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POTENTIAL FOOD SAFETY RISK IN FRUIT PRODUCTION FROM THE EXTENSIVE USE OF FLUORINE-CONTAINING AGROCHEMICALS

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ABSTRACT. The aims of this study were to investigate the use by farmers of fluorine-containing and other agrochemicals in the cultivation, ripening, and preservation of fruits and to explore the determinants which influence the use of agrochemicals. Ninety-four farmers were selected randomly from a total of 157 fruit growers in a major fruit production area in Bangladesh. The co-efficient of correlation was computed in order to explore the determinants of agrochemicals use. The values of the agro chemical use index (ACUI) indicated that Bistarin, Rigin, Cupravit, Tilt, Ridomil Gold, Basudin, Ciathian, and Dimecron were the agrochemicals most frequently used by the fruit growers. The farmers of the study area frequently used fluorinated agrochemicals which are harmful for human and environmental health. The majority of the farmers (63%) had a medium level of use of agrochemicals, while 23% were low users and 14% were high users. The analysis showed that farm size, annual income, area under fruit cultivation, and the innovation proneness of the farmers had significant positive relationships with the use of agrochemicals. Significant negative relationships with the use of agrochemicals were present for the farmer factors of age, level of education, agricultural knowledge, cosmopoliteness, communication media exposure, and awareness about pest hazards. The results of the study suggest that a comprehensive program is required for raising the awareness in farmers of the recommended level of agrochemical use and the adverse effect of agrochemicals on human health and environment.

Keywords: Agriculture; Agrochemicals; Bangladesh; Fluoride; Fluorine-containing agrochemicals; Food safety; Hazards; Pesticides.

INTRODUCTION

Bangladesh is a country with an agricultural orientation with approximately 80% of the people having a direct or indirect relationship to agriculture. Agriculture and environment have a close relationship and interact with each other. The health of agriculture depends on the proper functioning of the environmental process and the health of the environment depends upon respectful agriculture being practised.[1] The population boom of the world has tended in many respects to increase the agricultural production level so that the extra mouths may be fed. As a result, technological advancement has been occurring in one part and, in another part, all out efforts are being made for utilizing these technologies.[2] Fruit production is one of the major parts of agriculture. Fruit may supply several different types of nutrients, such as vitamins, calcium, phosphorus, iron, carbohydrate, protein, and fat, which help protect against disease.

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Although agrochemicals are widely used for successful fruit cultivation and play a vital role in increasing fruit productivity,[3] their use is now considered to pose a hazardous risk for the ecosystem. In fact, the scale and non-judicious use of agrochemicals for a long period has been damaging to natural resources such as land, fish, beneficial insects, and soil microbes, etc. The soils of Bangladesh have lost their fertility to a great extent due to the overuse of chemical fertilizers. The soil organic matter status has reduced to 0.5% and the activity on the land has increased.[4] In addition, about 50% of the fertilizers applied to soil remain unused which causes chemical reactions resulting in a deterioration in the water conservation capacity of the soil and an imbalance in the natural capacity of soils to resist decay.[1] Chemical fertilizers also contribute to global warming by emitting nitrous oxide, one of the greenhouse gases, into the atmosphere. The global warming potential of this gas is 180 to 300 times higher than that of carbon dioxide. Most of the emissions of nitrous oxide occur from a biotic source with nitrogen fertilizer application accounting for one fifth of the total volume. Although pesticides have become fundamental weapons for combating the pests and diseases outbreak in the fields of farmers,[5] their indiscriminate use has resulted in a devastating ecological imbalance.

Agrochemicals have a vital importance in fruit production but their excess use can cause various health and environmental problems. The optimal use of agrochemicals can enhance the yield of fruit production by controlling insects and diseases, and by giving protection from other pests. In last decade, a number of new agrochemicals have been introduced.[6] Among them, some are beneficial for crop production but their residual effects can cause various diseases for humans. Similarly, some chemicals are also harmful for environmental and soil health. Fluorine is considered to be one of the unique elements and it has strong biological activity in fungicides, insecticides, and herbicides.[7] The application of fluorine-based chemicals has enhanced the potential to control pests while appearing to have little impact on environmental health.[8] These characteristics of fluorine make it popular with the fruit growers. The major characteristics of fluorinated agrochemicals that can work effectively for fruit production are lipophilicity, steric effects, electronic effects, and stability.

The Department of Agricultural Extension (DAE), the largest extension organization in Bangladesh is directly involved in motivating farmers for using modern agricultural technologies in order to improve productivity and increase production. The DAE introduced the training and visit (T&V) system of extension work in 1978. The Agricultural Support Services Project is also being recognized under the New Agricultural Extension Policy (NAEP). Under this program, the Sub Assistant Agricultural Officers (SAAO) are supposed to contact the group members in their weekly/fortnightly meeting, which is known about by all the group members.[9] The SAAO usually delivers their extension to the group members in order to overcome the difficulties encountered in the previous (T&V) system of extension approach. The group members are then expected to transmit the idea and messages to the non-group members of the social system. In Bangladesh, at present, there are various non-governmental organizations (NGOs) working with a variety of programs that they have launched. Raising the awareness of people regarding environmental degradation is one of the fundamental issues. Apart from the government efforts,

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various programs are being undertaken by the NGOs, especially for improving awareness regarding health, sanitation, and the environment. As a result, the outcome has been quite satisfactory and the people are becoming more aware of the programs. Under these challenging circumstances, the SAAOs need to be competent enough to deliver their message effectively in order to be accepted by the group members, particularly in response to the situations arising out of the abuse of agrochemicals.[10]

At present, agrochemicals are extensively used in fruit cultivation, ripening, and preservation, especially with bananas and pineapples.[11] Although agrochemicals have increased fruit production, they may have a major harmful effect on both human health and the agroecosystem. It is therefore necessary for farmers to know about the harmful effect of agrochemicals. Only a limited amount of research has been done in Bangladesh on this aspect. Modern agriculture and public health are closely associated with the use of agrochemicals. Pesticide use, for controlling insect pests and diseases, is one of these agrochemical uses.[12] Although pesticide use is an integral part of the modern agriculture for protecting fruit crops, it unfortunately has a high level of adverse effects on environment because a high concentration of pesticides in the soil damages the living organisms in fertile soil.[11] The use of chemical fertilizer for fruit production creates a strong nutritional imbalance in soils by increasing the reserve of a particular nutrient or by decreasing the nutrient levels through enhanced uptake by fruit crops. Chemical fertilizer also affects the physical, chemical, and biological properties of soil. These adverse soil properties ultimately create a strong imbalance in soil ecology and affect the crop yields.[14] Organic fertilizers, on the other hand, tend to maintain good soil fertility without a significant decline in yield and they also maintain a healthy soil environment. From various viewpoints, it is clear that the use of pesticides and chemical fertilizers may have a serious effect on the ecosystem. The non-judicious use of agrochemicals may damage natural resources like the land, fish, beneficial insects, and soil microbes, etc.

In view of the foregoing discussion, the present study was undertaken. However, since the various characteristics of an individual are likely to have an influence on the formation of their attitude towards the use of agrochemicals, there was a need to ascertain the relationship between these component factors of attitude and the use of agrochemicals.

Although recent agricultural practices are more dependent on agrochemicals, nobody can deny their adverse effects on human health and the environment. The use of agrochemicals is allowed when they are used within the recommended limits but their excessive use pollutes soil, water, and the environment and poses a challenge for the future of conservation agriculture. Pesticide-dependent agriculture is not the proper way for achieving sustainable agriculture. It has on-site and off-site impacts on the environment and agriculture. Farmers are not only the producers but are also the consumers. Agrochemicals, particularly pesticides, have serious effects on the health of both the producer and the consumer. So, it is necessary that both producers and consumers have an awareness of the adverse impact of agrochemicals.

Although a few studies have been done on agrochemical use in agriculture, fruit production in a populous country like Bangladesh has received little attention. Therefore, the aim of the present study was to fill this research gap by addressing the issues through the study of areas of Bangladesh with high fruit cultivation. The

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specific objectives of the study were to ascertain the farmers' use of agrochemicals in the cultivation, ripening, and preservation of fruits, and the attitude of the farmers towards the harmful effects of agrochemicals on the agroecosystem and human health.

It was considered that the findings of the study might provide valuable guidelines for researchers, planners, policy makers, and other governmental and non-governmental organizations for developing policies for the betterment of rural people.

METHODOLOGY

The quantitative oriented qualitative mixed method was used for this study. The Ausnara union of Madhupur upazila under the Tangail district in Bangladesh was purposively selected as the study area due to its similarity to the areas involved with fruit production across Bangladesh (Figure 1). The geographical area, weather, and soil properties there are favorable for fruit production. A large amount of various kinds of fruits are produced in this area which regularly supplies the other areas of the country.

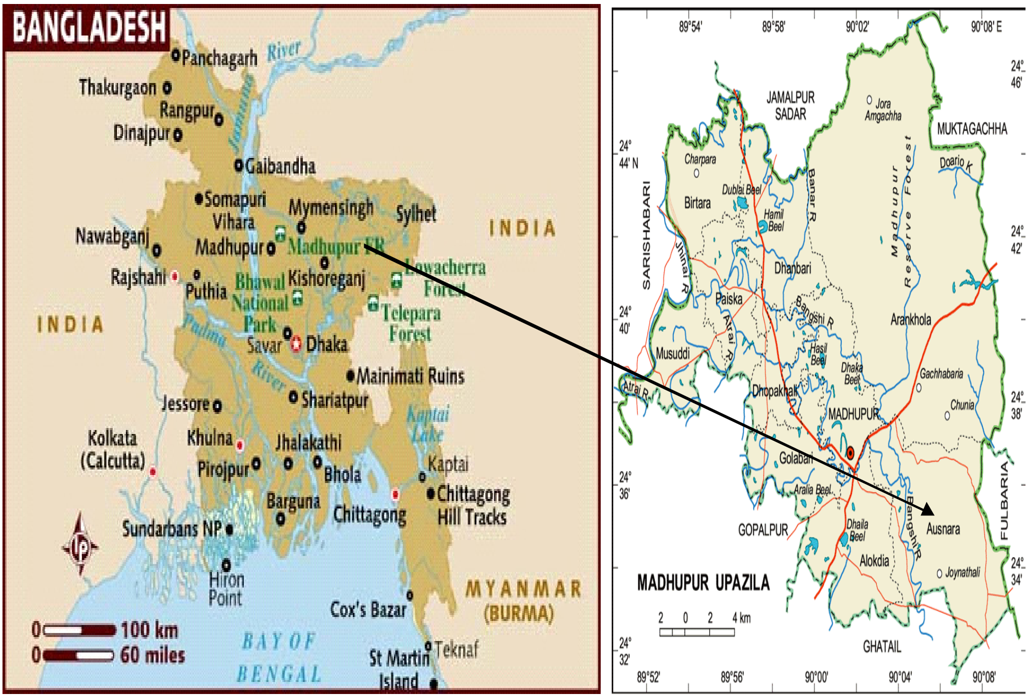

Figure 1A: The study area in Madhupur upazila, Tangail district, Bangladesh.

Population and sampling procedure: The farmers who were involved in the cultivation, ripening, and preservation of fruits in the Ausnara union under the Madhupur upazila of the Tangail district were considered for the study. The Ausnara union consists of three blocks namely Mohismara, Atra, and Holudia. Out of these, the Mohismara block was selected purposively since banana is widely cultivated in the block. In all, 157 farmers, who cultivated banana and pineapple, constituted the population for this study. Sixty percent of these 157 farmers were randomly selected as the sample. Thus, a total of 94 farmers were selected as the sample for this study out of the 157 farmers.

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Figure 1B: An enlargement of the left half of Figure 1A showing the study area in Madhupur upazila, Tangail district, Bangladesh.

Data collection: The data was collected from 94 fruit growers in a major fruit production area (Madhupur) in Bangladesh during January to February, 2017. In order to collect valid and reliable information from the farmers, an interview schedule was carefully designed keeping the objectives of the study in mind. Simple and direct questions and different scales were used to obtain the information. The direct questions were included to collect information on age, level of education, farm size, annual income, agricultural knowledge, area under fruit cultivation, innovation proneness, and awareness about pest hazards.[15] The scales were used to measure the

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cosmopoliteness and the communication media exposure. Four-point rating scales were used for ascertaining the use of agrochemicals by the farmers during their cultivation, ripening, and preservation of fruits.[16] The data were collected by means of interviewing the sampled farmers. Before going to the respondent farmers for interview, they were informed verbally to ensure their availability at the proper places as per the scheduled date and time. However, if any respondents failed to understand any questions, the researcher took great care to explain the issue. Six respondents from the reserve list were interviewed because the respondents were repeatedly unavailable for data collection. Excellent cooperation and coordination were obtained from all respondents.

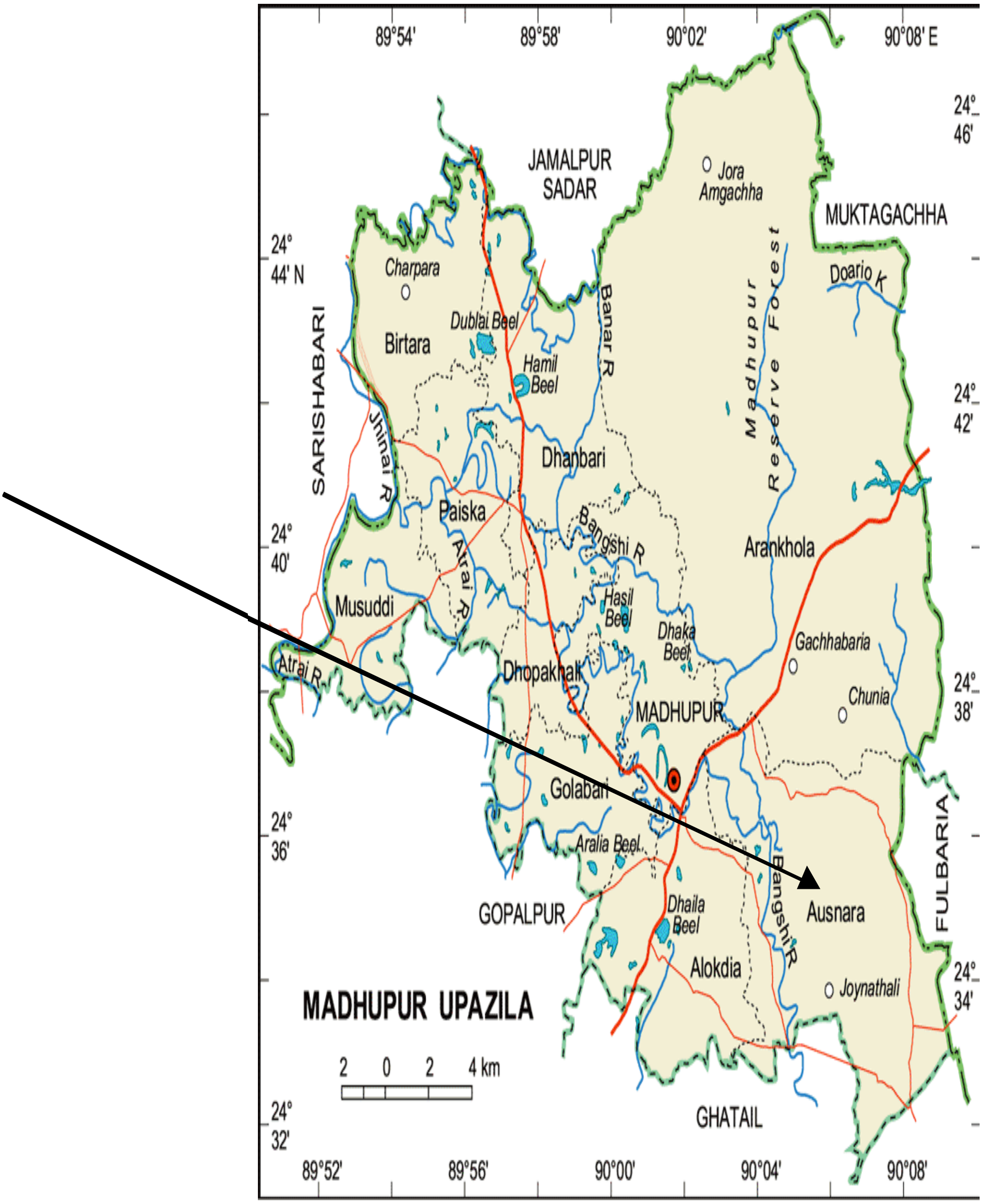

Figure 1C: An enlargement of the right half of Figure 1A showing the study area in Madhupur upazila, Tangail district, Bangladesh.

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Variables of the study: The dependent variable of the study was “use of agrochemicals.” The independent variables of the study were the farmers’ characteristics of (i) age, (ii) level of education, (iii) farm size, (iv) annual income, (v) agricultural knowledge, (vi) area under fruit cultivation, (vii) cosmopoliteness (the extent to which one possesses cosmopolitan traits), (viii) communication media exposure, (ix) innovation proneness, and (x) awareness about pest hazards. These ten characteristics of the farmers constituted the independent variables of this study. The age of the farmer was measured in terms of years from his birth to the time of the interview. The education of a respondent was measured on the basis of classes he had passed in formal educational institution. The farm size was measured as the size of his farm (including banana, pineapple and other crops) on which he continued his farming operations during the period of study. It included the area of farm owned by themselves as well as those obtained from others by lease or mortgage. The area was estimated in terms of the full benefit to the growers in terms of hectares. The farm size of a respondent was measured by using the following formula (Equation 1):

$$\textit{Farm size} = A_1 + A_2 + A_3 + \tfrac{1}{2}(A_3 + A_5) \quad \text{............................. Equation 1}$$

Where:

A_1	=	Homestead area
A_2	=	Own land under cultivation
A_3	=	Land taken from others on lease
A_4	=	Land taken from others on rent
A_5	=	Own land given to others on rent

The annual income of a respondent was measured on the basis of the total yearly earnings from agriculture and other sources (service, business, etc.) earned by the respondent himself and the other family members. The value of all the agricultural products, encompassing crops, livestock fisheries, fruits, and vegetables, were taken into consideration for calculating the annual income. It was expressed in USD (United States Dollars) with a unit score of one (1) being assigned for each one thousand Bangladeshi takas of income. The agricultural knowledge of a respondent was measured by asking 25 questions related to different aspects of agriculture and denoted by scores. The area under cultivation with banana, pineapple, and other fruits was measured in terms of hectares. The area covered by fruit cultivation in the season of collecting the data was considered as the area under fruit cultivation of a respondent. The cosmopoliteness score was computed for each respondent to determine the degree of his cosmopoliteness on the basis of his number of visits to different types of places and denoted by scores. The communication media exposure score was computed for each respondent on the basis of the extent of his contact with seventeen communication media and denoted by scores. Innovativeness, is the degree to which an individual adopts an innovation relatively earlier than other members in a social system,[17] and was measured on the basis of the period of uses of various agrochemicals and denoted by scores. Awareness referred to a farmer’s consciousness about an object or thing in different situations in his surroundings. It was measured by the total awareness scores of the respondent towards pests and agrochemicals and was denoted by scores.

Measurement of the extensive use of agrochemicals: The use of agrochemicals in the cultivation, ripening, and preservation of fruits was the dependent variable in this

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work. It was measured by using a 4-point rating scale. The respondents were asked to indicate their extent of use of different agrochemicals. A 4-point rating scale was used with categories such as not at all, rarely, occasionally, and frequently which were assigned values of 0, 1, 2, and 3, respectively. The agrochemicals use score of a respondent was measured by adding the scores for all the agrochemicals. Thus, the agrochemicals use score of a respondent could range from 0 to 45, 0 indicating no use of agrochemicals and 45 indicating the highest level of use of agrochemicals.

RESULTS AND DISCUSSION

The results of the study and its interpretation are presented in three sections in accordance with the objectives of the study. The first section deals with the individual characteristics of the farmers, the second section deals with the use of agrochemicals, and the third section deals with the relationships between the selected characteristics of the farmers and their use of agrochemicals.

Demographic characteristics of the farmers: The major demographic characteristics of the farmers selected for study were: (i) age, (ii) level of education, (iii) farm size, (iv) annual income, (v) agricultural knowledge, (vi) area under fruit cultivation, (vii) cosmopoliteness (the extent to which one possesses cosmopolitan traits), (viii) communication media exposure, (ix) innovation proneness, and (x) awareness about pest hazards.[18] The salient features of the different characteristics are presented in Table 1.

The highest proportion (44%) of the farmers was in the middle-aged category compared to 37% in the young-aged category and 19% in the old-aged category. This indicates that the decision making relating to farm affairs, especially in respect of using agrochemicals in the study area, was influenced to a considerable extent by the middle-aged farmers.

The education of a farmer was measured by the level of their education, i.e., highest grade (class) passed by them. The level of education score ranged from 0 to 12, the average being 4.12 and the standard deviation was 3.85. A large proportion (31%) of the farmers fell under the category of "can sign only." Among the educated farmers, the frequency of the secondary education group was the highest. Sixty-one % of farmers were literate at levels that varied from primary to higher levels and, although this was lower than the national average, it was near to the national literacy rate (72.76%).

The farm size of the farmers ranged from 0.48 to 4.42 hectares with an average of 1.97 and a standard deviation was 0.88. Based on the farm size, the farmers were divided into three categories. The highest proportion (62%) of the respondents fell under the medium farm size category compared to 25% in small and 13% in large farms. Thus, most (87%) of the farmers were in the categories of small and medium farms. The average farm size of the respondents was 1.96 hectares, which is higher than national average (0.81 ha). The medium and large farm families were usually reluctant to use agrochemicals in fruit production to increase their income.

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Table 1. Salient features of the demographic characteristics of the farmers*

Demographic characteristics	Scoring system	Categories	Farmers No.	Farmers %	Mean	SD
Age	Year	Young (up to 35)	35	37	37.83	8.95
		Middle aged (36–45)	41	44		
		Old (above 45)	18	19		
Education	Score	No education (0)	8	8	4.12	3.85
		Can sign only (0.5)	29	31		
		Primary education (1–5)	24	26		
		Secondary education (6–10)	26	28		
		Above secondary education (>10)	7	7		
Farm size	Hectare	Small farm size (0.01–1.0)	24	25	1.97	0.88
		Medium farm size (1.01–3.0)	58	62		
		Large farm size (>3.0)	12	13		
Annual income	USD	Low income (up to 250)	26	28	621.5	32.87
		Medium income (251–1000)	49	52		
		High income (>1000)	19	20		
Agricultural knowledge	Score	Low knowledge (up to 23)	23	25	21.89	6.85
		Medium knowledge (24–35)	53	56		
		High knowledge (>35)	18	19		
Area under fruit cultivation	Hectare	Small area (<0.47)	21	22	1.26	0.79
		Medium area (0.47–2.0)	61	65		
		Big area (>2.0)	12	13		
Cosmopoliteness	Score	Low cosmopoliteness (up to 4)	36	38	5.87	2.55
		Medium cosmopoliteness (5–9)	47	50		
		High cosmopoliteness (>9)	11	12		
Communication media exposure	Score	Low communication media exposure (up to 6)	17	18	8.99	3.35
		Medium communication media exposure (7–13)	64	68		
		High communication media exposure (>13)	13	14		
Innovation proneness	Score	Low innovation proneness (up to 45)	20	21	51.24	5.48
		Medium innovation proneness (46-56)	53	57		
		High innovation proneness (>56)	21	22		
Awareness about pest hazards	Score	Low awareness (up to 3)	26	28	5.37	1.87
		Medium awareness (4–7)	50	53		
		High awareness (>7)	18	19		
Use of Agrochemicals	Score	Low use (up to 14)	22	23	19.1	5.07
		Medium use (15–24)	59	63		
		High use (>24)	13	14		

*Source: Field survey, 2017

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The annual income in this study was determined by adding the income from the agricultural (crop, livestock, and fisheries) and the non-agricultural farms during a year. The score was expressed in one thousand taka. The range of annual income was USD 110.2 to USD 1,106.6 with an average of USD 621.5 and a standard deviation USD 32.87. The highest proportion (52%) of the respondents had a medium annual income compared to 28% in the low income group and 20% in the high income group. The farmers with a low income were generally hesitant to use agrochemicals because of their lower risk-bearing ability and their inability to make the necessary financial investment.

The agricultural knowledge score of the respondents ranged from 18 to 43 compared to the possible range of scores of 0 to 50. The average and standard deviation were 21.89 and 6.85, respectively. The highest proportion (56%) of the farmers had a medium level of agricultural knowledge compared to 25% with low and 19% with high agricultural knowledge.

The area under fruit cultivation in the study was found to vary from 0.3 to 4 hectares (ha). The average area under fruit cultivation was 1.26 hectares with a standard deviation of 0.79 ha. The highest proportion (65%) of the farmers had a medium area under fruit cultivation compared to 22.0% with a small and 13.00% with a big area. The value of the mean indicates that most of the farmers of the study area had a medium area under fruit cultivation.

The cosmopoliteness score of the farmers of the study area ranged from 3 to 13 compared to the possible scores of 0 to 21. The mean and standard deviation were 5.87 and 2.55, respectively. Half (50%) of the farmers had medium cosmopoliteness as compared to 38% having low and 12% having high cosmopoliteness.

The communication media exposure scores of the farmers ranged from 5 to 18 against the possible range of 0 to 51. The average communication media exposure score was 8.99 and the standard deviation of 3.35. The majority (68%) of the respondents had a medium level of communication media exposure while 18% had low communication media exposure and 14% had high communication media exposure.

The computed innovation proneness scores of the farmers ranged from 38 to 61 against the possible scores of 0 to 65 with a mean of 51.24 and a standard deviation of 5.48. The highest proportion (57%) of the farmers had medium innovation proneness as compared to 21% with low innovation proneness and 22% with high innovation proneness.

The highest proportion (53%) of the farmers had a medium awareness about pest hazards compared to 28% with a low and 19% with a high awareness about pest hazards. The value of the mean indicates that most of the farmers of the study area had a medium level of awareness about pest hazards (Figure 2). A similar study conducted by Damalas and Khan[19] on the attitude of farmers towards pesticide use found that 73% of the farmers did not read the instructions for the pesticide use.

The use of agrochemicals by the farmers ranged from 10 to 28 against the possible range of 0 to 45. The average use of agrochemicals was 19.1 with a standard deviation of 5.07. The highest proportion (63%) of the respondents had a medium level of use of agrochemicals compared to 23% having a low and 14% having a high use of agrochemicals (Figure 3).

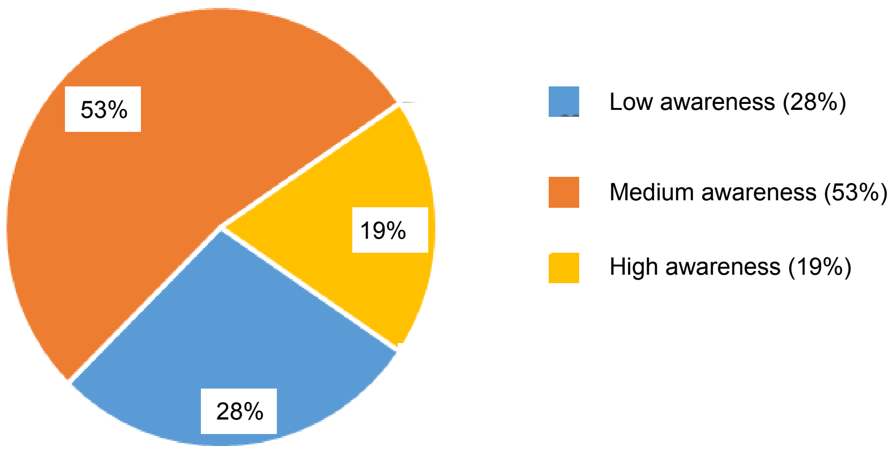

Figure 2. The level of awareness of the farmers regarding chemical use.

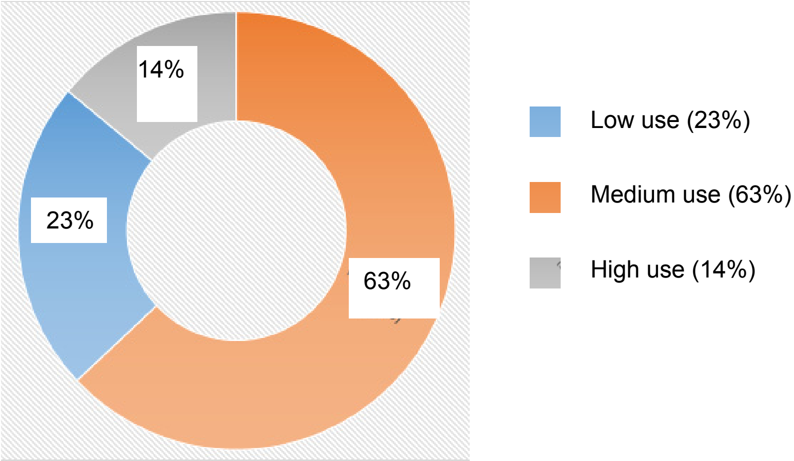

Figure 3. Use of agrochemicals by farmers

Effects of fluoride on fruit production and preservation: Fluoride is a simple anion of fluorine, inorganic in nature, and denoted as F^{-1}. Although fluoride ions at the level used in water fluoridation (0.7 ppm) are usually considered to be tasteless, fluoride salts typically have a bitter taste. Fluoride acts as an important ingredient in various pesticides. The major fluorinated herbicides are the dinitroaniline herbicides, urea herbicides, diphenyl ether herbicides, phytoene desaturase, and bleaching herbicides.[20] The major fluorinated insecticides are gamma-aminobutyric acid (GABA), insect growth regulator (IGRs), and pyrethroid insecticides. The major fluorinated fungicides are the β-methoxy acrylates, and the sterol biosynthesis inhibiting insecticides (triadimefon, imazalil, and triarimol).[6] Some plant growth

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regulators (flumetralin) and rodenticides (flocoumafen and bromethalin) are also used by the farmers. Fluoride has been used in agriculture from seed treatment to the crop post-harvest stage. Some of the fluoride-containing chemicals that are frequently used by farmers, middlemen, and traders may cause a harmful effect on human health.[21] Due to a lack of awareness, farmers may use fluoride-containing chemicals regularly. Some fluoride-based chemicals are used as food fumigants. The negative consequences of fluoride on agriculture were known after World War II but due to their having some positive effects, farmers have continued to use fluoride-containing chemicals.

Fluoride is generally neurotoxic in nature. Sulfuryl fluoride (SO_2F_2) is frequently used as a preservative for harvested fruits (Figure 4). The use of sulfuryl fluoride has increased as a replacement for methyl bromide which was phased out because of harm to the ozone layer. Environmentalists also consider sulfuryl fluoride to be a greenhouse gas.

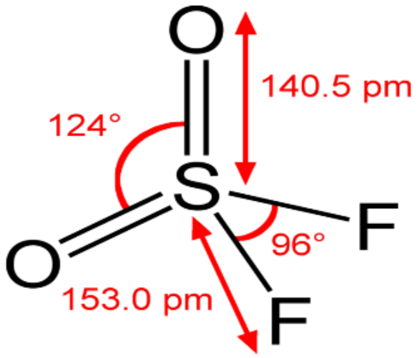

Figure 4. Atomic structure of sulfuryl fluoride (SO_2F_2)

Raw fruit contains fluoride (Table 2).

Table 2. Fluoride content of raw fruit*

Fruit name	Average fluoride content (ppm)
Apple (raw, with peel)	0.03
Avocado (raw)	0.07
Cantaloupe (raw)	0.01
Cherries (sweet, raw)	0.02
Grapefruit (raw)	0.01
Peaches (raw)	0.04
Pears (raw)	0.02
Plums (raw)	0.02
Strawberries (raw)	0.04
Watermelon (raw)	0.01

*Source: US Department of Agriculture. National fluoride database of selected beverages and foods, Release 2. Washington, DC, USA: USDA; 2005[22]

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Fluorine is neither an essential trace element for humans nor necessary for the development of healthy teeth and bones.[23] An excessive intake will cause chronic fluoride poisoning, such as dental fluorosis, skeletal fluorosis, and non-skeletal fluorosis.

In this study, farmers are asked to give their opinion and perception about the use of fluoride in their agricultural practices (Table 3).

Table 3. Pesticide use in fruit production

Item	Positive response by farmers (%)
Do you use any fungicides?	42
Do you use chemical for delay ripening of fruits?	78
Do you use chemical for growth retard?	57
Do you use chemical for fasten ripening of fruits?	79
Do you use fumigants to control insect?	73
Do you use food additives?	54
Do you know the negative effect of fluoride chemicals?	91

Source: Field survey 2017

The results show that although most of the farmers (91%) know about the negative effect of using fluoride-related chemicals they use them to obtain temporary benefits. A strong initiative should be taken by the government to create an awareness about the harmful effects of the use of various pesticides for sustainable agricultural production.

Measurement of pesticide hazards through the agrochemicals use index: In order to understand the pattern of use of agrochemicals by the farmers, the frequency of their use was ascertained during the data collection. By using the frequency distribution of the agrochemical use index (ACUI) of the farmers, the rank order of the agrochemicals was determined (Tables 4A and 4B). From the Tables, it is evident that most of the farmers use some pesticides in their fruit production such as Bistarin, Rigin, Tilt, Cupravit, Ridomil Gold, Basudin, Ciathion, and Dimecron. These agrochemicals belong to different groups like organochlorine pesticides, organophosphate pesticides, organocarbamate pesticides, etc. The above agrochemicals have various harmful effect on human health such as headache, dizziness, weakness, shaking, nausea, stomach cramps, diarrhea, sweating, vomiting, loss of appetite, weight loss, and a general feeling of sickness. The effect of these chemicals on human health have been discussed by several scholars.[1,24,25] The neglect of the recommended practices for the use of agrochemicals and their excessive use may cause various foodborne diseases which originate from both the farmers' fields and the food market sellers.[26] Pesticides can cause many types of cancer in humans. Some of the most prevalent forms include leukemia, non-Hodgkin's lymphoma, brain, bone, breast, ovarian, prostate, testicular, and liver cancer.[27] People are now aware of the emerging threat of pesticides that disrupt the endocrine system and play havoc with the complex regulation of hormones, the reproductive system, and embryonic development.[28,29]

Table 4A. Use of agrochemicals in fruit production with their ACUI (Agrochemicals Use Index) and rank order

Sl no.	Agrochemicals	Extent of use				ACUI	Rank order
		Frequently	Occasionally	Rarely	Not at all		
1	Use of Bistarin and Rigin insecticides during the ploughing of the soil in banana cultivation.	153	86	0	0	239	1
2	Use of Tilt and Cupravit for controlling the Sigatoka disease of banana.	48	142	7	0	197	2
3	Use of Tilt fungicide for controlling fungus disease of pineapple.	0	138	24	0	162	3
4	Use of Ridomil Gold for controlling the heart rot disease of banana.	3	116	35	0	154	4
5	Use of Basudin, Ciathion, and Dimecron for controlling Bittle insect during banana cultivation.	0	106	41	0	147	5
6	Use of Carata and Sobicron insecticides for controlling the banana stem weevil.	0	100	42	0	142	6
7	Use of Ripen and Profit for the ripening of Banana.	0	108	32	0	140	7

Table 4B. Use of agrochemicals in fruit production with their ACUI (Agrochemicals Use Index) and rank order

Sl no.	Agrochemicals	Extent of use				ACUI	Rank order
		Frequently	Occasionally	Rarely	Not at all		
8	Use of Ocogim hormone for getting a bigger size of pineapple	0	74	55	0	129	8
9	Use of Bistarin and Rigin insecticides during the ploughing of soil in banana cultivation.	0	54	56	0	110	9
10	Use of Tilt and Cupravit for controlling the Sigatoka disuse of banana.	0	40	57	0	97	10
11	Use of Tilt fungicide for controlling fungus disease of pineapple.	0	36	39	0	75	11
12	Use of Ridomil Gold for controlling g the heart rot disease of banana.	0	20	52	0	72	12
13	Use of Basudin, Ciathion. Dimecron for controlling Bittle insect during banana cultivation.	0	16	46	0	62	13
14	Use of Carata and Sobicron insecticides for controlling banana stem weevil.	0	12	42	0	54	14
15	Use of Ripen and Profit for ripening of banana.	0	6	19	0	25	15

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Endocrine disruption can produce infertility and a variety of birth defects and developmental defects in offspring, including hormonal imbalance, incomplete sexual development, impaired brain development, behavioral disorders, and many others.[30-32] The foregoing facts clearly indicate that the agrochemicals used by the farmers in fruit cultivation are very harmful to human health by causing a variety of physiological dysfunctions.[33] Hence, the concerned authorities should give due attention to minimize the indiscriminate use of agrochemicals by the farmers involved in fruit cultivation. Chalermphol and Shivakoti[34] conducted a study on the pesticide use and prevention practices of 312 farmers in Thailand and found that while 87.8% of the farmers used agrochemicals, only of 36% of them maintained the practices recommended for their use

Relationship between the demographic characteristics of the farmers and their use of agrochemicals: The coefficient of correlation was computed in order to explore the relationships between the selected characteristics of the farmers and their use of agrochemicals. A descriptive interpretation of the meaning of "r". is shown in Table 5.

Table 5. The meaning of the coefficient of correlation (r) values

Coefficient of correlation (r)	Meaning
0.00 to 0.19	A very low correlation
0.20 to 0.39	A low correlation
0.40 to 0.69	A moderate correlation
0.70 to 0.89	A high correlation
0.90 to 1.00	A very high correlation

Source: Cohen and Holliday[35]

The relationship (r) between the selected characteristics of the farmers and their use of agrochemicals is shown in Table 6. The co-relationships among the different independent and dependent variables were also been computed by using Pearson's product moment correlation co-efficient.

Relationship between the age of the farmers and their use of agrochemicals: The relationship between the age of the farmers and their use of agrochemicals was examined by testing the following null hypothesis: "There is no relationship between age of the farmers and their use of agrochemicals". As shown in the Table 6, the co-efficient of correlation between the concerned variables was computed and found to be –0.594 which was larger than the tabulated value (r=0.334) with 92 degrees of freedom at the 0.001 level of probability. Accordingly, the null hypothesis was rejected. The findings indicate that the age of the farmers had a significant negative relationship with their use of agrochemicals, which implies that the use of agrochemicals decreased as age of the farmers increased. This meant that the tendency to use agrochemicals in fruit production was observed more among the younger farmers. [12]

The level of education of the farmers and the use of agrochemicals: The co-efficient of correlation between the concerned variables was found to be –0.291 which was greater than the tabulated value (r=0.263) at the 0.01 level of probability (Table 6).

This allowed the rejection of the null hypothesis. It revealed that the level of education had a significant and negative relationship to the use by the farmers of agrochemicals. The result suggests that the lower use of agrochemicals by the more educated farmers may be related to more education leading to more knowledge of the adverse effects of agrochemicals.[36]

Table 6. Relationship between the characteristics of the farmers and their use of agrochemicals

Demographic characteristics	Computed r values	Tabulated r values with df 92(N-2)		
		0.05 level	0.01 level	0.001 level
		0.202	0.263	0.334
Age	–0.594†			
Level of education	–0.291*			
Farm size	0.526†			
Annual income	0.614†			
Agricultural knowledge	–0.820†			
Area under fruit cultivation	0.312*			
Cosmopoliteness	–0.793†			
Communication media exposure	–0.764†			
Innovation proneness	0.301*			
Awareness about pest hazards	–0.817†			

* = Significant at the 1% level, † = Significant at the 0.1% level.

Farm size of the farmers and the use of agrochemicals: The computed value of the co-efficient of correlation between the farm size of the farmers and their use of agrochemicals was found to be 0.526. The relationship showed a positive trend which was larger than the tabulated value (r=0.334) at the 0.001 level of probability and the null hypothesis was rejected. The findings indicated that the farm size of the farmers had a significant positive relationship with their use of agrochemicals. The findings indicated that a farmer with a large farm was more likely to take the risk of using more agrochemicals and bearing the financial investment.[37]

Annual income of the farmers and the use of agrochemicals: The calculated value of the correlation co-efficient between the annual income of the farmers and their use of agrochemicals was found to be 0.614 which was larger than the tabulated value (r=0.334) at the 0.001 level of probability. The trend of the relationship was positive and the null hypothesis was rejected. The results indicated that the annual income of the farmers had a significant positive relationship with their use of agrochemicals. The use of more agrochemicals in fruit production by the farmers who had a high annual income may have been due to their being able to invest more money in the use of agrochemicals.[38]

Agricultural knowledge and the use of agrochemicals: The co-efficient of correlation between the concerned variables were found to be –0.820 which was larger than the tabulated value (r=0.334) at the 0.001 level of probability and indicated that the null hypothesis was rejected. The results showed that the agricultural knowledge of the farmers had a significant negative relationship with their use of agrochemicals. The findings also suggested that the farmers with more agricultural knowledge used fewer agrochemicals because their greater agricultural knowledge may have helped them to grow fruit using more environmentally friendly cultivation practices.[3,39]

Area under fruit cultivation and the use of agrochemicals: The calculated value of the correlation co-efficient between the area under fruit cultivation of the farmers and their use of agrochemicals was positive (0.451) and larger than the tabulated value (r=0.334) at the 0.001 level of probability which allowed rejection of the null hypothesis. This meant that the area under fruit cultivation of the respondents had a significant positive relationship with their use of agrochemicals.[40]

Cosmopoliteness of the farmers and the use of agrochemicals: The co-efficient of correlation between the concerned variables was found to be negative (–0.793) and larger than the tabulated value (r=0.334) at the 0.001 level of probability which indicated that cosmopoliteness of the farmers had a significant and negative relationship with their use of agrochemicals. It also meant that farmers who were more cosmopolite possessed made less use of agrochemicals. Cosmopoliteness indicates an individual's degree of orientation external to his own social system.[17] A cosmopolite farmer is likely to visit many places outside his own social system and consequently come into contact with different things, personnel, organizations, ideas, and practices. This broadens his outlook and leads to him developing a negative state of mind regarding the use of agrochemicals.

Communication media exposure of the farmers and the use of agrochemicals: A positive trend (0.764), larger than the tabulated value (r=0.334) at the 0.001 level of probability, was found in the co-efficient of correlation between communication media exposure of the farmers and the use of agrochemicals which allowed rejection of the null hypothesis. Accordingly, communication media exposure of the farmers had a significant and negative relationship with their use of agrochemicals. Communication media exposure generally enables individuals to come in contact with different kinds of communication media namely personal, group, and mass media.[41] Through the increased contacts with these information media, it is probable that the farmers gained more knowledge regarding the adverse effect of agrochemicals on the environment.[1]

Innovation proneness of the farmers and the use of agrochemicals: The co-efficient of correlation between the concerned variables was found to be positive (0.524) and larger than the tabulated value (r=0.263) at the 0.01 level of probability which allowed the rejection of the null hypothesis. It meant that innovativeness of the farmers had a significant and positive relationship with their use of agrochemicals.[42]

Awareness about pest hazards of the farmers and the use of agrochemicals: The calculated value of the correlation co-efficient between awareness about pest hazards of the farmers and the use of agrochemicals was negative (–0.817) and larger than the tabulated value (r=0.334) at the 0.001 level of probability resulting in rejection of the null hypothesis. It meant that awareness about pest hazards had a significant negative

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relationship with their use of agrochemicals. The results suggested that the farmers who were more aware about the pest hazards applied their knowledge and made decisions to use fewer agrochemicals in fruit production.[16]

CONCLUSIONS AND RECOMMENDATIONS

The study explored the status of agrochemical use by fruit growers and the factors responsible for their extensive use. The values of agrochemical use index (ACUI) indicated that Bistarin, Rigin, Cupravit, Tilt, Ridomil Gold, Basudin, Ciathian, and Dimecron were the agrochemicals most frequently used by the fruit growers. It was found that 63% of the farmers were medium users, that 23% were low users, and that 14% of them were high users. This study also revealed that the farmers in the study frequently used fluorinated agrochemicals which were harmful for human and environmental health. The analysis of the study indicated that awareness about pest hazards had a significant negative relationship with their use of agrochemicals. When the education level of the farmers was low they were less aware of the harmful effects of agrochemicals. The growers who were more aware of the harmful effects of agrochemical in fruit production were lower users of them. A program for increasing knowledge, the level of education, and cosmopoliteness is needed in order to raise the awareness of the farmers about the harmful effects of agrochemicals. This increased knowledge should lead to a reduced use of agrochemicals in fruit production. The findings of the study suggest the following recommendations:

(i) At present a considerable proportion (77%) of the farmers have a medium or high level of use of agrochemicals in fruit production. Decreasing the rate and extent of use of agrochemicals in fruit production are vitally important for sustainable agriculture. It is therefore recommended that effective steps should be taken by the Department of Agricultural Extension and by Non-Government Organizations (NGOs) for strengthening extension services and up-skilling the knowledge of farmers so that they have a better understanding of the problems caused by agrochemicals and can appreciate the benefits of making less use of agrochemicals in fruit production.

(ii) As a large number of the farmers who are medium and high users of agrochemicals belong to the young and middle-aged groups, it is recommended that the extension workers should work with the young and middle-aged groups of farmers to promote making less use of agrochemicals in fruit production.

(iii). As the farmers with more education are likely to have a lower use of agrochemicals, it is recommended that steps should be taken for motivating the adults in farming families to attend adult literacy programs and for the children to attend village schools.

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