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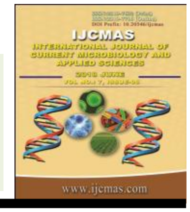

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Integrated Pest Management in Rice and its Future Scope

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A B S T R A C T

Prior to the introduction of the modern varieties, the rice crop survived for centuries with traditional varieties with robust plant type but low yield. The farmers started applying higher doses of fertilizers in general and nitrogen in particular as these varieties were fertilizer responsive and these changes in rice cultivation resulted in an altered micro-climate, which led to the accentuation of the insect pest and disease problems. Many diseases such as sheath blight, sheath rot, false smut and leaf scald have become severe in several parts of the country. Yield-losses ranging from 21 to 51 percent have been estimated due to moderate to serious incidence of stem borer, gall midge, plant-hoppers and other sporadic pests in the rice growing areas of the country. To overcome the biotic constraints mainly pests and diseases for realizing yield potential of rice, development of suitable Integrated Pest Management (IPM) strategy is important. But as the farmers have been mostly confident on chemical control for managing the pests, it has become imperative to develop a holistic system of tackling pests, which is environment-friendly, economically viable and socially acceptable. Time, money, patience, short- and long-term planning, flexibility and commitment are required for any IPM programme to be successful. The Indian Council of Agricultural Research (ICAR) and the Department of Agricultural Research and Education of the Ministry of Agriculture, Government of India, are focused on the development and promotion of IPM in the country. It is the topmost priority of the ICAR and the Government of India to provide safer and effective technologies to protect against unacceptable losses due to insect pests, weeds and diseases.

Introduction

Rice, being the principal food for majority of the overall human population plays a crucial role in the Indian economy and livelihood. It is the agricultural commodity with the third-highest worldwide production (rice, 741.5 million tonnes in 2014), after sugarcane (1.9 billion tonnes) and maize (1.0 billion tonnes). However, modern high yielding varieties (HYVs) were developed and introduced during the mid 1960s which could cope up with a range of biotic and abiotic stress. These varieties were photo-insensitive and could be cultivated in nontraditional areas also. Further, the farmers started growing the varieties of crop with different genetic backgrounds in a mosaic fashion, meaning existence of several varieties in the field during the crop season with low or no fertilizer use probably, which was the major reason for the maintenance of pest populations at low level. Insect-pests are yield-limiting factors of rice production with an estimated yield loss of about 25% describing the pest population in relation to environmental weather variables. The pest complexity of rice that attacks the crop from nursery till maturity necessitates the use of 22% of pesticide share in India even when the ecological approach of integrated pest management (IPM) is in focus.

Rice is the most important grain with regard to human nutrition and caloric intake, providing more than one-fifth of the calories consumed worldwide by humans. There are many varieties of rice and edible preferences that tend to vary regionally. Rice, being the labor-intensive crop to cultivate and as it requires ample water, is well-suited to cultivate in the countries and regions with low labor costs and high rainfall. However, rice can be grown anywhere, even on mountain area or on a steep hill with the use of water-controlling terrace systems. Centuries of trade and exportation have made rice common in many cultures worldwide, although its parent species are native to Asia and certain parts of Africa.

Integrated pest management (IPM) is an adaptation to the life cycle of the insect and its behavior. For developing a successful IPM plan, it is essential to know the farmer's agricultural practices and knowledge of pest species in a given agro-ecosystem. A farmer's practices and a well-designed IPM plan should be closely linked in rice ecosystems.

An ecosystem level understanding of pest life cycles provides the basis for successful design and implementation of an IPM strategy. The primary focus of the National IPM program of any country in the world is to protect the crop against the pesticide-induced pest resurgence. A successful IPM plan accounts for the protection of beneficial insects, secondary pest outbreaks, spread of disease, contamination of air, water and soil resources and pest resurgence. Weather-based forecasts of insect pests provides information on the timing and intensity of the pest infestation beforehand that guides the farmers to take up timely, cost-effective and eco-friendly protection measures in addition to enhanced resilience to climatic variability. The farmers in the number of countries could be benefitted on a large scale by the vast scale adoption of IPM in rice agro-ecosystem. In the past, agricultural production increased through area expansion and increasing use of high yielding seeds, chemical fertilizers, pesticides and irrigation water. Over the next three decades, production of foodgrains in India has increased to about approx. 2 million tonnes a year to meet the food demand of the growing population.

Biotic Constraints

Major Insects Pests: National Significance

Yellow stem borer
Brown Plant hopper
Leaf folder
Gundhi bug
Gall midge

Major Diseases: National Significance

Rice blast
Bacterial leaf blight
Sheath blight
False smut
Brown spot

Major Nematodes: National Significance

Root Knot nematode
White tip nematode

Major Weeds: National Significance

Weedy rice
Cyperus rotundus (L.)
Echinochloa crusgalli (L.) (Beauv)

IPM Approach

There are multiple definitions of IPM issued by government, research organization, NGOs and Universities. IPM is a pest management system that, in the context of the associated environment and the population dynamics of the pest species, utilize all the feasible techniques and methods in a compatible manner as possible and maintains the pest population at levels below those causing economically unacceptable damage or loss. Thus IPM is the best combination of cultural, biological and chemical measures that provides the most cost effective, environmentally sound and socially acceptable method of managing diseases, insects, weeds and other pests.

Crop Monitoring

Crop Monitoring is the basis of IPM and keeps the track of the insect-pests and their possible damage on the crop. It is helpful in selecting the best possible combinations of the pest management methods, also provides knowledge about the current pests and crop situation. There are several crop monitoring tools, but Pheromone traps being light and sticky have got advantage over the other tools. They have proved their importance in large scale IPM validations in cotton, basmati rice, chickpea and pigeonpea, being selective to specific pest.

Cultural Pest Control

Crop rotation, fallowing, manipulation of planting and harvesting dates, manipulation of plant and row spacing and destruction of old crop debris are a few examples of cultural methods that are used for management of the pests. The important management techniques include Planting of cover crops, nectar producing plants and inter-planting of different crops to provide habitat diversity to beneficial insects. It includes crop production practices that make crop environment less susceptible to pests. A cover crop can also be used as a green manure, which is incorporated in the soil to provide nitrogen and organic matter to the subsequent crop. Cultural controls are selected based on knowledge of pest biology and their development.

Physical or Mechanical Controls

Hand picking of insect pests is perhaps the simplest physical method to control the pest. Mechanical control methods are based on the knowledge of pest behavior. Placing plastic-lined trenches in potato fields to trap migrating Colorado potato beetles is one example of the physical control.

Shaking of the pigeonpea plant to remove Helicoverpa larvae is a common practice in pigeonpea growing areas. Installation of dead as well as live bird perches in cotton and chickpea fields has proved effective in checking the bollworm infestation. Using mulches for smoothening weeds and providing row covers to protect plants from insects are other examples of such control methods.

Biological controls

A number of microorganisms such as Trichoderma spp., Verticillium spp., Aspergillus spp., Bacillus spp. and Pseudomonas spp. that attack and suppress the plant pathogens have been exploited as biological control agents. Biological control includes augmentation and conservation of natural enemies of pests such as insect predators, parasitoids, parasitic nematodes, fungi and bacteria. The native natural enemy populations are conserved in IPM programmes and non-native agents may be released with utmost caution. Trichogramma spp. are the most popular parasitoids being applied on a number of host crops.

Chemical Controls

When the pests cannot be controlled by other means, pesticides are used to keep the pest populations below economically damaging levels. A wide range of man-made chemicals are included in the Synthetic pesticides which are fast-acting, easy to use and relatively inexpensive.

Because of their potential negative effect on the environment, ideally pesticides should be used as a last resort in IPM programmes. Pesticides with the least negative impacts on non-target organisms and the environment are most useful. Fortunately, new generation pesticides with low environmental effects and novel modes of action are being developed and registered for use.

Pesticides that are short-lived or act on one or a few specific organisms fall in this class. There is much research, that has been done to determine the damage thresholds for a variety of crops and pest situations, yet the studies are inconclusive. Economic threshold assessment is based on the concept that most plants can tolerate at least some pest damage. In an IPM programme where the economic threshold is known, chemical controls are applied only when the pest's damaging capacity is nearing to the threshold, despite application of other alternative management practices.

Some botanicals are broad-spectrum pesticides and can be prepared in multiple ways as raw crushed plant leaves, extracts of plant parts, and chemicals purified from the plants. Pyrethrum, neem, tobacco, garlic and pongamia formulations are few examples of botanicals and are generally less hazardous to transport and less harmful to the environment because of their quick degrading property. The major advantage is that these can be formulated on-farm by the farmers themselves.

Pest Resistant Varieties

Breeding for pest resistance is a continuous process. At the same time the pests also, particularly the plant pathogens, co-evolve with their hosts. Thus, gene transfer technology is useful in developing cultivars resistant to insects, plant pathogens and herbicides. An example of this is the incorporation of genetic material from Bacillus thuringiensis (Bt), a naturally occurring bacterium, in cotton, corn, and potatoes, which makes the plant tissues toxic to the insect pests. Scientific community is impressed by its huge potential in managing the pests, but is also concerned about the possibility of increased selection pressure for resistance against it and its effects on non-target natural fauna. However, due to ethical, scientific and social considerations, this potential technology has been surrounded by controversies.

IPM on an ecological basis

IPM in rice is now strongly based on its interaction with soil nutrients and varieties and ecological understanding of the crop. The rice ecosystem in Asia is primitive to the region as rice was first domesticated before the recorded history, perhaps more than 6000 years ago (Ponting, 1991), while reaching cultivation similar to that of modern days in the sixteenth century (Hill, 1977).

This lengthy time period shows that the rice crop, pests and their natural enemies have existed together and coevolved for thousands of generations. Rice ecosystems, during the season with regular flooding from irrigation or rainfall, typically include both a terrestrial and an aquatic environment. These two dimensions of the rice crop may account for the extremely high biodiversity found in the rice ecosystem and its stability even under intensive continuous cropping- in contrast with the relative instability of rice production under dryland conditions.

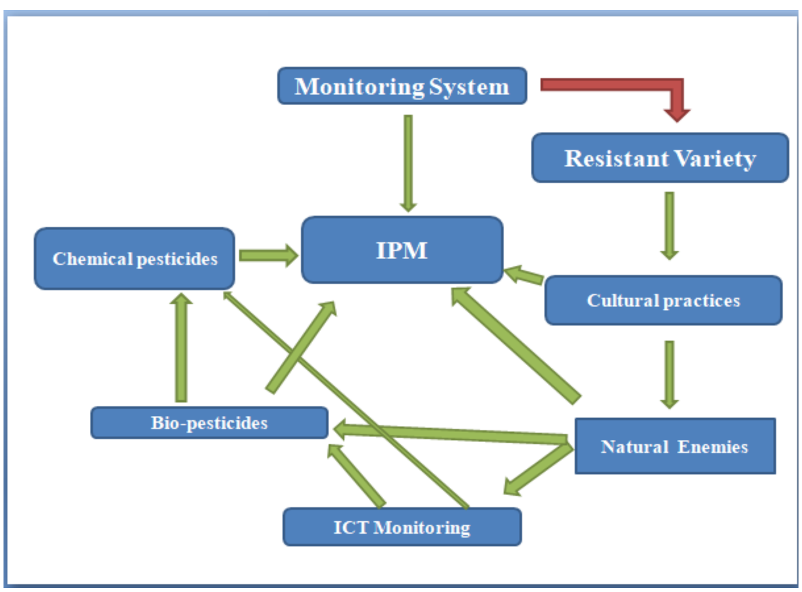
Economic Incentives

Economic Incentives encourages farmers to switch over to IPM. The price of a technology is the most important factor in farmers' decision for its adoption. At present, bio-pesticides are often provided at subsidized prices under IPM programmes and a bulk comes from public sector. The evidence shows that benefits of adoption of IPM are marginally higher than the conventional chemical pest control. An increase in the price of bio-pesticides due to cost considerations or withdrawal of subsidies would be one reason for disturbing the economics of IPM. Since bio-pesticides generate considerable social and environmental benefits, the government should think of classifying them into 'green box' for provision of subsidies. Linking of agricultural credit and insurance to IPM can also facilitate its faster and wide distribution.

To make the production and use of chemical pesticides unattractive through fiscal instruments of taxes, excise duties, sales taxes, etc. on intermediary inputs and final output could be an alternative. The account of imposition of heavy taxes on pesticide industry was one reason for decline in pesticide use during the early 1990s.

The pesticide industry, which has established strong market over the last three decades, may resist it, but it may be pursued to switch over to production of safer pesticides and bio-pesticides. Withdrawal of subsidies on chemical pesticides and diversion of the same towards production and use of biopesticides, and linking institutional credit and insurance with IPM adoption would induce farmers switching over to IPM.

Fig.1 Diagrammatic representation of IPM components



On-farm implementation of IPM

A collective action, cluster approach of selecting villages and farmers in contiguous areas, co-ordination of the government agencies, NGOs, industry and farmers for the large-scale implementation of IPM. The Indian Council of Agricultural Research (ICAR) initiated multiple Operational Research Projects (ORPs) on IPM for rice under the supervision of the Directorate of Rice Research (DRR), Hyderabad, Kerala Agricultural University and Department of Agriculture, West Bengal and also adoption of IPM practices resulted in increase in the rice yield. There are also other examples of successful implementation of IPM in rice in selected districts of the states like Haryana, Tamil Nadu, Andhra Pradesh, Uttar Pradesh, Kerala and Madhya Pradesh (Razak, 1986).

The above concept follows a 'prescriptive approach' wherein technologies appropriate to farmers' conditions are developed in the research institutes and transferred to the farmers for implementation. But, many technologies developed by the researchers are irrelevant to the farmers' conditions and are finally abandoned. For instance, seedling root dip technique of insecticide application for controlling early season pests after transplanting could never found place among the farmers' practices. This is mainly due to the fact that the procedure of seedling root dip is considered cumbersome, and carrying the treated seedlings on heads is detrimental to human health. Similarly, many of the varieties developed with BPH resistance could not find their due place in farmers' fields due to poor threshability and grain quality. The latest trend in IPM is 'bottom-up' or 'participatory approach'. Therefore, IPM can be described as the best combination of control tactics resulting into better yield and profit and safety to the humans and environment. In situations where pesticides have been in use for a long time, the aim is to minimize their use as much as feasible. The main focus is to maximize the use of biological and cultural components, including host plant resistance and biological control agents. This clearly shows the necessity of understanding the farmers' perceptions, knowledge and conditions in the context of farming systems and not just the rice crop alone. Therefore, IPM involves working with the farmers in their fields and devising technologies suitable to their conditions. Many farmers rarely differentiate between the disease symptoms and the nutritional disorders.

Development of market for pesticide-free products

To decrease the use of pesticides, markets could be developed for pesticide-free or low-pesticide residue produce by creating consumer awareness about health benefits of such produce. There are no premium markets and standards for organic food in India at present. Since in the short-run there is a possibility of decline or decrease in yield on switching over to IPM and farmers even-if, are willing to adopt IPM may not do so. In developed countries market for pesticide free products are being developed and these products fetch premium prices which is however lacking in India. This would require not only development of certification procedures but also the labeling system to gain confidence of the consumers. The cost of certification is high for an individual farmer but the cost can be brought down considerably if a group approach is followed. Evolving simple and cost-effective certification and labeling systems to enable farmers to produce pesticide-free products and to gain confidence of the consumers will boost adoption of IPM.

Essentials for implementation

In order to implement a successful IPM program, an IPM plan must be developed, supported and implemented from the top of the organization down. Once the program is developed, communication of the plan is essential. Following are the few points:

Availability of location-specific IPM modules, which are ecologically sound, viable and socially acceptable.

Target group participation at a higher level.

Area-wide dissemination strategy.

Removal of obstacles in dissemination of IPM.

Measuring, evaluating and publicizing the impacts of IPM.

Conservation of natural enemies of pests and their augmentation is of prime importance. Hence, to maintain ecological balance and to manage the pests, the use of bio-agents and biopesticides/botanicals must receive priority attention.

Does IPM work for rice farmers?

Although there is a great amount of literature related to the impact of rice-IPM on farmers but there are few published data. This lack reflects the technical and financial difficulties in carrying out such studies. Longitudinal studies (e.g. data collected over time) in agriculture are especially difficult owing to seasonal changes. Horizontal studies (e.g. comparisons across sites) are also difficult as it is impossible to find an identical IPM and non-IPM control in view of the diversity of interactions and social variation. Both types of studies are costly, especially considering the limitations on methodology but nevertheless, there are strong indicators of IPM benefits for rice farmers. Wide area outbreaks accompanied by massive losses have rarely been experienced in the 15 years during which IPM programmes have been implemented in both policy and field training. In most cases, changes in policy involved restrictions on outbreak-causing pesticides, removal of pesticide subsidies, investment in biological research programmes or educational programmes for decision-makers, extension workers and farmers. These policy changes usually came about as a result of field trials, either by research bodies or within farmer training activities.

IPM needs a continuous upgradation of the technology as per the changing pest scenario as it is a dynamic process and requires adoption of modern and intensive agricultural practices by farmers to achieve the target of increasing the productivity levels to meet the future demand. More than 100 species of insects have been recorded as pest of rice, of which about a dozen are of significance in India. Green revolution has now been widely adopted and the process of diminishing returns to additional input usage has set in. In mid-1960s, it gave a fillip to pesticide use. However concomitant with the practice of intensive agriculture, there is aggravation of biotic constraints like insect pests, diseases and weeds. Nevertheless, pesticide use has started declining since 1990-91, reaching 265g/ha in 1998-99, without much affecting the agricultural productivity. The phasing out of subsidies was initiated during 1990s and taxes were raised, so that the use can be decreased. In fact in 1985, the Government of India had adopted IPM as a cardinal principle of plant protection. The training programmes on IPM were started throughout the country for both the extension workers and farmers. Notwithstanding these initiatives, adoption of IPM has not been very encouraging as bio-pesticides capture hardly 2 percent of the agrochemical market.

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