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Farmers' education and perception on pesticide use and crop economies in Indian agriculture

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Abstract

Intensive survey involving 1039 farmers belonging to 28 districts in 12 Indian states was carried out in pesticide use predominant regions to study the influence of farmer's awareness, education and practices related to pesticide use as well as Integrated Pest Management (IPM) measures. Data were collected through pre-tested schedules by trained field investigators and the data were analysed by suitable statistical package (SPSS). The results revealed that though overall consumption of pesticide decreased, the expenditure incurred on pesticides remained high. Most of the respondents in the surveyed area followed their own spraying schedules and pesticide doses to manage ever increasing insect pests and disease problems. More than 50 % of the respondents applied both single and cocktail pesticides to manage their crop pests. Greater number of the literate farmers had strong perception on the negative impacts of pesticides on soil, water, air and beneficial organisms. Only 20 % of the respondents obtained their information on plant protection aspect from the agricultural extension officer and the rest of 80% of the farmers used unreliable information in crop production of surveyed areas. The respondents in the study regions were of the opinion that chemical methods of pest control are very effective in combating serious pest infestation. In the study area it was observed that only 3 % of the respondents followed organic farming in a successful way. The total area under organic farming in India is negligible. There is a tremendous scope for agricultural extension activity through which stewardship can be achieved in these pesticide predominant regions. Nevertheless, costs on ever increasing safety measures for pesticide applicators would be an additional burden which is to be considered seriously under resource poor small and medium holding systems in India.

Keywords: Awareness, crop economies, farmers, pesticide use predominant regions, perception

Introduction

Agriculture is an important sector for economic development in India. Crop production is an important income source for millions of farmers in some cases with few cropping alternatives due to ecological constraints. All over the world majority of farmers rely on pesticides and fertilizers to increase yields. Pesticide use in most Indian agriculture is an essential part of production technology. Therefore farmers in developing countries are perceived as overusing pesticides, both in quantity and quality, with mixtures of chemicals, known locally as cocktails, being the favoured form of application (Crissman *et al.,* 1994). In India pesticides were introduced in 1948 but production was started in the year 1952 mainly benzene hexa chloride (BHC) to use against locust incidence. Farmers were then becoming dependent to pesticides and to some extent they used excessively and inappropriately until today. India is the second largest user of pesticides after China in Asia (Soerjani 1990). India, 51% of foods commodities are contaminated with pesticide residues and out of these, 20% have pesticides residues above the maximum residue level values (Gupta, 2004). Maximum contamination was reported in milk products (85%) in Punjab (Menon, 2007). In another survey based on market basket samples in Kolkatta was found out of 62 samples; 19 samples were contaminated with organochlorine pesticides. Residues of endosulfan were reported in 14 samples, residues of BHC in 6 samples and residues of heptachlor in two samples. Interestingly in all the samples the levels of pesticide residues were below permissible level (Auroville, 2003). It has been observed that their long-term, low-dose exposure are increasingly linked to human health effects such as immune-suppression, hormone disruption, diminished intelligence, reproductive abnormalities, and cancer. In this light, problems of pesticide safety, regulation of pesticide use, use of biotechnology, and biopesticides, and use of pesticides obtained from natural plant sources such as neem extracts are some of the future strategies for minimizing human exposure to pesticides.

Food and water samples collected across many countries were found to be contaminated with various organochlorine pesticide residues of DDT and its metabolites, HCH and its isomers, heptachlor and its expoxide and aldrin. The amount of pesticide detected was higher than the permissible limits prescribed by FAO/WHO (2005). In drinking water only a few pesticides exceeded the permissible limits. Seasonal variations of pesticides residues were also observed during the study period. The tested samples showed 100% contamination with low but measurable amounts of residues. Among the four chemical groups, the organophosphates were dominant followed by organochlorines, synthetic pyrethroids and carbamates. About 23% of the samples showed contamination with organophosphorous compounds above their respective MRL values. More extensive studies covering different regions of Haryana state are suggested to get a clear idea of the magnitude of vegetable contamination with pesticide residue (Kumari et al., 2002; John & Bhatnagar 2004).

The Indian pesticide market is the twelfth largest in the world with a value of US $ 0.6 billion, which is 1.6 % of the global market pie. Western Europe and USA are the world leaders with shares of about 30.2 % and 22.7 % respectively. Currently there is a boom in the global pesticide market and new insecticides, herbicides and fungicides and their formulations are being introduced with greater level of activity. There is however, being done with a conscious effort to minimise the hazards to human beings and the environment (TIFAC, 2004 a). Nevertheless, TIFAC (2004 a, b) reported encouraging developments in recent years, which includes almost total self-reliance, with imports constituting less than 5 % of total consumption, indigenous development of several new products and processes and on penetration into overseas markets with exports already having touched a level of about US $ 3 million. In India the use of plant protection chemicals varies with the cropping pattern intensity of pests and diseases and agro-ecological situations. Farmer's education levels plays an important role as it widens the vision of the farmers and exposes them to various aspects and opportunities related to agriculture particularly to promote pesticide and environmental stewardship.

Quantitative and descriptive analysis of pesticide uses in different agro-ecosystems in India illustrates the unquestionable complexity of usage patterns. They are driven by many biological, management and regulatory factors, which continually fluctuate in relative importance from year to year. Yet farmers choose pest management options that appear to meet their objectives, an assessment based on their attitude of pest damage and control. Therefore, an understanding of the factors that affect their perceptions, knowledge and practices is critical for designing effective management strategies or refining the existing ones for optimum benefit (Litsinger *et al.,* 1980; Escaleda, 1985; Sivakumar *et al.,* 1997). Besides, identifying the factors influencing pesticide use could be

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important step in designing policies and programs to reinforce factors which reduce pesticide misuse and thereby nullifying the misuse factors.

Farmer's survey is an important data-gathering process for assessing the needs of intended beneficiaries to determine their knowledge and perceptions of pest problem, their constraints in dealing with the problem and their attitudes in pest management. Such works related to rice farmers of Asia have been documented by Heong and Escalada 1997; Katti *et al.,* 1999). On an average, 33 % of crop loss in India occurs exclusively due to crop pests (Puri *et al.,* 1999). In monetary terms the annual loss caused by pests and weeds is estimated to be US $ 4 billion (Singh, 1999). In a recent study on pre and post harvest loss by pests has been estimated to be around 4,000 million dollars. The loss due to only one insect species, Helicoverpa armigera, which attacks many crops such as cotton, tomato, brinjal, cabbage, cauliflower, bhendi, strawberry and apple, is estimated to exceed 500 million dollars in a year. In order to meet the demand of a growing population we need to protect our crops from pests as India needs to increase the annual food production by 5 million tones per year as against the current rate of 3.1 million tones.

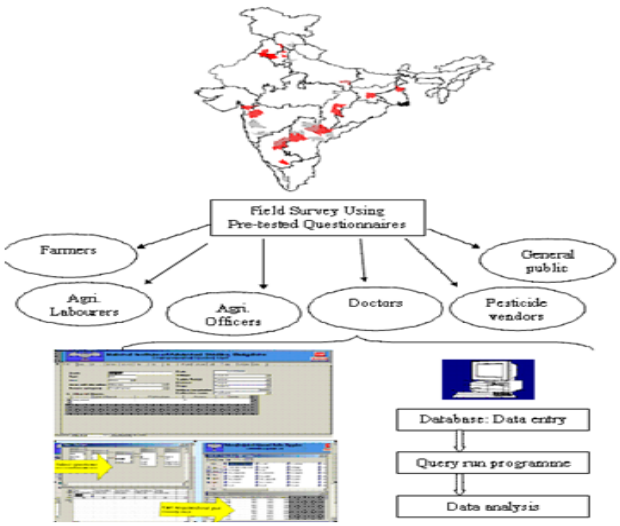
Pesticides have become a weapon in the farmers struggle to protect crops. The consumption of pesticide in India has been increased recently to 0.5 kg ha^{-1} from as low as 0.28 kg ha^{-1} a pentad ago. This quantity is very low when compared to 7.0 kg ha^{-1} by the US, 2.5 kg ha^{-1}in Europe, 12 kg ha^{-1} in Japan and 6.6 kg ha^{-1}in Korea (JPCR, 2004). The present study on the farmers' education and perception levels in the pesticide predominant zones of India was done to have a base line data on the use and misuse of pesticide under various cropping situations.

Materials and Methods

Study sites and data collection

The study was carried out in 28 districts from 12 Indian states based on the type of crops grown and pesticide consumption pattern (Fig 1). The focus was on pesticide use intense crops such as paddy, cotton, sugarcane, wheat, apple, pomegranate, mango, grapes and vegetables covering different agro-ecological zones in India. Primary data were collected from farmers, agricultural labourers, pesticide vendors and agricultural officers with the help of pre-tested schedules. A total of 1039 samples from 290 randomly selected villages across the 12 Indian states were drawn. Farmers from each village were selected randomly and were classified as small (≤ 2 ha), medium (2 - 4 ha) and large farmers (≥4 ha). Data collected through schedules were keyed in to Visual Basic front end in MS Access data base. Schedules of farmers, agricultural officers, vendors, labourers had a separate software package and data were then analysed through suitable statistical technique (SPSS).

Figure 1. Schema illustrating selected hotspots and survey methodology



Survey questionnaire

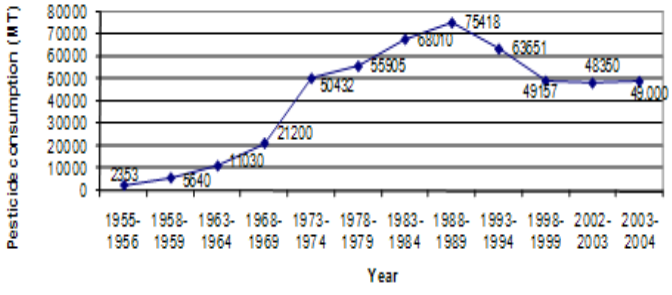
The study data were generated through the use of pre tested schedules given out to the respondents and collected back by the field investigators. The survey questionnaire for the farmers was designed to collect information on awareness of pesticide usage pattern. Pre-coded options based on existing understanding secondary research and pilot surveys were used in the schedules. Specific information was collected from individual schedules served to agricultural labourers, Agricultural Officers and pesticide vendors. To measure the awareness of respondents regarding the ill effects of pesticides, awareness questions were asked with two possible answers, i.e., complete awareness and no awareness with scores of 1 and 0 respectively. These responses by the farmers were recorded against the appropriate statement and were classified into two groups using mean as measure of check. Respondents with total score less than mean was categorised as low awareness group and others as high awareness group. Data were compiled and mean as well as percentages for the intended parameters were calculated to draw results.

Results and Discussion

Consumption trend and share of pesticides in relation to the cost of cultivation of crops

Consumption of pesticides remained high in the initial years of Green Revolution and reached a peak in the year 1988-89. Fig.2 illustrates the pesticide consumption trend in India since 1955-56 to 2003-2004. Between 1999-2000 and 2000-2001 there was a significant decline in pesticides use from 75,418 to 43, 584 tones. This decline began with the banning of few organochlorine insecticides such as DDT, BHC for use in agriculture. BHC represented 30% of India's total pesticide consumption. Yet, the consumption of pesticides between 2001-02 and 2003-04 showed a slight increase for various reasons. Among the states increasing trend of pesticide consumption was noticed in Arunachal Pradesh and Nagaland while no trend had been noticed in Punjab, Haryana and Rajasthan. Interestingly declining trend was observed in major consumers including Andhra Pradesh, Gujarath, Karnataka, Tamil Nadu, Pondicherry, Kerala and Sikkim. From this survey we found reasons that farmers often apply pesticides very frequently in very high doses. It was common for farmers to use pesticides over many times in one season. The spray solution used was a mix of numerous insecticides, fungicides and bio-insecticides even on crops such as vegetables and fruits. This increasing trend of pesticide application therefore would aggravate the socio-economic and environmental and human health problems. Same is the trend in pesticide consumption in other Asian countries like Cambodia and Vietnam, where in the former case the crops are sprayed up to 20 times per season and at least 63% of the farmers don't feel pesticide handling could be a health hazard. Pesticide use in this country is on the incline with 64% more reliance on pesticides (Sadavy et al., 2000). Pesticide consumption has been increased due to change in the cropping pattern, and crop loss in all major crops in many developed and developing countries.

Figure 2. Pesticide consumption trend from 1955 to 2004 in India



Though the overall consumption of pesticides decreased since 1998-99, the expenditures incurred on pesticides were remained high in the study area (Table 1). This could be attributed in increased and higher prices of recent pesticides. The percentage share of pesticides varied within a district for a specific crop. Relatively high standard error for a crop indicated drastic variation in amount spent

on pesticides from one district to another and from one farmer to another. Maximum was reported in cotton (36%) followed by pomegranate (35%). Lowest share (6%) was observed in apple while its return is maximum (Rs. 94783 per acre). The main reason for increase in expenditure on cost of production could be related to increase out breaks and incidences of pest and diseases and insect pest resurgence. Recently, some of the new pesticides marketed are highly priced (most of them are narrow spectrum pesticides) and not affordable to the small and medium farmers. The survey found that cotton consumes 36% of plant protection chemicals in terms of its total cost of cultivation followed by pomegranate, cole crops (31%) and vegetables (30%) and paddy (26%). However the share of plant protection chemicals in the cost of cultivation of fruit crops like grapes (24%) and mango (21%) has been found high. The gross returns of heavy consumers like cotton, vegetables are low when compared with fruit crops like grapes, mango in which crops the percentage share of pesticides in the cost of cultivation is less than cotton and vegetables. The gross return was maximum for apple which is the least consumer of pesticides. Nevertheless, the demand for pesticides would be high in the future owing to intensification of agriculture, change in cropping pattern, and local and regional climate change.

Table 1. Cost of cultivation and returns per acre and percentage share of pesticide

Crops	Cost of cultivation per acre (Rs.)	Amount spent on pesticides per acre (Rs.)	SEM	% Cost of pesticides	Returns per acre (Rs.)	Gross returns per acre (Rs.)
Cotton	11629	3878	390.47	36	16915	5286
Paddy	6292	1630	118.84	26	9351	3059
Vegetables	11115	3297	400.72	30	21322	10207
Cole crops	11449	3580	567.65	31	19855	8406
Grapes	38219	9003	2000.65	24	86611	48393
Pomegranate	7567	2264	503.50	35	11334	3767
Apple	43174	2470	-	6	94783	51609
Chick pea	6000	1500	-	25	10000	4000
Mango	7373	1395	196.87	21	26717	19343
Wheat	4311	624	61.07	14	9087	4776

SEM –Standard error mean

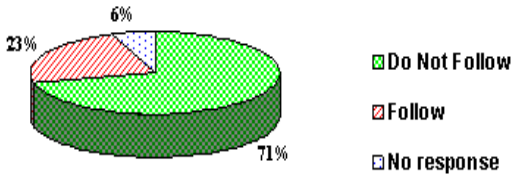
Table 2. Number of pesticide sprays given in a season for different crops in the selected districts

District	Crop	Average no. of sprays
Bathinda	Cotton	15-20
Ghaziabad	Sugarcane Vegetables	6-8 11-12
Guntur & Warangal	Cotton	20-30
Karimnagar	Mango	4-6
Khammam	Paddy Cotton	8-10 10-15
Kurukshetra	Paddy Wheat	5-8 2-3
Murshidabad	Paddy	8-12
Mahabubnagar	Cotton Paddy	10-11 6-8
Nashik	Cole crops Grapes	15-20 12-16
Panipat	Paddy Wheat	6-7 1-2
Pune	Grapes	12-18
Raichur & Bellary	Paddy	15
Raipur	Vegetables	5-6
Rajamundry	Paddy	8
Ranchi	Vegetables	10-15
Rangareddi	Grapes	5-17
Sangli	Grapes	12-18
Simla	Apple	8-12
Sirsa	Cotton	15-20
Surat	Cotton	15-20
Varanasi	Brinjal Cauliflower Cabbage Tomato Chilli	14-16 6-8 7-9 6-8 8-10

Application of pesticides

Majority of respondents (71%) did not follow the current optimum dose or number of sprays as per recommendation (Fig 3) as the current dosages were not effective to control increased intensity and incidences of pests and diseases in agro-ecosystems and also some of the major pests have developed resistance to pesticides commonly used in these districts. It was observed that most of the respondents followed their own spraying schedules to control pests and diseases of crops in all of the selected districts. The number of sprays given to manage cotton pests in Bathinda, Surat and Sirsa was15-20 while in Guntur and Warangal districts it was 20-30 sprays. In Raichur and Bellary the number of sprays was 15, whereas in Kurukshetra, Mahabubnagar and Panipat it was 5-8 sprays. The increased number of sprays in some districts made agriculture less profitable and also resulted in development of insect pest resistance. This has led to pesticide treadmill and also provoked the farmers to go in for higher doses and frequent application of pesticides and also resorted to combination sprays of two or more chemicals because most of the farmers regarded pesticides as drug treatment rather than toxic compounds. Therefore, it is not surprising if they use pesticide more than required. For instance, the optimum dose of monocrotophos in a litre of water is 1.3 ml to manage an insect pest of paddy in its infecting stage of life cycle. But the farmers in Raichur and Bellary use 4-4.5 ml per litre of water. These farmers' characters are common in agricultural practices of other Asian countries like Indonesia and Vietnam. On the contrary some respondents use lower concentration than the recommendation. For example in Bathinda district, farmers use 500 ml per acre of Triazophos instead of 600 ml per acre to manage cotton boll worm. This was mainly attributed to non availability of 600 ml pack in the market. Consistent and contradictory findings were given by Palestine workers where only 56.1% used the recommended concentration of pesticides and nearly 43% of the applicators used more than the prescribed but none used less than the recommended. A total of 89.9% reported that they mixed two or three or more pesticides before they applied them (Yassin et al., 2002).

Figure 3. Percentage of respondents following optimum dose in agroecosystems



In all the selected districts, at least 52.49% of the farmers applied combination of 2-3 pesticides against major pests like Helicoverpa, Brown plant hopper, white flies and stem borers. Nearly 48% of the respondents in the study area sprayed pesticides without mixing two or more pesticides (Table. 4). More than 50% of the farmers followed both single and cocktail (many pesticides in combination) sprays. From this study it has been clear that the practice of cocktail spray of pesticides helped aggravate pest resistance and related problems. Such cocktail recommendations were given to farmers mainly by pesticide retailers in many cases just to increase the sales and profits. Similar type of gathering information and knowledge on this aspect from the dealers or retailers has been reported in other Asian countries where only one per cent of the required information had been collected from the technical field officer (Sadavy et al., 2000) which is a surprising thing to all concerned. This type of practices among the farmers in the study area can be overcome by good extension and foresighted government policies. Similar type of cocktail spray of plant protection chemicals has been common in other developing countries like Indonesia, Vietnam, Ecuador etc. (Indraningsih et al., 2005; Crissman et al., 1994). On the contrary and interestingly the survey also found that combination sprays were not popular among the farmers in Ernakulam, Bellary, Mandya and Raichur districts owing to higher level of awareness on the implications.

Table 3. Pesticide application practice in the sample

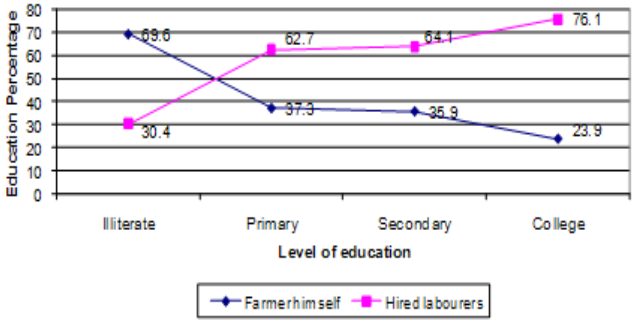
District	Single	Combination	Both
Bathinda	28.0	25.5	46.5
Bellary	100	0	0
Ernakulam	100	0	0
Ghaziabad	6	0	94
Guntur	18	17	65
Hisar	38	0	62
Karimnagar	20	50	30
Khammam	0	71	29
Kurukshetra	30	62	8
Mahabubnagar	35	60	5
Mandya	100	0	0
Murshidabad	92	2	6
Nashik	10.0	15.5	74.5
Panipat	39	49	12
Pune	54	2	44
Raichur	100	0	0
Raipur	84	8	8
Rajamundry	62	34	4
Ranchi	28	24	48
Rangareddi	63	18	19
Rupnagar	22	7	71
Sangli	12	16	72
Shimla	42	0	58
Sirsa	0	0	100
Surat	48	0	52
Varanasi	98	2	0
Warangal	24.5	33.0	42.5
Total	1341.5	496	962.5
Average	47.91	17.71	34.38

Education level on the awareness of pesticides

Education plays very important role as it widens the vision of the farmers and exposes them to various aspects and opportunities related to agriculture and related fields. In this study nearly 15 % of the farmers had either college level education or no education at all. Close to 40 % of the samples had only primary level of education. The rest of the samples were having secondary education (30.8 %). Regarding awareness of pesticides 70% of the illiterate farmers undertook spraying of pesticides themselves, while about 76% of the college educated farmers preferred hired labourers for spraying pesticides. Looking at this for comparison, farmers (91.1%) who had completed secondary school in Indonesia could reduce the pesticide consumption to nearly 50% without compromising on the yields of rice in national IPM programme. However, the number of pesticide application was more than recommended in 58.6% of the farmers' case in other cropping systems in Indonesia (Indraningsih et al., 2005). Data showed that more than 40% of each category of medium and large farmers hired agricultural labourers on contract basis for spraying chemicals. Contract labourers are the most frequent regular applicators followed by the farmers themselves and family members and such type of results were also reported for Latin American agriculture (Crissman et al., 1994). These labourers were illiterate and did not follow recommended dose or sprays and often their method of application resulted in misuse of pesticides (Fig. 4). Majority of the literate respondents in this study expressed strong perception on the negative impacts of pesticides on soil,

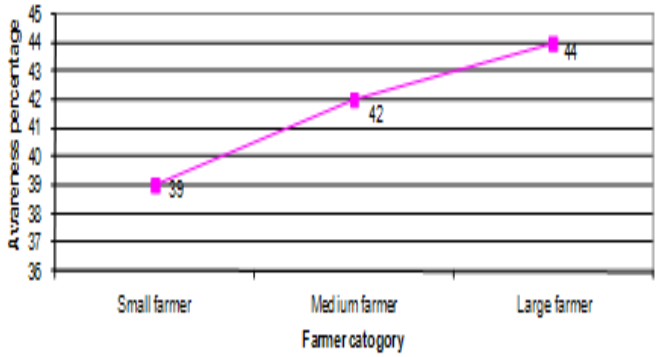
water, air and other beneficial organisms in the environment. Yet it was observed that illiterate farmers had only medium to poor perception on these aspects. However, low education level may have led to farmers' misperception on pesticides ill effects. In a developing country like Egypt the low level of knowledge about pesticides can be attributed to relatively low levels of education and almost all the participants in a survey have never participated in a pesticide education programme at all (Ibitayo, 2006).

Figure 4. Educational level and pesticide applications



The data showed that large and progressive farmers have a greater access to new and latest information on improved agricultural practices as compared to small or marginal farmers (Fig. 5). The awareness on the ill effects of pesticides among different categories of respondents reported to be 42%, 44% and 39 % respectively for medium, large and small farmers. It was observed that there existed an unhealthy competition among some respondents to achieve higher yields, thereby led to misuse of pesticides. Always the neighbours take up pesticide spray fearing that the pests from the neighbour field may enter and damage crops. The survey results showed nearly 60% of the farmers across the category are not aware of the ill effects of pesticides to the total ecosystem. Interestingly, other developing region like Palestine 97.8% of the farm workers had knowledge about the adverse effect of pesticides on human and ecosystem health. Therefore, they were against the use of pesticides in pest management. However, they justified the use of pesticides by the absence of other successful alternatives for pest management (Yassin et al., 2002).

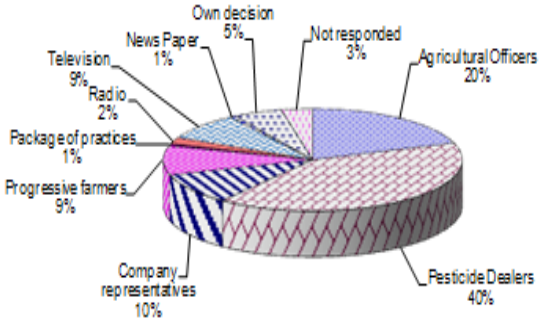
Figure 5. Awareness about ill effects of pesticides among different categories of respondents



Sources of advice and information on crop protection

Farmers obtain required information on plant protection from various sources such as pesticide dealers, company representatives, agricultural extension officers, news papers and progressive neighbour farmers. In the sample about 40% of the respondents in the districts were depending on pesticide dealers (Fig. 6), 20% of the farmers were getting the information from agricultural officers and the rest of the respondents relied upon other sources like company representatives (10%), progressive farmers (9%) and media like Radio (2%), TV (9%) and Newspapers (7%). Nearly 40% farmers get totally unreliable information from untrained persons. Only 20% of the farmers collect proper information from the technical officer who can give field specific recommendation rather than other sources. Therefore 80% of the farmers use unreliable information in crop production of surveyed areas. Interestingly in other South Asian countries the access and availability of information about pesticide use was very limited or non-existent. Forty seven per cent farmers said they obtained information from pesticide sellers in the market and 33% from neighbours or relatives. Only 1% had been given any information from a technical field officer. Nearly 19% said they had never received any information about how to use pesticides on their crops (Sadavy et al., 2000).

Figure 6. Source of technical information to the farmers regarding crop protection



Concluding remarks and suggestions for pesticide reduction

During the last ten years has witnessed a major thinking in the principles and organization of agricultural and rural development as a whole. It was found from the survey that pesticide abuse was greater in some areas in selected districts. No pesticides of other countries are used illegally in India without having gone through the health and safety testing required by Central Insecticide Board of India. Monoculture of a few market oriented crops resulted in increased incidence of pests and diseases in the pesticide use predominant regions of the country. The respondents in the study regions were of the opinion that chemical methods of pest control are very effective in combating serious pest infestation.

A large number of pesticide applicators in the areas are illiterate and they are either agricultural labourers or small and marginal farmers. They do not follow recommended dose or spraying hence often their method of application resulted in misuse of pesticides. Since there is a need to improve awareness among the pesticide applicators and farmers on correct handling and storage of pesticides for which education and training programmes for the farmers in these regions should be strengthened. A wide range of media, including radio, newspapers, posters, communication with extension officers, progressive farmers can be used to communicate the relevant information to pesticide users. These campaigns should be formed towards anybody who buys pesticides and uses them for agricultural purposes. In addition, educating farm women, children and health workers on good stewardship practice may influence pesticide applicators for safe and effective handling of pesticides. Nevertheless, additional cost on ever increasing safety measures for applicators has to be considered seriously under resource poor small and medium holding systems.

To reduce the dependence on pesticide it is important to promote both Integrated Pest Management practices and other non-chemical methods in these regions. To achieve this national level protocol would be required with minimum pesticide input and to apply only recognised IPM techniques on a preventive basis, wherever possible. In the study area it was observed that only 3 % of the respondents follow organic farming in a successful way. The total area under organic farming is negligible. India has very strong local demand and market for most of the produces and the export is limited to few spice crops only. If crops were grown for export in significant acreage then chances are high for less pesticide consumption. But, Policies and activities that support low external input systems, including organic farming and IPM should be mandatory to each farm and each farm should be treated as an individual world of its

own, and the farmer has to find out what works best for his situation to reduce pesticide consumption.

Most of the companies selling pesticides are adopting aggressive marketing strategies to promote their products. Similarly, traders and retailers involved in the marketing of pesticides are also the main point of contact for the farmers and are active in providing credit and often dictate by promoting only certain products of their choice. Respondents were often concerned about sale of spurious and sub standard chemicals which don't yield good control of insect pests when sprayed. Therefore strict monitoring by government machinery and imparting training for the retailers on the use and misuse of pesticides for the effective management of pests and diseases is needed so as to achieve the goal of pesticide reduction to bare minimum level.

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References

Auroville (2003) Innovative Urban management IND-015, Heavy metals and pesticides residue in the foodstuff -Final Report. Annexes 1-9.

Kumari, B. Madan, V. K., Kumar, R. and Kathpal, T. S. (2002) Monitoring of Seasonal Vegetables for Pesticide Residues. Environ. Monit. Assess. 74 (3): 263-270.

Crissman, C.C., Cole, D.C. and Carpio, F. (1994) Pesticide use and farm worker health in Ecuadorian potato production Amer. J. Agr. Econ. 76: 593-597.

Escalada M M.(1985) Baseline survey of rice farmers' knowledge. Attitudes and practices of Integrated Pest Control (Western Leyte): Final Report. A project funded by UNFAO Inter-country programme on Integrated Pest Control (Rice), FAO, Rome, Italy.

FAO, (2005) Committee on commodity problems: Report of Intergovernmentalgroup. http://www.fao.org/docrep/meeting/009/j5314e.htm

Gupta, P. (2004) Pesticide exposure-Indian scene. Toxicology 198(1-3): 83-90

Ibitayo, O. O. (2006) Egyptian farmers' attitude and behaviours regarding agricultural pesticides: Implication for pesticide education. Risk analysis 26 (4): 989.

Indraningsih, Sani, Y. and Widiastuti, R. (2005) Evaluation of farmers' appreciation in reducing pesticide by organic farming practice. Indonesian J. Agrl. Sci. 6(2).

John, B. N. and Bhatnagar, P.J. (2004) Organochlorine pesticide residues in wheat and drinking water samples from Jaipur, Rajasthan, India. Earth and Environ. Sci.98 (1-3):381-389.

Heong, K.L. and Escalada, M.M. (1997) Pest management of rice farmers in Asia, Manila (Philippines): International Rice Research Institute, pp 245.

JPC, (2004) Report. Pesticides and good agriculture practises In: Joint Parliamentary Committee on Pesticide Residues in and Safety Standards for Soft Drinks, Fruit Juice and Other Beverages, New Delhi, pp 98-123.

Katti, G, Pasalu I C, Krishnaiah Rao P R M.(1999) Assessment of change in farmer's perception with change in pest management practices at Maruteru, India- A case study: 1999 pp 61-64, In: Progress Report (June 1998-1999), Rice IPM Network- Phase III, Irrigated Rice Research Consortium, supported by Swedish Agency for Development and Co-operation.

Litsinger, J.A., Price, E.C. and Herrera, R.T. (1980) Small farmers' pest control practices for rain fed rice, corn and grain legumes in Philippine provinces. Philippine entomologist 5: 65-86.

Menon, R. (2007) Are we being slow poisoned. Health and Fitness. http://www.boloji.com/health/articles/01054.htm

Sadavy, P., Sitha, M., Nugent, R., and Murphy, H. (2000) Farmers' awareness and perceptions of the effect of the pesticides on their health. Field document, FAO community IPM programme, Vietnam.

Singh, S. P. (1999) Biological control in India. Indian J. Plant Protection, 27(1&2), 126-138.

Sivakumar, S. D., Subramanian, S. R., Suresh, S. and Gopalan, M.(1997) Pest management practices of rice farmers in Tamil Nadu, India, In:K.L. Heong and Escalada (eds.) Pest management of rice farmers in Asia. Manila, Philippines.

Soerjani, M. (1990) Trend of pesticide use in Indonesia and Asian countries with negative impact to the environment. In S. Prawirosoemardjo and Basuki (eds.). Crop protectionToward the Sustainable Agriculture and environmental Save.Agricon. p.719-745.

TIFAC, (2004a) Technology Information, Forecasting & Assessment Council: Technology for Futuristic Pesticides. Technology Information, Forecasting & Assessment Council, D-1, Qutab Hotel, New Mehrauli Road, New Delhi-110 016, India.

TIFAC, (2004b) Technology Information, Forecasting&AssessmentCouncil: Bio- Pesticides. Technology Information, Forecasting & Assessment Council, D-1, Qutab Hotel, New Mehrauli Road, New Delhi, India.

Yassin, M. M., Abu Mourad, T. A. and Safi, J. M. (2002) Knowledge, attitude, practice, and toxicity symptoms associated with pesticide use among farm workers in the Gaza Strip Occup. Environ. Med. 59: 387-393.