Crop protection stewardship in India: Wanted or unwanted

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Use of pesticides in India has substantially increased in recent years. It is increasingly becoming an inevitable input in intensive agriculture systems, which have mainly been fuelled by changes in cropping pattern and practice. Survey results confirmed that there has been a widespread lack of awareness on pesticides and their appropriate handling among the applicators in India. Implementation of alternate pest management strategies to reduce pesticide consumption was found to be ineffective. Pesticide policies must be effectively linked with appropriate pest management strategies in order to achieve systematic reduction in the usage of pesticides for agricultural sustainability.

Keywords: Agriculture, crop protection, pesticides, stewardship.

ONE of the eight goals listed by the United Nations Hunger Task Force is related to the conservation of nature and protection of the environment[1]. Pesticides (crop protection chemicals) are specifically formulated to be toxic to living organisms and as such they are equally hazardous to humans. The impact of pesticides on the environment is alarming[2]. Pesticide use is increasing even in developed countries like the United States; substantial increase (26%) of pesticides like methyl bromide has been reported particularly for the benefit of tomato and strawberry growers[3]. India has 170 mha of arable land with average pesticide consumption of 0.5 kg/ha. In terms of total consumption, India is placed tenth in the world[4]. However, the present level should not be equated with low risk to health and environment, given the prevalence of toxic pesticides allowed in India. Interestingly, there is always scope for more pesticide consumption in India in the coming decades owing to the growing population coupled with high demand for foodgrains and intensification of agriculture under fast changing climate. Plant protection chemicals currently cover about 30% of the total cultivated area in India, of which insecticides account for 61.39% followed by fungicides (19.06%), herbicides (16.75%) and others (2.80%)[5]. The green revolution was possible in India due to application of only a few chemical pesticides and fertilizers, particularly in Punjab and Haryana, and this had led to serious soil–water problems. Now there are more than 200 registered pesticides (majority of them are toxic insecticides and fungicides) available for the Indian farmers. Developed countries use more herbicides than insecticides and fungicides, whereas Indian farmers apply more insecticides and fungicides. On comparing toxicity levels (per unit basis) of various pesticide categories, insecticides and fungicides have several times more toxicity than herbicides. These toxic chemicals are used indiscriminately and therefore, both environmental and health problems could be alarming in India.

The cropping pattern in India is fast changing, particularly towards export-oriented, value-added crops (mainly major spices, fruits, vegetables and industrial crops). Some of these crops like grapes require as high as 20 sprays in a year. Similarly, other crops such as small cardamom (12 insecticide and six fungicide sprays per year), irrigated chillies and cotton need 12 rounds of pesticide sprays per season. Therefore, pesticides are being pumped into such agro-ecosystems in India. Interestingly, majority of small farmers doing subsistence farming under rainfed condition (sorghum, bajra, etc.) use limited chemicals and biopesticides as they have fewer problems due to insect pests and diseases. As far as pesticide price is concerned, it is not always true that biopesticides are cheaper than synthetic pesticides. For example, neem-based branded biopesticides in India (US$ 10/l) are costlier than endosulfan (US$ 7/l) or dimethoate (US$ 7/l). Unfortunately, the area under subsistence farming is decreasing drastically because of the fast changing socio-economic conditions and climatic vagaries. The changing regional climate is also exerting pressures on the pest population, which is directly reflected in the consumption of pesticides. India is the second wettest country in the world, receiving maximum rainfall run-off considering its geographical area. Practically 1% loss of one pound pesticide applied in an acre can contaminate all of the drainage from a field in a normal rainfall year at 5 ppb level, according to a recent study[6]. Pesticides are either soluble or less soluble in water; therefore, it is obvious that the chance of contaminating and polluting the environment is high under Indian

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conditions. Therefore, pesticide stewardship may help in reducing pollution and contamination of the environment. Pesticide stewardship is an activity approach to managing the risks of agricultural pesticides based on sound science-based regulation and innovation. The spectrum of international initiatives to reduce risk associated with pesticides includes regulatory, voluntary and industry-led programmes. They are mainly based on policy regulations, capacity building, partnerships (e.g. national obsolete pesticide product management and pesticide environmental stewardship programmes in the US) and economic instruments (e.g. environmental taxes and charges in Sweden, Denmark and Norway). The approach of stewardship is rooted in a commitment for now and the future – the safety, health and well-being of our farmers and the environment by responsible management and minimization of pesticide risks. For the 21st century nothing more is important than sustainability of the ecosystem. This article forms a part of the findings from a national survey conducted during 2002–05. The focus is on intensive pesticide use on crops such as paddy, cotton, sugarcane, wheat, apple, pomegranate, mango, grapes and vegetables covering different agro-ecological zones in India. Although the total area under integrated pest management (IPM) is estimated to be only 2% in India, in recent years, the consumption of biopesticides has increased steadily in many parts of the country. About 64% of respondents (farmers) in this survey followed at least one of the IPM tools in different agro-ecosystems of India.

Relevance of pesticide stewardship in Indian agriculture

Types of pesticides used

In a survey undertaken across Indian states, it was observed that the respondents continue to use hazardous pesticides (World Health Organization (WHO) classes Ia, Ib and II) to manage insect pests and diseases in most of the agro-ecosystems**.** Pesticides account for a major share of the cost of cultivation of crops in India. In normal seasons, in the selected districts, they account for 36% of the cost for cultivation of cotton, 35% for pomegranate, 30% for vegetables, 31% for cole crops, 26% for paddy, 25% for chickpea, 24% for grapes, 21% for mango, 14% for wheat, 8% for cardamom, and 6% for apple. Pesticide consumption in subsistence rainfed farming conditions is negligible. However, substantial reduction in the number of pesticide sprays has been reported from a few areas in the Indian Punjab. The survey confirmed that 34% of the respondents had no idea about IPM and only less than 5% of them had been following complete IPM measures[7]. It was observed that the average per acre toxicity units associated different chemicals varied considerably. For instance, in case of herbicides 0.3, fungicides 2.0 and insecticides 41. Insecticides contribute more than 60% of the total consumption of pesticides, that too class I and II (WHO) chemicals in the surveyed districts. Based on the current measures of acute toxicity, fungicides as a class are far less acutely toxic than insecticides, and variability within this class is much less than for insecticides[8]. However, no effort has been taken up so far for stewardship activity in India. The consumption of herbicides in India is the lowest in the world; at the same time use of toxic insecticides is high. Whereas herbicide consumption is high in USA than those of insecticides and fungicides, and the commitment to pesticide stewardship is strong. In India, to address the problem of stewardship, one has to start with changing current policies and traditional paradigms concerning long-held views on the need for pesticides.

Commodity export and maximum residue level

In a survey of the National Agricultural Technological Project[8] on vegetables, the number of pesticide sprays given to brinjal and cabbage was found to be 20 in a season, i.e. farmers spray pesticides every six days. Small cardamom consumes more than 100 kg/ha/yr of phorate in Kerala[9]. In this rainfed (high rainfall) area, the pesticides used are quinalphos, monocrotophos, chlorpyriphos, fenthion, methyl parathion, endosulfan and emisan. Because of the high pesticide residue problem[10] the export of cardamom has decreased by 80%. India is unable to export even 10% of its production. However, the export rejection of commodities by developed countries due to residues of pesticides is only 10%, which is small compared with rejections due to other aspects like presence of foreign bodies, and microbial toxins and pathogens[11]. Except quinalphos and monocrotophos, all other pesticides have been banned by at least two developed countries. Interestingly, the use of these two pesticides is common in most of the agro-ecosystems in India. Keeping in view these important issues along with socio-economic and agro-ecosystem climatic conditions, crop protection stewardship is inevitable for India. Farmers tend to be risk-averse with respect to pest management and this often results in over use and misuse. Without consideration of external costs (the cost of using the environment for economic activity, most of which affects the environment), the net benefits of pesticide use tend to be overestimated. As in the case of developed nations, it is essential to strategically plan pesticide use in a safe and productive way. The need of the hour is to follow good stewardship practices, as these deal with activities that have positive impacts on the safety and efficacy of pesticides right from their manufacture, through marketing and transport, storage and use, disposal of unwanted or unusable leftover products, and ultimately to management of emptied containers and obsolete stock. From the present scene it is clear that

for any agri-environmental project at local and regional level, pesticide stewardship is imperative for agro-environmental sustainability.

Role for the private sector

Importance of label norm and direction

Label norms and directions are important in a country like India, with 1652 languages, including dialects (428 languages and 1224 dialects). Labels need to be in local languages and include pictograms that clearly identify product hazards, appropriate modes of storage and handling, and other precautions that users should be aware of. Also, authorities or local vendors must ensure that products that have no labels, have damaged labels or are labelled in a language other than the most commonly used local language, are not sold or supplied. The labels should be printed legibly and be reader-friendly. Illegal trading of pesticides (both spurious and genuine) is visible among the southern states, particularly Tamil Nadu and Kerala. This has taken a serious turn after Kerala banned endosulfan. Nearly 60% of the cardamom planters in Idukki, Kerala are from Tamil Nadu; therefore, these planters buy chemicals (endosulfan) from Tamil Nadu and spray their fields in Kerala. The same chemical has also been used for other crops (unintended crops). There are many tribal farmers who cannot speak any language other than their mother tongue and as a result face difficulty in following the label norms. Therefore, targetted training on stewardship may be useful. The label should give warning indication on repeated and cocktail use of pesticides. In the case of drift management of pesticides the label should clearly give directions on drift mitigation, as this is an important issue in small-holding multiple-cropping systems and homestead farming.

Container disposal and recycling

Most of the respondents in the survey conducted from 2002 to 05 reused the emptied pesticide containers for storing kerosene, diesel, etc.[12]. This type of usage is contradictory to the philosophy of stewardship, where the emptied container has been recycled and used for non-consumer purposes (pipes, plastic pillars). A series of procedures must be followed for safe disposal of pesticide containers. For instance, it is important to triple-rinse (or pressure rinse) empty pesticide containers before recycling or disposal; in order to remove 99.99% of the pesticides. Essentially all empty pesticide containers are to be triple-rinsed once empty. The container is filled at least one-fifth with rinsing agent (clean water). The container is closed and shaken to rinse the inner surfaces, then opened and drained for at least 30 s. This is repeated twice. The container is then cut so that it cannot be reused[3]. Besides, the rinse water in the spray tank is stored for further application, thereby utilizing the pesticides efficiently and economically. Correct disposal of pesticide containers is necessary because residues in unrinsed containers could pose risks for the environment. Poor disposal practices also lead to wastage of pesticides. Canada is recognized as a world leader in its empty pesticide container stewardship initiative. Since 1989, the crop protection industry in Canada has contributed more than US$ 20 million towards this initiative[13]. In Canada, 100% of the collected containers are recycled; and nearly 80% of the used containers are collected back. These containers also contain mercury, lead, cadmium, arsenic and other inorganic chemicals that are toxic to human health and the environment at very low concentrations. Priority needs to be given to the systematic collection and recycling of plastic or metal plant protection-product containers. In addition, if the deposit-refund system is implemented for used containers, there is a possibility of getting positive response from the farmers.

Obsolete stocks

Obsolete pesticides are those that can no longer be used for their intended purpose or any other purpose because of prohibition or severe restriction of use, or deterioration of the chemical as a result of improper or prolonged storage beyond the expiry date. These chemicals thus become toxic pesticide waste, which cannot be reformulated or modified to become usable again and hence require safe and speedy disposal to prevent environmental and human health hazards. India has at least 200 tonnes of obsolete pesticides in terms of active ingredients[14], for which there is no facility to dispose-off the materials safely.

The threat of a stockpile of obsolete chemicals in India is also alarming, because the cost of disposal of these pesticides is high, in some cases even exceeding the cost of procurement of these chemicals. As much as US$ 500 million would be required to clean up the obsolete chemicals in the critically affected areas of the developing world at the rate of US$ 3000 per tonne of the obsolete chemicals[15]. Also, safe and environmentally accepted methods of obsolete pesticide disposal are limited. However, most of the developing countries, including India lack even an inventory of outdated and obsolete products. Most of the obsolete pesticides have been either repacked or their date of expiry been erased and a new date of expiry given; and subsequently such pesticides are being sold in the market. Also, such pesticides are sold at a reduced price in the pesticide mela during festival season.

A stewardship commitment from the pesticide companies towards funding of safe disposal of obsolete stocks supplied and standardization of the process of industry participation in disposal projects should be aimed at along with stewardship at the level of awareness raising and re-

sponsible use to prevent stockpiling. But what is needed urgently before embarking on either of these strategies, is a detailed inventory of the stockpile of obsolete chemicals in the country.

Stewardship at the end-user level

Selection of pesticides

Stewardship begins at the point of analysing the pest problem and identifying the right approach to solve the same. If pesticide use is unavoidable, the users need to be trained in safe-use practices. In a survey of farmers in southern India on the management of tomato leaf curl virus, only 2% of them knew the actual causal organism for the leaf curl disease. The others were not aware of the causal organism, but worked towards the management of the disease, as suggested by the traders and dealers. Sometime this results in misuse of chemicals. Such practices lead to skepticism on the right selection of pesticide[16]. The risk is greatest during mixing and loading, where good measuring devices are needed. Risks also increase through substandard spray equipment and untrained operators[14]. It is essential to maintain written records of application of pesticides in a particular season, including chemical names, dose applied and total number of applications. This helps in tracing pesticide usage patterns in a farm or region. Such records are also helpful to the growers, as they can be used for future planning of pesticides, crops, etc. Normally record-keeping is poor among farmers in India. The small size of the farms and non-availability of required quantities of packed and labelled products often force small and marginal farmers to buy larger quantities than is actually required. This leads to both economic and environmental burden[12]. In a survey it was found farmers using only classes Ia and Ib category pesticides, which include phorate, phosphamidon and fenthion and methyl parathion, the use of which is banned in developed countries. The farmers of this eco-region select such toxic pesticides because of non-availability of IPM compatible pesticides[9].

Safe and responsible use of pesticides

The survey results confirm that farmers in Guntur District, Andhra Pradesh have been spraying 15–20 rounds of pesticides on cotton. Similar higher usage in rice in Raichur and Bellary districts, Karnataka has been reported in the survey[12]. The pesticide consumption in cotton varies with region even within a season. For some crop ecosystems, particularly small cardamom and grapes, the number of pesticide sprays is as high as 20 per season; e.g. in Kerala (Cardamom Hills) and Tamil Nadu (Cumbum Valley) respectively. The ability of farmers to use the products effectively and safely is lagging. This has resulted in environmental contamination, severe health problems and unprofitable crop production. Pesticides are often used under conditions that generate or aggravate hazards to human health and the environment under the tropical, wet climate. These conditions include lack of protective clothing, use of substandard spray equipment, lack of training, illiteracy, inadequate information, labels not being in local languages, insufficient water used for cleaning equipment and inaccessible medical facilities. The results of a survey showed that not adequate attention was paid to safety precautions while handling these hazardous chemicals. One of the reasons for this was the hot and humid climate that did not allow the respondents to completely abide by the safety precautions. About 69% of the respondents interviewed covered only their face with a towel/cloth, particularly to avoid the smell and did not use any other protective clothing while spraying pesticides[12].

As a result, untrained personnel take up spraying activities in an unprofessional manner, posing risks to their health and the environment. Institutional and economic structures in the rural sector in India are such that policy interventions are usually needed to reconcile with long-term societal objectives and short-term individual objectives in pest control[17]. Apart from agricultural consumption, pesticides for non-agricultural use, particularly for pest control in the construction of buildings, is increasing at an alarming rate. For example, civil engineers in Cumbum, Tamil Nadu, recommend the application of at least 10–15 l of chlorpyrifos (50 EC) for drenching to manage soil-dwelling termites and ants in the foundation pits taken for 2000 sq. feet building. Chlorpyrifos, one of the most toxic soil insecticides banned in the US long ago, is readily available in India.

Drift management

Drift is unavoidable once pesticides are applied, but they can be used with minimal drift problems. Common crop-protection products are liquids, wettable powder, emulsifiable concentrates and dust. When these are sprayed, they move through the air and eventually end up in soil and water. The Environmental Protection Agency (EPA), USA, defines spray or dust drift as: 'The physical movement of pesticide droplets or particles through the air at the time of pesticide application or soon thereafter from the target site to any non or off-target site. Spray drift shall not include movement of pesticides to non- or off-target sites caused by erosion, migration, volatility, or wind-blown soil particles that occur after application or application of fumigants unless specifically addressed on the product label with respect to drift control requirements'.

A classic case of improper drift management was reported in Kerala, where aerial spraying of endosulfan in cashew plantations has resulted in serious consequences to human health. According to the Environmental Justice

Foundation[18], aerial spraying of endosulfan has resulted in the contamination of surface and groundwater, causing serious health problems to the inhabitants of the region. Virtually every pesticide application produces some amount of drift. The extent depends on factors such as formulation of the material applied, how it is applied, the volume used and the prevailing weather conditions at the time of application. Cool and humid weather favours greater off-target movement and allows particles to stay intact longer periods prior to evaporation. This has been the typical case of lack of understanding and commitment on the use of pesticides in fragile ecosystems, even by the public sector undertaking in India. Considering the topography of the Western Ghats states and the climatology of wind and rainfall during the summer monsoon period, it is not advisable to allow the pesticide spray to drift from the target site and contact sensitive areas of the Western Ghats, because most of the rivers in South India originate from the Western Ghats. During the first monsoon period the average wind velocity in the windward slopes exceeds 40 km/h in the spice and plantation sectors. The average rainfall from the first monsoon period (June–September) ranges from 800 to 6000 mm. Permanent frosty and misty weather respectively, during the winter and rainy seasons also favours pesticide drift in hill agriculture systems. Considering these, label-based mitigation needs to be encouraged in such sensitive areas to ensure the sustainability of agriculture.

Major constraints to pesticide reduction

IPM as an alternative to chemical pest control

The United Nations Conference on Environment and Development (UNCED) Agenda 21 (Chapter 14) emphasizes IPM as the best tool for 21st century plant protection services. The IPM strategies involve all relevant control tactics and locally available methods which are sensitive to local environments and social needs. Therefore, effectiveness of IPM measures can only be achieved if there is user participation at all levels. This is particularly important as pesticide use appears to be on the rise despite the widespread commitment to IPM. The long-term aim of any policy towards pesticide management should be to bring down the pesticide usage in the country. IPM practices that reduce the risks to the environment and public health are favoured. Nevertheless, in the case of multiple spice-cropping systems (small cardamom, black pepper, vanilla and areca nut) in southern Western Ghats, even IPM would consume more pesticides per unit area. For, the presence of several pests at any point of time (depending on the individual crop stage) in a field, necessitates application of more pesticides. Another good example is chilli-based multiple cropping system (chilli, small onion, red gram, yam, sesbania, and bottle and ribbed gourd), where many crops are raised under irrigated condition in Tamil Nadu. Majority of these crops are prone to a high level of pest attack. Hence pesticide consumption is high in this multiple cropping system compared to monocropping system. Although mixed dynamic farming is more sustainable under small holdings, total chemical consumption per farm would be higher when a large number of animals and birds are maintained under intensive management. Indeed, total pesticide consumption depends on the farm size and productivity. Therefore, it is essential to develop a protocol for farming based on ecological principles in each sensitive and vital agro-ecosystem. The role of self-help groups in popularizing the use of biopesticides among local farmers could be appropriate.

However, the development of organic and biological farming packages for complex multi-cropping spice plantation systems is difficult. Till now we have not developed standard organic practices for crops like small cardamom. Since spice commodities are costly in the local and international market (cardamom and vanilla), farmers are interested in higher yields; therefore, intensive cultivation with chemicals is unavoidable. Once the package is ready, then knowledge can be disseminated through the village knowledge centres, wherever such centres are active. In other words, the most problematic pesticides (WHO classes Ia and IIb) need to be addressed first. Strict adoption of IPM in at least 75% of the gross cropped area in every state of India, along with declaration of some sensitive ecological zones as Pesticide Free Zones, where no pesticide marketing or use is allowed, should be one of the main policy components (e.g. national parks and protected areas as well as dams and water bodies used for drinking purposes). The periphery of these important areas should not be sprayed with pesticides. Phase-wise reduction of toxic pesticides should also be included in this framework for pesticide policy.

Policies, government regulatory systems and pesticide stewardship

India urgently requires a pesticide policy that is based on a well-structured overview of the crop protection situation in the country and which is well integrated into the mainstream of agricultural, socio-economic and environmental policy-making. Pesticide policies must be effectively linked with appropriate pest-management policies in order to achieve systematic reduction in the usage of pesticides over time, leading towards the larger goal of agricultural and environmental sustainability. India can formulate a National Pest and Pesticide Management Policy that will take into consideration all aspects of pest control, including environmental (fate and effect) and human health risks, and hazard to applicators and other associated social and economic issues of agricultural sustainability.

The policy can be made more rigorous by incorporating responsible pesticide stewardship at all levels of use. Pesticide stewardship would ensure that the enforcement of pesticide regulations is carried out effectively beyond just complying with regulatory standards and would also help in successful integration of pest management and pesticide use reduction beyond the policy (rhetoric). Thus stewardship forms a crucial part of the overall framework of any pesticide policy. Stewardship risk assessments can be improved in terms of their precision and broadened in terms of their scope.

As of now, India lacks compliance to any of the pesticide management aspects specified by the FAO[19] (Table 1). This situation co-exists with an excellent infrastructure for testing and quality control in India. Hence stewardship measures within a well-formulated pesticide policy can help in the enforcement of strict pesticide management in the country, thus ensuring greater agricultural sustainability. At the level of the industry, pesticide stewardship should cover the complete life cycle of the products that are created and marketed, including container management and obsolete-stock disposal. The industry should also cooperate in achieving the targets set for the reduction in the use of pesticides over time.

Challenges ahead of the Indian crop protection stewardship

Socio-economic challenge

Indian farmers are used to the chemical pest management system and consider that alternative approaches pose new risks and create demands for new sources and information. Recent survey results revealed low literacy, poor awareness and positive attitude on pesticides among the small and medium farmers, who constitute the majority. Only less than 5% of farmers followed IPM practices across all agro-ecosytems[12]. Convincing the farmers to venture into the stewardship activity could be a challenging task to researchers and extensionists, because an additional expenditure on protective clothing, improved and efficient equipment, extra labour and high cost of compatible chemicals is required. This could be possible for high-return crops like orchard crops (grapes and mango) and major spices (cardamom and black pepper). Blanket recommendation of stewardship practices is not possible, because activities would vary with a set of conditions, primarily depending on the dosage and inherent toxicity of the chemicals, besides mitigation potential (e.g. buffers, spray-drift reduction). Lack of finance to carry out locale-specific research and subsequent dissemination of information through extension personnel and farmers poses yet another challenge to India. Finally farmers must recognize that change in the pest management system has lesser impact on the ecosystem and environment as well as human health, without any significant reduction in the yield. If genetically modified crop varieties are introduced as a part of pesticide reduction strategy, then the poor farmers will have to also follow agricultural biotechnological stewardship, which is an additional burden.

Table 1. Compliance of Asian countries to the FAO guidelines on the Code of Conduct regarding pesticides

Country	Toxic restriction	Licensing enforcement	Collection of used containers	Inventory of outdated/ obsolete pesticides
Bangladesh	√	√	√	√
Republic of Korea	√	√	√	√
Laos PDR	√	√	X	X
Indonesia	√	X	√	√
Nepal	√	X	√	√
Pakistan	√	X	√	√
Thailand	√	X	√	√
Vietnam	√	X	√	√
DPR Korea	√	X	√	X
Singapore	√	X	√	X
Sri Lanka	√	X	X	√
Cambodia	√	X	X	X
China	√	X	X	X
Malaysia	√	X	X	X
Myanmar	√	X	X	X
Philippines	√	X	X	X
India	X	X	X	X
	16/17	3/17	8/17	7/17

Biotic stresses

Lepidopteron, coleopteran and dipterans insect pests cause severe yield losses in many of the commercial crops grown all across India. For instance, *Helicoverpa armigera* infests a variety of crops like cotton, tomato, brinjal, cabbage, cauliflower, bhendi, red gram, etc. The tropical climate is more conducive for the development of insect pests, than the disease-causing pathogens. However, fungal diseases in many crops of commercial importance are a problem in India during the rainy season. The genus *Phytophthora* is the most severe across many crops, including potato, cardamom, banana, etc. Powdery mildew affects a wide range of crops (cucurbits and grapes), including major cereals like wheat, sorghum and millet. Fungal anthracnose affects crops such as black pepper, beans, cassava and sorghum. Bacterial diseases cause huge crop losses, particularly diseases caused by the genus *Xanthomonas*, which include blights in banana, rice and cotton in India[20]. Problems due to soil insect pests and nematodes are also on the rise because of soil climate change. This is true, particularly for shallow-rooted crops like cardamom and banana. Because of the increased biotic stress, the consumption of pesticides to manage these pests has increased many folds in the recent years. IPM is one of the viable alternate pest management practices, but

has profound limitations in the Indian agro-ecosetting. The findings of a recent survey concluded that only less than 5% of the farmers follow IPM packages despite huge networks and efforts in various cropping systems[12]. Virtually, there has been little effort to integrate the locally available and compatible management measures to develop economically viable IPM practices. The IPM system must be cost-effective and synthesized based on the best available scientific evidence. Research on native strains and their mass multiplication using locally available substrates, enhancing the shelf life and improving the delivery system is sought. In general, IPM has not been successful in spices and plantation crops system, except coconut. Spices are the major export-earning crops for India. In order to improve the IPM performance, forecast (good) of key insect pests and diseases needs to be addressed and the same must be verified in the fields.

Under changing climatic conditions in all ecosystems, the severity of infection and infestation can change, thereby changing the usage pattern of pesticides in most of the agro-ecoregions. In the plantation areas (cardamom and tea) pesticide sprays are not advised during the first monsoon period (June–September), considering the heavy downpour. The spread of diseases and insect pests, particularly rot diseases and sucking pests that have been severe in the recent years due to climate change, forces farmers to take up pesticide sprays to save the crops. This will have considerable impact on plantation industry and human health.

Cross-border trading of pesticides

Kerala is considered as the land of spices. It produces 60% of the cardamom and black pepper in India. Therefore, Kerala is considered the hotspot for these two major spices in the world. Cardamom is being farmed (in Cardamom Hills, southern Western Ghats) in the intensive manner, consuming maximum fertilizers, pesticides and manure. As far as Kerala is concerned, 50% of the total pesticide consumption goes to cardamom. Most of the pesticides are sold through the produce marketing corporations like Kerala Cardamom Produce and Marketing Corporation (KCPMC) and Cardamom Marketing Corporation (CMC). For sometime, the use of endosulfan was banned in Kerala due to drift impact. However, the use of endosulfan for cardamom was found to be beneficial, because endosulfan was safe to honey bees which are the main pollinators in cardamom. Therefore, cardamom farmers in Kerala received endosulfan directly from Tamil Nadu through salesmen from various companies. The impact of the ban of endosulfan in Kerala in Cardamom Hills had little effect, because of the easy availability from the neighbouring state of Tamil Nadu. Commodity corporations also promote the unscrupulous sale of pesticides, which will ruin cardamom production.

Conclusion

Although several alternative strategies continue to evolve in pest management, pesticides will continue to be used in agriculture. There are no data generated on the exact quantity of pesticides consumed by each crop in India (except rice and cotton). Such data could be useful for EI studies. Educating farmers and training them, especially regarding safety measures such as using protective clothing, proper measuring techniques using appropriate devices, empty container recycling and disposal, are some of the important steps identified to achieve the goals of pesticide stewardship. Also, improving label language and quality, pesticide drift management and involvement of the industry in pesticide stewardship activities would play an important role in the sustainability of agro-ecosystems. The complexity of pesticide application and management has been vastly under-estimated, and recognition of the need for farmer training is growing. We have seen dealers selling pesticides whose expiry dates have elapsed. This is mainly because of the lack of awareness among the farmers. Surprisingly, farmers are forced to buy pesticides along with fertilizers, because the dealers make it as a precondition. It is essential for all the stakeholders, including industry, government, the farming community and the public to share the responsibility to protect public health and the environment during all phases of pesticide production and use, in a participatory manner. What we require now is a sound pesticide and pest management policy for India based on the best available science.

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