological control, use of least toxic insecticides and integrated pest management (IPM) are crucial in reducing pest populations and minimizing the damage caused by pests while maintaining biodiversity and protecting the environment. By implementing these GAPs,

farmers can improve the sustainability, safety, and quality of their crops, and ultimately, increase their yields and profits. By implementing strict sanitation protocols, using an integrated pest management approach, and using proper storage conditions, it is possible to effectively manage pest populations and reduce the risk of pest infestation.

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