Farmers' Knowledge on Agrochemicals and Their Use: A Case Study from Tsirang Dzongkhag, Bhutan

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ABSTRACT

This paper is based on the case study on agrochemical knowledge and its usage by farmers of Tsirang Dzongkhag. The data was collected from 205 households out of 5063 through semi-structured questionnaire, informal group discussions and secondary information. Bhutan imported more than 12000 Mt of agrochemicals worth over Nu. 6000 million between 2014 to 2017. These agrochemicals were imported from seven countries with almost 100% import from India. More than 20 different types of agrochemicals were supplied to the farmers. The study found that 49.26% of the respondents used one or other form of agrochemicals in 2017. In the last three years 71.04 Mt (0.54%) of agrochemicals were supplied to Tsirang dzongkhag. Among the agrochemicals supplied, fertilizers (70.58 Mt) dominated the supply followed by insecticides (0.25 Mt). The least supplied was rodenticide (0.007 Mt). Per hectare application rate of agrochemicals in 2017 was recorded at 0.0048 kg/ha which was comparatively very low than in other countries. Consumers generally associate farm produces from Tsirang as natural and have gained market popularity. Therefore, to uphold the consumers' health and market niche the use of agrochemicals need to be reduced from the present scenario.

Keywords: *Agrochemicals, Natural, Safety, Import, supply, Produce, Quality*

1. Introduction

Agriculture is paramount in supporting rural livelihood in Bhutan. Achieving food self-sufficiency is the national priority. To achieve this goal various strategies have been adopted from the use of high yielding crop varieties to various agrochemicals such as fertilizers and pesticides. Agrochemicals are those chemicals such as fertilizers, hormones, fungicides, insecticides, herbicides or soil treatment that improve crop productivity.

In Bhutan agrochemical particularly fertilizers and pesticides have been in use as early as 1960s (Kobayashi, Chhetri, & Fukamachi, 2015). Since the introduction of fertilizers, their application was based on the practices in neighboring countries. Only after 2001, standard recommendations were made after the findings of multi-location farmers-extension fertilizer use (NSSC, 2013).

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Gradually with the change in cropping practices, introduction of hybrid crop varieties and change in soil nutrient management practices, there have been changes in both types and amount of fertilizer application.

Insect pests and diseases are a major cause of crop yield losses and their management plays a critical role in providing food security and farming income. The use of plant protection chemicals has also been practiced since the introduction of conventional agriculture in the 1960s. Like in many countries the use of use of agrochemical is guided by legislations such as Pesticide Act of Bhutan, 2000; Pesticide Rules and Regulations of Bhutan 2019.

Despite educating farmers on proper handling of agrochemicals, there are still high chances of over and under usage which may have harmful effects in human health and the environment. Elahi, Weijun and Nazeer (2019) reported that the indiscriminate use of agrochemicals for the maximization of crop yield has adverse effects on the air, water, soil, non-target organisms, and human health. There is no record on or documents of agrochemical usage in the field. Therefore, this study was conducted to assess farmers' knowledge on proper use of agrochemicals and chemicals imported over last three years.

2. Materials and Method

2.1. Study site

The study was carried out in Tsirang Dzongkhag which constitutes 12 gewogs. The site is located in the south-central part of the country between the altitude range of 400 to 2000 meters above sea level (masl) between 27^{o} 30'11'' N and 89^{o} 52'42''E.

The dzongkhag has a humid subtropical to warm temperate climate with the mean annual rainfall of 3000-3700 mm. Of the total land area of 638.80 km^2, about 78% of the dzongkhag is under forest cover consisting mainly broadleaf and chirpine tree species. The arable land constitutes 13.73% of the total area. According to land registration by type there were 3925.10 ha of dry land, wet land and orchards.

2.2. Sample Size

The survey for the study was conducted from September to December, 2017. There were 5063 permanent households in Tsirang Dzongkhag with a total population of 22,376 (NSB, 2017). The sample households were randomly selected from 12 gewogs. The sample size (n) was calculated following Yamene formula with the margin of error of 7% as mentioned below.

$$n = \frac{N}{1+Ne^2} \quad \text{---------- I}$$

Wherein, 'n' = Corrected sample size; 'e' = Margin of error; 'N' = Population size

$$n = \frac{5063}{1+5063(.07*.07)} = 205.15 = 205 \text{ Number of households}$$

2.3. Date collection

Primary data was collected through household interview using semi-structured questionnaire. Several group discussions were also organized wherever possible. The information gathered were on pesticide usage in the field, reasons for using chemicals, and farmers' knowledge on application and safety measures, crops most applied with agrochemical, accessibility and awareness on the Pesticide Act of Bhutan 2000. Secondary information on import and supply of agrochemicals were gathered from published papers such as Bhutan RNR Statistics 2017, and Dzongkhag wise pesticide distribution list.

2.4. Data Analysis

Data were analyzed with the help of excel spread sheet and Statistical Package for the Social Sciences (SPSS) package, version 22. The descriptive, frequency and graph were used to determine the numbers of people who used agrochemicals, the crops that were applied with agrochemicals, agrochemicals application, knowledge and who were aware of Pesticide Act of Bhutan.

3. Results and Discussion

3.1. National agrochemicals import

Bhutan imported 12,980.48 Mt of agrochemicals worth more than Nu. 6,000 million from countries like India, China, France, Japan, Thailand, Singapore and United Kingdom from 2015 to 2017 (Tables 1, 2 & 3). India being the major trading partner, almost 99.99% of agrochemicals was imported from there.

Table 1. Quantity of chemicals imported from India and cost incurred during 2015 to 2017

Commodity	Volume (MT)			Value (Nu. In millions)		
	2015	2016	2017	2015	2016	2017
Insecticides	77.44	553.13	53.09	12.24	37.20	18.91
Fungicides	0.00	1.90	1.98	0.00	0.66	0.66
Herbicides	314.00	45.66	0.08	8.52	2.40	0.48
Disinfectants	59.33	88.40	69.93	6.04	8.06	6.89
Other PP chemicals	185.87	132.72	438.80	8.47	5760.28	16.97
Total	636.64	821.81	563.88	35.27	5808.60	43.91

Source: RSD (2017)

During the last 3 years, more than 2,000 metric tons of different plant protection chemicals worth close to 5,800 million was procured. It was in 2016 that maximum quantity of chemicals was imported. However, in 2017 the quantity decreased to 563.9 metric tons.

Table 2. Quantity of chemicals imported from other countries and cost incurred during 2015 to 2017

Commodity	Country	Volume (MT)			Value (Nu. In millions)		
		2015	2016	2017	2015	2016	2017
Insecticides	Thailand	1.32	0.76	0.38	3.70	0.12	0.04
	China	0.06	0.24	0.16	0.00	0.01	0.01
	France	0.00	0.01	0.00	0.00	0.27	0.00
	Singapore	0.00	0.02	0.00	0.00	0.22	0.00
Herbicides	Japan	0.00	0.00	0.02	0.00	0.00	0.03
Disinfectants	United Kingdom	0.05	0.00	0.00	0.15	0.00	0.00
Total		1.43	1.03	0.56	3.85	0.62	0.08

Source: RSD (2017)

Likewise, chemical imported from other countries excluding India was 3.02 metric tons, incurring Nu. 4.55 million in expenditure. The highest import was in 2015 (1.43 metric tons) and thereafter the volume reduced over the years.

Table 3. Quantity of fertilizers imported and cost incurred during 2015-2017

Commodity	Volume imported (MT)			Value (Nu. In millions)		
	2015	2016	2017	2015	2016	2017
Urea	2142.00	2935.15	1196.00	31.38	44.48	17.69
Ammonium sulphate	0.00	0.04	3.50	0.00	0.03	0.03
Ammonium nitrate	0.00	0.01	7.51	0.00	0.00	0.29
Single super phosphate	2888.95	1771.75	0.45	75.27	47.16	0.55
Potassium chloride	0.42	0.42	0.01	0.06	0.10	0.04
Potassium sulphate	0.00	0.13	3.45	0.00	0.03	0.09
Mixture of NPK	2.10	1.00	2.25	0.07	0.05	0.04
Total	5033.47	4708.50	1213.17	106.78	91.85	18.73

Source: RSD (2017)

Among the fertilizers imported urea topped the import volume with 6,273.15 metric tons whereas maximum expenditure (Nu. 122.98 million) was made on purchasing 4,661.15 metric tons of single super phosphate. However, looking at the overall agrochemical import trend it is found that import had decreased from more than 5,600 metric tons in 2015 to just over 1,500 metric tons in 2017 unlike in India where Devi, Thomas and Raju (2017) reported that the agrochemical

consumption in 29 states and union territories of India saw a positive growth in trend during 2000 to 2013. In another study by Kalauni and Joshi (2019) trend in agrochemical in Nepal has been found to have increased and in 2016 alone the country imported 635.73 tons (active ingredient) worth more than USD 6.6 million of pesticides.

3.2. Quantity of agrochemical supplied to Tsirang Dzongkhag

More than 20 different types of agrochemicals (insecticides, herbicides, rodenticides, fungicides and fertilizers) have been supplied to the farmers. In the last three years 71.04 Mt, which is just 0.54% of the national supply of agrochemicals, was supplied to the dzongkhag (Table 4). Among the agrochemicals supplied, fertilizers group (70.58 Mt) dominated the supply followed by insecticide group (255.80 litres). The least supplied was rodenticide (7.83 kg).

The per hectare agrochemical application rate in Tsirang was recorded at 0.0048kg/ha in 2017 which was very low compared to other countries. For example, the mean world application rate was 3kg/ha with 0.29 kg/h in India, China (14kg/ha), Japan (11kg/ha) and US (4.5kg/ha) in 2011 (Devi et al., 2017).

Table 4. Quantity of agrochemicals supplied to the dzongkhag in last three consecutive years

Fiscal Year	Fungicides (kg)	Herbicides (kg)	Rodenticides (kg)	Insecticides (l)	Non-toxic chemicals (l)	Fertilizers (Mt)
2014-15	2.00	19.23	0.45	81.50	70.00	39.35
2015-16	38.70	17.03	6.78	108.00	0.00	12.45
2016-17	33.10	9.52	0.60	66.30	7.50	18.78
Total	73.80	45.78	7.83	255.80	77.50	70.58

Source: RSD (2017)

3.3. Agrochemical accessibility and application

The respondents reported that sources of chemicals include Agriculture Sales and Service Representative (ASSR), Gewog Extension Centers, Thimphu and Gelephu. Out of 101 respondents who used agrochemicals, 80.19% reported that the chemicals were easily available in the market. Among them 82 respondents said that they procured chemicals from ASSR.

It was also found that fertilizer was mostly applied for paddy and maize crops. On the other hand, more than 80% of insecticides were used in vegetable crops. Respondents also reported that in the recent years, the use of herbicide has increased due to shortage of farm labour force in the villages. The main reason to apply insecticides and fungicides was to enhance production by preventing crop loss to pests and diseases. However, there is a decline in the import of agrochemicals (e.g.

herbicide) indicating the reduction of these chemical use in Bhutan (see Table 4). On the contrary, a study conducted in India by Devi et al. (2017) fount that herbicide use has the fastest growth mainly due to rise in wage rage.

3.4. Storage and disposal of agrochemical containers

Safe storage and proper disposal of agrochemical containers is one key area of focus in terms of safety. Agrochemicals are generally incompatible with agricultural ecosystems because all proportion of agrochemical that we use will not be absorbed by the crop and certain percent escape into the environment, and polluting it. Generally, only 20-30% of insecticides are absorbed by crops (Van Der Hoek, Konradsen, Athukorala, & Wanigadewa, 1998). This study had tried to find out how and where farmers store remaining agrochemicals use.

Table 5. Percentage of respondents who practice safe and unsafe storage and disposal

Variables	Safe storage/disposal (% respondents)	Unsafe storage/disposal (% respondents)
Storage of Agrochemicals	79	21
Disposal of containers/ plastics/sacks	68	32

From the survey it was understood that most of the respondents (79%) stored agrochemicals in safe locations like boxes or cupboards under lock and key. Some of the farmers also stored in bamboo where children cannot reach. They also ensured that the agrochemicals are packed in water proof package and maintain air tight to avoid spoilage (Table 5). Likewise, 68% farmers reported that they try to dispose empty containers in pits. They ensured that these disposal pits are located far away from water sources or natural drainage. It was also found that farmers usually do not re-use containers or plastics for other purposes. However, few farmers responded that they re-use fertilizer sacks like those of urea or suphala after cleaning them thoroughly.

3.5. Respondents' knowledge on usage and safety measures

The study indicated that 74.5% of respondents had the knowledge on application dosage and safety measures (Figure 3). According to Singh (2009), only 41% of farmers in western Uttar Pradesh were aware about pesticide hazards. Likewise, in a study by Zhang et al. (2018) in Nigeria, 96% of respondents considered chemicals as hazardous.

Although 74.5% respondents were aware of safety measures, only 66% used protective gears like long sleeve shirt, hat, gloves, mask, goggles, gum boot and apron. It was also found that only 15% respondents were aware of 'The Pesticide Act of Bhutan 2000'. In a report by Mahmoud (2017) about 25% of developing nations in the world don't have proper agrochemical regulations. Even in those countries that have proper rules and regulations, 80% of these nations lack adequate

resources to enforce them. As a result agrochemical poisoning is a serious concern in developing countries.

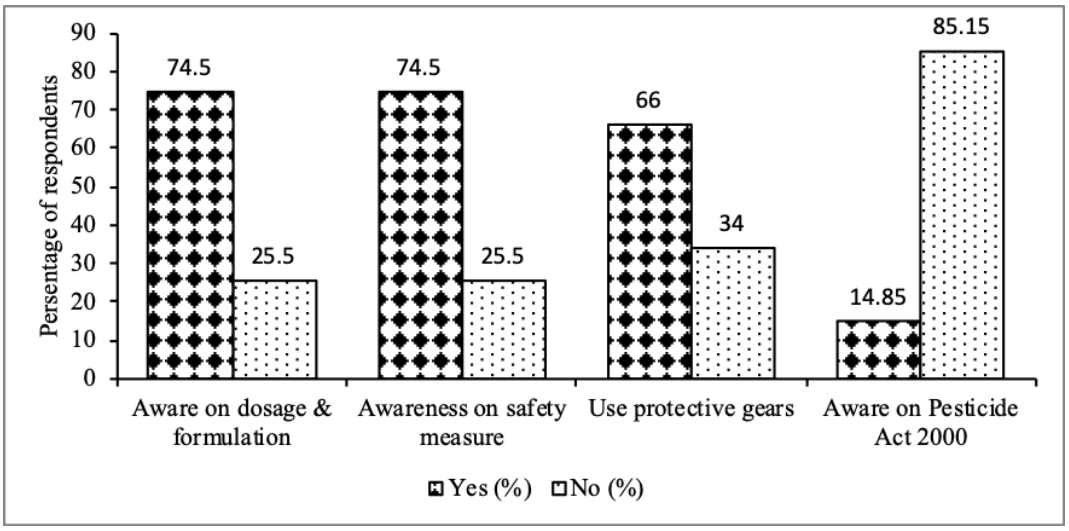

Figure 1. Knowledge on use of agrochemical

3.6. Proportion of agrochemicals usage by crop

The study found that the application of agrochemicals was highest (57%) for cereal crops, particularly paddy (Figure 4). The chemicals applied in cereal crops were fertilizers followed by herbicide and insecticide. Other group of crops was vegetables where insecticide was applied the most. Likewise, in orchards insecticide was mostly used followed by fungicide. This was because these two crops were cultivated in large area. Likewise, minimum agrochemical (4%) (i.e. fertilizers) was used in fodder production.

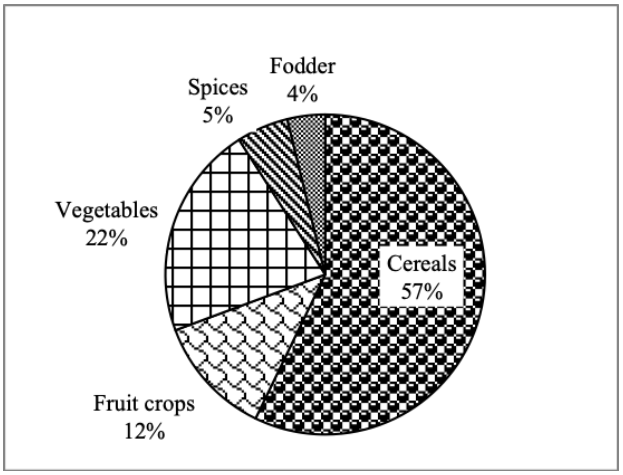

Figure 4. Percentage of crops applied

Fertilizers applied by the farmers were urea (70%) and suphala (30%) only. Among the herbicides, Butachlor (57%) outweighed Glyphosate (43%). In the insecticide use category, 39% of the respondents used Cypermethrin (45%) followed by Fenvalerate (28%). The study also found that 16% of the respondents used bio-pesticide like neem oil as insecticide.

4. Conclusion

Reducing the impacts of agrochemicals on the environment and human health has become very instrumental for agricultural sustainability and cleaner production. Abhilash and Singh (2009) have mentioned that in developing countries the exposure to pesticides causes human health problems such as immune suppression, hormone disruption, diminished intelligence, reproductive abnormalities and cancer. In India, to minimize health hazard from pesticide exposure and reduce residue in several crops, the Indian government implements key strategies such as pesticide safety, regulation of pesticide use, proper application and integrated pest management. The same strategies can be initiated in Bhutan. Prior to 1980s, agrochemicals were procured and freely distributed by the government to enhance agricultural production. However, from 5th and 6th Five Year Plan period many reforms were initiated to reduce the use of agrochemicals through the promotion of integrated pest and nutrient management systems with the support of donor-assisted projects such as the European Union projects.

The government's support to promote organic agriculture and good agricultural practices will reduce the use of agrochemicals in Bhutan. Although less than 50% of the respondents were found using agrochemicals there is still a need to educate farmers on negative effects of their use and try to further reduce the use. Farmers acknowledged that over the years, the use of agrochemicals have increased. This was mainly because of easy accessibility, lack of awareness on pesticide regulations and outbreak of pests and diseases. At the same time government should provide subsidies to those organic farmers by promoting organic plant protection chemicals and manures and higher premium prices for organic produces. Besides, educating our producers and consumers on side effects of chemicals on human, animals and soil health through various means would be another area of focus.

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