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Farmers perception on pesticide application and related environmental pollution in Rangpur, Bangladesh

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Abstract

Vegetables are indispensable in people's daily life. Pesticides are widely applied to kill harmful insects and promote the yield of vegetables. To know about farmers' practice on pesticide usage and their perception towards environmental pollution, a survey was conducted in intensive vegetable growing areas in Rangpur district of Bangladesh. A total of 90 respondents consisting of 30 each from 3 villages were interviewed randomly in field using a predesigned questionnaire having both close and open ended questions. The result indicated that the maximum number (45%) of vegetable cultivators belonged to the age group of 21-40. About 48% of respondents completed their primary education, and 25% of respondents passed secondary level. Different insects, pests attacked vegetable fields in the study area, and the farmers relied upon chemical pesticides irrespective of hazards. Almost half of the farmers (48.18%) received usage directions from the local pesticides dealers and 37.65% of farmers' overused pesticides. Most of the farmers sprayed pesticides every 8 to 12 days, and more than half (64%) of the respondents adopted safety measures partially; about three-fourth didn't know the waiting period before collection. About one-third of the farmers were blamed for improper use of pesticides, and one-fourth of them believed that lack of proper education was the major cause of pesticide-related environmental pollution. It is necessary to ensure educational program, training and enforcement of the law to avoid vegetable and environmental contamination and raise awareness regarding pesticide use practices and safety precautions.

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Introduction

Safety vegetables are nutritional for our good health. Vegetables are considered indispensable for a well-balanced diet since they complement the need for energy and nutrition. In many areas round the world, vegetables make up the portion demand of the diet and perform a significant role in human nutrition, especially as a source of vitamins (A, B1, B6, B9, C, and E), minerals, dietary fibers, and phytochemicals (Dias and Ryder, 2011). Vegetables in the daily diet have strongly associated with sound health, improvement in gastrointestinal and visionary health, and reduced risks of some form of cancer, strokes, heart diseases, diabetics, and other chronic diseases (Prior and Cao, 2000). However it is essential to consume less than 0.20 kilograms vegetables per person per day in many countries which may causes an unacceptable level of mortality and malnutrition in preschool children and other vulnerable groups (Keatinge *et al*., 2011). To meet the required availability, vegetable production has been increased rapidly worldwide over the past two decades. Total vegetable production over the world in 2018 was 1088.9 million metric tons which are about 1.5 times higher than the annual production of 2000 (FAO, 2020). To enhance the yield quality and quantity and ensure food security for the ever-growing world population, pesticides are used extensively in modern vegetable production. Approximately 2 million tons of pesticides are used annually in the world where China is the major consumer followed by the USA and Argentina (Sharma *et al*., 2019), and in 2020 pesticide use has been increased to 3.5 million tons in the world (FAO, 2020).

In Bangladesh, agriculture is the sole sector that provides much employment (about 41%) of the people, and contribution ratio to the gross domestic product was 12.68% in 2019 (BBS, 2019). The Government of Bangladesh has promised to acquire food independency but apprehended about environmental degradation. Because of favorable weather, though all types of crops are affected by pests, vegetables face relentless attack. Vegetables farmer in Bangladesh heavily rely on pesticides to withstand pests attack. They apply insecticides, fungicides, herbicides, and rodenticides in liquid, granules, and powder form. Farmer's perception of pesticide use relies on their belief in pesticides, and they frequently replaced pesticides if the effectiveness is not enough to kill the pest. They may be engaged in pesticide overuse as they try to control different pests without knowing the pesticides occurrence and appropriate method of control (Chen *et al.,* 2013). About three-fourth farmers (80%) use little or no protective measures while applying pesticides in Bangladesh and 92% of them do not take any protective device during use, storage, transport, etc. (Dasgupta *et al*., 2007). Pesticides impose problem when they are misused or overused, and farmers in Bangladesh apply different chemical pesticides irrationally and inappropriately. Improper pesticide usage (e.g. increased doses, higher frequency, not using protective measures, etc.) impact crop yield and cause harm to human health and the environment. Farmers might absorb hazardous pesticides unaware in different ways, including inhalation. Excessive and whimsical usage of pesticides has not only retarded crop yield, often led to crop losses by unintentionally damaging non-target essential organisms in the soil. It creates pesticides resistance and emergence of secondary pest. NEMAP (National Environmental Management Action Plan) of Bangladesh warned that continuous overuses of pesticides contribute to the pollution essential sub-surface and ground water. Pesticides residues moves into water reservoir from field or by irrigation and rain drainage pose a serious threat to living species. Left over residues of pesticide cause food contamination, and consequently brings potential risks to health and many types of foodborne diseases. In Bangladesh, an investigation indicated 60% of tomato, and 50% of eggplant samples of Narayangonj district contaminated with pesticides, and contamination levels exceeded the MRL proposed by European Commission (Alam *et al*., 2015).

There are some studies conducted in other districts of Bangladesh. But pesticide use knowledge and attitude of farmers and perceptions to related environmental changes have not yet been documented in Rangpur district.

This study established relations involving socioeconomic factors of the farmers, handling of pesticides, and the invisibility stage of pesticides. So the findings of the study could provide background to the concerned authorities while arranging educational program for the farmers to protect them from the hazards of pesticides and taking preventive measures to minimize environmental pollution.

Materials and methods

Study areas

The survey was conducted in several important vegetable-growing areas of Rangpur Sadar Upazila in Rangpur district. Rangpur sadar is one of the eight upazilla of Rangpur district. The upazilla has an area of 330.33 square kilometer and located in between 25°29' and 25°50' north latitudes and in between 89°05' and 89°20' east longitudes. It has a warm and temperate climate with an average annual temperature of 24.3 degree Celsius and annual rainfall of 2498mm. Land of Rangpur sadar is composed of mainly alluvium soil (80%) of the Teesta river basin and, the remaining is barind soil. It was selected as a sample area because of its high participation in vegetable production and consumption. The main crops and vegetables grown here are paddy, jute, potato, cauliflower, brinjal, chili, cabbage, carrot, tomato, cucumber etc.

Sampling procedure and data collection

The study is explorative and descriptive in methodology. Three vegetables namely, cauliflower, brinjal, and tomatoes were selected based on their high pesticide use in the intensively cultivated area. Thirty farmers from each of three village of Rangpur Sadar were selected as sample respondent to make the total numbers of respondents ninety as a whole. The respondents involved in growing the selected vegetables over the last couple of years. Their opinions were listed randomly using a predesigned questionnaire to account for the use pattern of pesticides. Three groups of questions were asked (1) personal (2) pesticide use practice and (3) perception towards environmental degradation.

Personal question included close type questions on socio-economic characteristics of the farmers, such as age, education level etc. as these question defines production and decision making process. Second group included both open and close ended questions. These questions delved out their understanding in pesticides use, direction of use, doses and frequency, protective measures taken, waiting period before harvesting etc. Third group of questions which meant to determine farmer's perception towards adverse effect of pesticides on environment (soil fertility, biodiversity, water pollution, air pollution) was obtained. The respondents were asked to extent their opinion about these statements in three points (Yes, No, No idea). In addition to the interviews, field observation surveys and spraying practices of respondent farmers were discreetly conducted.

To get valid and reliable data, data were verified, corrected, and rationalized by repeating questions, asking neighboring farmers and dealers of pesticide, interviewer's judgment in evaluating the accuracy of responses. Collected data were summarized, processed, and analyzed using computer software like MS Excel and presented in table and chart form using average, percentage, and ratio to provide a picture of pesticide use in vegetable crops in the study area.

Results

Socio-economic characteristics of the farmers

Socio-economic characteristics of the farmers affect their production patterns; technology uses and influences their farm decision-making process. It also gives a picture of their present farm activities, possible development opportunities, and potentials for more efficient vegetable farming. Fig. 1 shows respondents profile regarding respondent's age and education. The maximum respondents (45.0%) belonged to the age group of 21-40 years. The lowest (5.95%) belonged to the age group of 20 or below (Fig. 1A). According to the educational level, primary and secondary level education was recorded by 48.1% and 24.90% of the farmers, respectively (Fig. 1B).

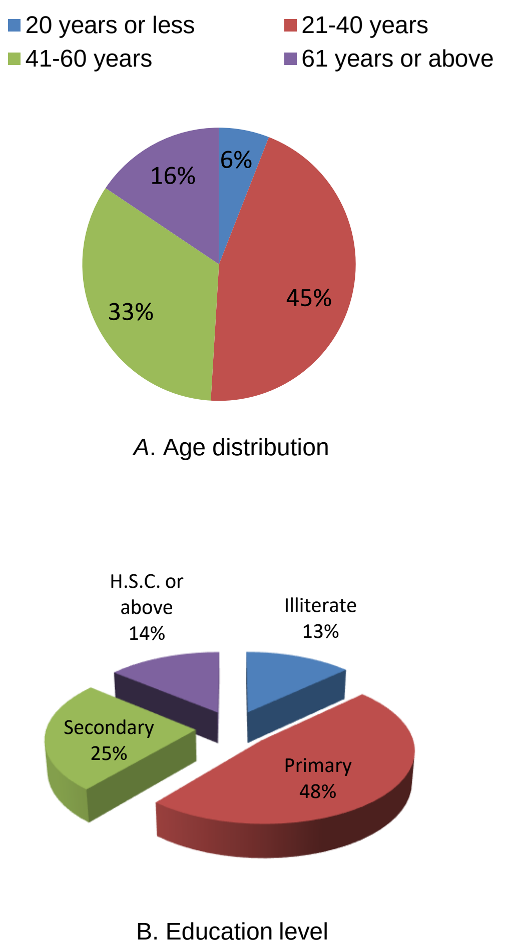


Fig. 1. Socio-economic profile of respondents.

Type of pesticides used for the selected vegetables

Four different types of pesticides were adopted. But no respondent farmer claimed to use herbicides as they control herbs manually and the seeds have already treated with herbicides. All the respondent farmers required insecticides as insect attack is severe than fungicides (Fig. 2).

Both insecticide and fungicides were applied together almost every time at different stages of cultivation. The tomato growers used various synthetic pesticides at vegetative, flowering, and fruiting stages of tomato plants. But cauliflower growers needed fewer fungicides as they buy seeds that were already treated with fungicides. Alternative pest management strategies such as bio-pesticides (natural materials, microbial pesticides, biochemical pesticides) are required (Srinivasan, 2012) but still cover a low percentage (1.49 & 2.22) of total pesticide use.

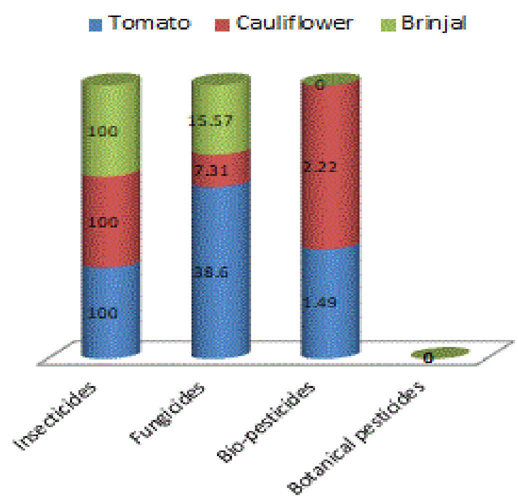


Fig. 2. Use of plant protection chemicals.

The farmers used pesticides belonging to organochlorines, organophosphate and pyrethoids, Carbamate, and other chemical groups (Table 1). Pesticides applied by the respondents belonged to the low risk (category III), followed by moderate risk (category II) and high risk (category I) groups which were classified based on acute dermal LD_{50} for Rabbits/Rat. Brinjal cultivators use more hazardous pesticides than those for cauliflower and tomato. Pyrethoids and organophosphate such as cypermethrin, methyl parathion were used for all three types of vegetable cultivation. Spinosad, karate, chlorpyrifos, imidacloprid, mancozeb, emanectin benzoate, abamectin, vitrako, carbofuran, etc. were mostly used in the study area. A study conducted by a group of scientists in Ghana also showed application of almost the same pesticide in vegetable cultivation (Donkoh *et al.*, 2016).

Direction of pesticide rates, and frequency used by the farmers

In the selected locations of the Rangpur region, 48.18% of farmers received pesticide usage suggestions from the dealers, 35.13% of farmers didn't consult with anyone but used based on their own experience, 14.39% percent farmers used pesticides according to the label's direction, and 2.30 % received training and suggestion from the local agriculture extension office on pesticides usage (Table 2).

Table 1. Types of pesticides used by the farmers.

Pesticide	Hazard Category	Percentage of area applied		
		Tomatoes	Cauliflower	Brinjal
Organophosphates				
Methyl Parathion 50%EC & 2% EC	I	35.6	46.20	21.50
Diazinon	II	24.75	-	45.25
Quinalphos 25% EC	II	-	-	63.25
Vulcan	III	54.50	-	-
Shobicron 425 EC (profenofos 40% + Cypermethrin 2.5%)	II	-	-	73.45
Carbamates				
Mancozeb	III	36.56	57.89	-
Furadan 15G (Carbofuran)	II	-	61.25	-
Knowin 50 WP (Carbendazim)	III	42.20	-	
Goldazim 500 SC (Carbendazim)	II		50.30	
Jazz 80 WP (Mancozeb)	III	-	-	57.76
Mancer 75 WP (Carbendazim 12% + Mancozeb 63%)	III		45.30	
Ridomil gold MZ 68 WG (Mancozeb + Metalaxyl)	II		15.5	
Pyrethoids				
Cypermethrin	II	32.99	28.44	59.48
Karate 2.5 EC (Lambda+ cyhalothrin)	I			59.20
Ripcord 10EC	III			30.5
Organochlorines				
Chlorpyriphos	II			54.20
Vitrako 40 WG	II	-	-	56.90
Endosulfan	I	-	45.3	-
Others				
Saham 5 SG (Emanectin Benzoate 5% SG)	II	43.20	65.50	-
Proclaim 5 SG (Emanectin Benzoate 5% SG)	II			
Confidor 350 SC (Imidacloprid)	II	25.60	-	-
Spinosad 2.5% SL	III	-	56.70	-
Actara 25 WG (Thiamethoxam 25% WG)	III	64.20		
Thiovit 80 WG (Sulphur)	III		54.50	-

Category I→ high risk, Category II → moderate high risk, Category III → low high risk

Table 2. Pesticide use practice of farmers, and precautionary measures taken.

Variables	Respondents (%)
Spray interval of pesticides	
• 3-7days	21
• 8-12 days	60
• 13-17 days	19
Dose of pesticides used	
• Higher dose	37.65
• Lower dose	13.20
Direction of pesticide dosages used by the farmers	48.18
• Dealer's advice	35.13
• Own experience	14.39
• Label's direction	2.30
• Receive training	
Periods of vegetable collection after using pesticides	3.0
• Next day	5.0
• Two day	8.7
• Three day	46
• Four day	20
• Five day	18
• One week	
Protective measures taken by the farmers during spraying pesticides	12.30
• Cover face	28.30
• Cover body	24.60
• Cover body and face	13.33
• No safety measures	87.65
• Washing hand, face and body after spray	62.5
Felt uneasy	

Highest extent of farmers (60%) sprayed pesticide in 8-12 days interval compared to 21% in 3-7 days interval and 19% in 13-17 days interval (Table 2). In the study areas, 37.65% of farmers used higher dose, in contrary to 13.20% of farmers who use lower dose of pesticides (Table 2). Some respondents also argued that a higher dose is used due to the apparent inactivity of the sprayed pesticides to kill the target pest. On the other hand, a lower rate was used due to the high price of pesticides.

Last spraying time before harvesting vegetable

According to Dr. Kamal Humayun Kabir, Chief Scientific Officer, PRET (Pesticides research and environmental toxicology) "the level of harm caused by synthetic pyrethoids is low and vegetables should be collected at least four days after its application. Similarly, farmers should wait at least 11 and 13 days after using organophosphate and organocarbamet group pesticides." In the study area, it is common practice to spray pesticides immediately before collection.

They sprayed pesticide immediately before harvesting/collecting, and the danger of pesticide residue on the vegetable is more. The respondents ensured that they do not use pesticides on the day of collection. Also, almost half (46%) of the farmers usually collect vegetables after three days of using pesticides. Though harvesting time varies with vegetable types; 3%, 5%, 9%, 20%, and 18% of farmers have been marketing vegetables on the next day, two days, three days, four days, and a week later after using pesticides, respectively (Table 2).

Protective measures taken by the farmers during pesticide spray

The vegetable growers in the study areas applied pesticides to the crop with their hand pump sprayer. Almost 65.25% of farmers had taken partial protective measures (wear additional cloth/trouser etc.) during pesticide spray/handling. 12.3% of respondents covered their face with cloth/mask; nearly 28.30% of them covered their body and wore shirts at the time of pesticide spraying. 24% of respondents had reported that they covered both their face and body. About 87.65% of farmers washed their hands, face, and body with soap after working with pesticides to avoid bad smells. In the study area, 13.33% of respondents thought it unnecessary to take any safety measure during spraying (Table 2) though it was a matter of concern for their health. None of them used a mask, eyeglass, and gumboot, which are considered basic safety measures. About 62.5% of workers, who were directly involved in pesticide application, expressed that they felt uneasiness like severe headaches with vomiting tendency, sneezing, nausea, skin and eye irritations, weakness, and chest discomfort after a long time work with pesticides. In Nepal, people use pesticides without taking basic safety measures neglecting human health (Atreya, 2007).

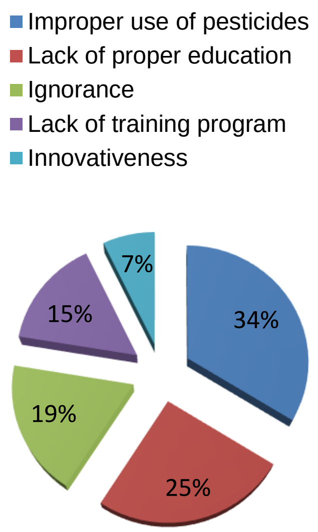
Farmer's perceptions on the role of pesticide in environmental pollution

Farmers apply pesticides in a small area; it spreads in the air, is absorbed in the soil, dissolves in the water, and eventually reaches a large environment. Once pesticide releases into the environment may have indulged in different fates. When asked to indicate their views on the causes of environmental pollution, with respect to pesticide application, a majority (34%) of the respondents blamed the improper application of pesticides followed by lack of proper education (25%), ignorance (19%), lack of training and extension service (15%), and innovativeness (7%) (Fig. 3A).

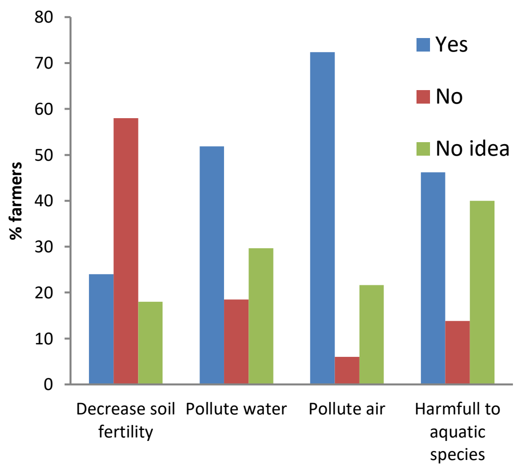
Farmers were asked to express their views on the extent of pesticide related environmental pollution. More than half (58%) of respondents in the study area thought pesticide didn't decrease soil fertility, 24% thought it decrease soil productivity, while the other 18% had no idea on this issue (Fig. 3B).

Pesticide residues in water are a concern as they threaten aquatic communities and humans. About 51.85% of respondents are concerned about the detrimental effect of pesticide residues in water. But 18.52% of respondents think that pesticide residue doesn't pollute water, and 29.63% of respondents were unaware of this issue. About 67.21% of the respondents opinioned that pesticides are responsible for air pollution.

Sometimes, a pesticide eliminates essential species promoting the dominance of undesired species or simply decreasing the number and variety of species present in the community. Due to the high water solubility of the pesticides, pesticides contamination of the water and sediments are very common and sometimes exceed the lethal limits for organisms that provide food for the fish. Many pesticides, on the other hand, are very toxic to aquatic species. In this study, the majority (44.20%) of the respondents agree that use of pesticides is harmful to aquatic species, 13.80% of farmers contradict the majority, and 40% farmers have no idea about the impact of pesticides on aquatic species.



A. Causes of Environmental Pollution



B. Extent of environmental pollution

Fig. 3. Farmers' perceptions towards environmental pollution.

Discussion

The study explores perceptions; and pesticides use practices of vegetable farmers by portraying a situation of pesticide use in Rangpur, Bangladesh. The data revealed a cross-section of vegetable cultivation throughout Rangpur. Socio-economically the farmers are inefficient to have a good pest management process. Farmers having primary education and limited access to training and extension services are a couple that they are aged. So, they have implications on selecting the type of pesticide, spraying time, the interval of spraying, and quantity of pesticide for vegetable cultivation. But increasing participation of the young generation in vegetable farming denotes a positive sign as it will add educated people in agriculture.

Though there are several laws and rules to regulate the import, manufacture, formulation, sales, and use of pesticides, a consolidated and uniform system is absent in pest management in Bangladesh. The presence of unregistered pesticides in the study area has pointed out the failure of the present legal regime of pesticide management. The government has banned or restricted the use of some pesticides, and many others are under review for their potential adverse impact on health and the environment. A single-ingredient pesticide has hundreds of trade names in Bangladesh that makes the monitoring and chemical inventory difficult. Such a large number of pesticides lead to unhealthy business competition, and the businessman adopts illegal means to maximize profit. These types of misleading advertisements confuse farmers in Rangpur. PAN (pesticide action network) considered Emanectin Benzoate as a hazardous pesticide. European Chemical Agency found it damaging to organs and skins. It is sold in different trade names in potato, rice, brinjal, bean, and jute cultivation in the study area. Endosulfan, Chlorpyriphos are other banned pesticides but still can be found in the registered pesticides list in Bangladesh. Farmers use these pesticides for their effectiveness and low cost. Farmers are the immediate victims of these pesticides as most of them don't care about reading the labels and taking protective gear while handling.

However, manufacturers have highly influence on growers to use more pesticide in the study areas. Pesticide dealers are carrying out their business in the farming communities and are very interested in achieving large sales of their pesticides. Chemical pesticides are currently the cheapest and most effective means of pest control in the short run. It is becoming difficult to have high productivity on many farms without pesticides and financial affordability and reluctance to the alternative to chemical pesticides responsible for the overuse of pesticides.

Improper use of pesticides (increased doses & frequency, not wearing protective cloths) causes directly cropping loss, and indirectly health and environmental damages by killing useful animals (Thuy *et al.*, 2012).

Particularly small-scale farmers select pesticides according to product prices irrespective of its hazards associated. In addition to that, pesticide overuse is related to farmers' accessibility to pesticides; the more pesticides are readily available to farmers, the more likely farmers will use them. Scientists in Pakistan also urge that improper and excessive use of pesticides, especially in developing countries, is related to lack of training and formal education on pesticides, lack of alternative to pesticides, lack of information on the hazard associated with pesticides, and the unwillingness of the farmers to accept the crop loss (Khan *et al.*, 2015). Another survey in the Gazipur district in Bangladesh indicates most of the respondents have medium level knowledge on pesticide use, and 70% of respondents have a medium practice of pesticide use for vegetable cultivation (Yeasmin *et al.*, 2018). Toxicity of insecticides commonly expressed in terms of lethal dose 50% (LD_{50}) or lethal concentration 50% (LC_{50}). LD_{50} is the single exposure dose of the poison per unit weight of the organism required to kill 50% of the test population, where the population is genetically homogeneous. It is expressed in milligram per kilogram body weight.

More commonly agricultural farmer is at a higher risk to be affected. Farmers in the study area don't care about the waiting period though they know the waiting period roughly for a particular pesticide. To earn money, they sell the vegetables before passing the waiting period. They excuse that if they are waiting they lag in the competition in the market and vegetables look wilt and consumers don't like to buy such vegetables. The presence of pesticide residues in daily taking vegetables is an indicative change in the use pattern of pesticides in Bangladesh. Consumers living in Rangpur district in Bangladesh are at high risk due to contaminated food and water or pesticides drift from the fields (Zaman *et al.*, 2012).

Most of the pesticides adsorbed easily, persistent, and volatile. They are degraded by microbial action in soil, by photodegradation under sunlight, or by chemical degradation such as hydrolysis (Tadesse and Kasa, 2017). Thus pesticide gets accumulated in plants part, soil, water, and environment. The injudicious deposition of pesticides or organic chemicals in soils directly affects the soil microorganism and spoils future soil repercussion that severely impacts the soil ecosystem, water bodies, and plants. A research found the presence of organophosphorus and carbamate pesticides residues in surface water and ground water samples (Zaman *et al.*, 2012). Pesticides sprayed on the vegetable evaporate and mix with air. Sometimes pesticide damages the protective ozone layer that eventually results in deleterious sun rays reaches in the earth. Widespread use of fumigant such as MtBr and Methyl Bromide has been found to cause stratospheric ozone layer depletion resulting serious health issues (Sande *et al.*, 2011). A considerable amount of respondents are unaware of the fact that pesticides have a lethal effect on non-target beneficial species in soil. They even tended to overlook or deny the harmful effects of pesticides on air and water. In India, surface water is found more contaminated than groundwater with concentrated pesticides (Z Lari *et al.*, 2014).

Conclusion

Different insect-pest causes diseases of vegetables at different growth stages in the survey areas. Almost all vegetable growers used synthetic pesticides, and they were reluctant to depend on organic pesticides. They carelessly and whimsically took pest control decisions by themselves or were misguided by the local pesticide dealers. These were reflected in overuse, and misuse of chemical pesticides through the improper estimation of the timing and frequency of application, not reading labels on pesticide containers, not wearing proper protective equipment. The study also indicated that fewer farmers were conscious about the pesticide residues left in vegetables, and they had medium or low level perceptions on the adverse effect of pesticides on the environment.

In conclusion, government and concerned authorities need to put into effect pragmatic initiatives to curb, or at least, minimize pesticide misapplication and its consequent complexities on health and the environment. Arrangement of free access training program for the farmers about the judicious use of pesticide will raise their awareness and inclined them to adopt organic farming practices. The government had to ensure proper regulations on the sales of hazardous pesticides through monitoring and enforcement of the law. Moreover, linkages were needed to build up among the concerned researchers, extension workers and intermediary for greater expansion and dissemination of pest management.

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