Restructuring Extension on Herbicide Usage of Paddy Farmers in Anuradhapura District

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ABSTRACT

Among various novel technologies which have been adopted in agriculture, agro-chemical usage is very wide. Herbicide is one such agro-chemical used extensively by farmers around the globe. It is believed that herbicides are a must for commercial level cultivation in order to eliminate unnecessary competition of weeds. However, in recent past, there have been many incidences of excess usage of herbicides, causing direct health and environmental issues around the world, including in Sri Lanka. In light of this, objective of the study is to explore how paddy farmers in Anuradhapura District utilize herbicides, factors affecting herbicide usage and to explore the most effective extension point related to herbicides usage. Four district secretaries namely: Nochchiyagama (n=68) and Thabuththegama (n=62) representing major irrigation scheme; Galenbidunuwewa (n=60) and Kahatagasdigiliya (n=60) representing minor irrigation scheme were proportionately selected according to farmer number. A multiple linear regression model was deployed to elicit the relationship between selected factors with usage of chemicals. Primary data were collected randomly from a sample of 250 farmers, targeting 2014/15 *maha* season. Results highlighted, frequency of extension received by the farmer ($p<0.01$), degree of understanding the label ($p<0.05$), education level ($p<0.1$), age of the farmer ($p<0.05$) and farming know-how ($p<0.01$) were significant on herbicide usage. Most frequently overused herbicide was Glyphosate (93%) and the exact amount would be 26.64g per acre. The overall average exposed time to chemicals for an individual was 3.5 hours per acre and average land extent was 5.5 acres. Only a very few (2%) used safety mix (gloves, masks, caps and boots) during handling and spraying of herbicides. Interestingly, the study revealed that the highest number of farmers (36%) preferred primary extension source on herbicide as agro-chemical retailers. Most effective extension point was identified as the agro-chemical retailer. Therefore, formal extension services should augment both agro-chemical retailer and distributors. As a regulatory body government should conduct regular monitoring process of the overall extension services.

KEYWORDS: Extension, Herbicides, Paddy

Introduction

Sri Lanka is a country based on the agriculture. Nearly 30 percent of the 6.5 million ha of land area in Sri Lanka are utilized for agriculture. According to the Central Bank annual report in 2016, current share of agriculture to the GDP is 7.1 percent. Gross harvested extent of paddy in *maha* season from 2010/2011 to 2015/2016 has continuously increased. It is also projected that demand for rice will increase at 1.1 percent per year and to meet this, the rice production should grow at a rate of 2.9 percent per year (Department of Census & Statistics, 2016). Apart from the main cultivation; vegetables, fruit crops and other field crops also play a significant role in the Sri Lankan agriculture. However, it has been estimated that, in general, 20% to 30% of rice yields are lost due to weed competition (Velmurugu 1980; Gunasena 1992). Weeds are plants of native value; those compete for space, water, nutrients and carbon dioxide thus limiting the availability of basic requirements of the economic crop and decrease yield up to 20% to 40% (Oad *et al.,* 2005). Yield losses from 5% to 100% have been reported in various crops in various areas depending upon the weed density, frequency, type and intensity of competition for growth / yield components (Ashiq *et al.,* 2003). The losses due to weeds have also been estimated from 20% to 21% in South Asia while 8.0% to 9.5% in USA (Malik *et al.,* 2009). Further, weeds also increase harvesting costs, reduce quality of product, and increase fire hazards (Arnon, 1972).

Usually, yield losses due to weeds are higher in rain-fed than in irrigated lower lands. Further, in irrigated lower lands, greater losses are encountered in well drained soils than in poorly drained soils (Amarasinghe *et al.,* 1998). Extent of yield losses could be further aggravated when various weed control strategies apart from direct methods, are not effectively adopted by the farmers (Ranasinghe, 2003). In irrigated areas, weed problem is becoming severe due to increased cropping intensity. If weeds are controlled by proper weed control approaches at the time of seeding or immediately afterwards, crop plants can make the best use of soil and environmental resources leading to enhanced crop productivity (Marwat *et al.,* 2008; Akhter *et al.,* 1991).

Losses caused by weeds can be managed by multitude of approaches such as manual methods, mechanical methods, allelopathic control, biological control and chemical control. Among these, chemical weed control is the most improved weed control technique. This method involves the use of chemicals commonly known as herbicides or weedicides (Malik *et al.,* 2009). Chemical control is usually easy; highly effective and the most economical approach to weed control (Marwat *et al.,* 2008). Unlike manual and mechanical methods, chemical weed control is less dependent on weather and hence the most practicable for use during the critical period of weed-crop competition (Bibi *et al.,* 2008).

Vast increase in the use of agrochemicals and inorganic fertilizer over the past several decades along with wide scale adoption of high yielding rice cultivars is a serious concern of many pressure groups, since overuse and misuse of these synthetic chemicals may pose potential environmental degradation and long term health hazards. The present annual synthetic pesticide consumption is estimated at 1,700 tons of active ingredients amounting to Rs. 4.6 billion (Registrar of Pesticides, 2014). There is increasing concern over synthetic pesticide usage due to their adverse long-term effects on human health, the environment and natural pest management systems (Krishanthi, 2006). The current cost of production of rough rice is Rs. 8.57 per kg. The cost of labor, farm power and tradable inputs constitutes 55%, 23% and 23% respectively. The labor cost has risen at a higher rate than other costs over the last few years

(Department of Agriculture Sri Lanka, 2014). As a result of high input oriented cultivation practices, despite the increase crop yields, cost of cultivation has also increased tremendously (Amarasinghe, 2013).

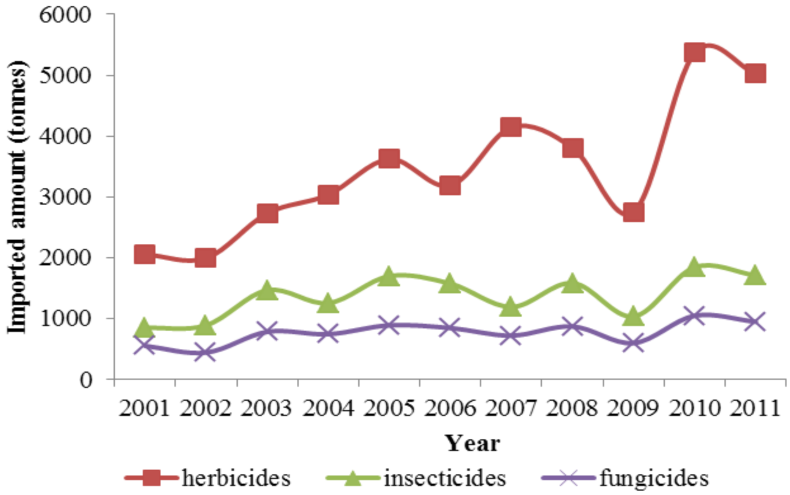

Figure 1: Agro Chemical Imports to Sri Lanka

Source: Registrar of Pesticides, 2014

Figure 1 illustrates total imported quantities of herbicides, insecticides and fungicides into Sri Lanka during the period of 2001 to 2011. Among those three categories herbicide imports were significantly high and up to 2007 it has an increasing trend. However, in 2009 there was a sudden drop of imports of herbicides due to import restrictions and health concerns. Although, government policies on agro-chemicals were unfavorable, in 2010 more than 5000 tons of herbicides were imported into the country. This clearly shows cases the sudden boost in the demand of stakeholders' interest on herbicides. Further, herbicide consumption in worldwide has increased drastically from 20% in 1960 to 48% in 2005 (Zhang *et al.,* 2011). Hossain (2015) in his study revealed that, at the end of each five years, global herbicide consumption will be increased by 15-24%. Furthermore, by the end of 2025, it is estimated that herbicide consumption will be increased by 150,000 million pounds.

According to Mabe *et al.,* (2017), most of the agricultural commodities are highly contaminated due to misuse and overuse of agro chemicals. Furthermore, it is said that these practices directly cater for both environmental and health issues among the farmer communities. Since most of the farmers lack proper training, protection equipment and safety information on chemicals there is a growing tendency of over application than the recommended rates or frequencies. Also, this would boost chemical runoff and spreading of chemicals over water bodies. Further, Anang and Amikuzuno, (2015) stated that chemical accumulation is one of the crucial issues and it accounts as many as 300,000 deaths globally every year. Also, the study illustrated that most of the farmers in Asian context practice improper usage or dangerous combinations of chemicals in order to eliminate weeds as much as possible and therefore, to increase the productivity at a higher level.

Hence, the vital issue at the present is whether farmers use weedicides according to the recommendation; what are the critical factors that may affect the usage of chemicals and how corporate bodies could involve in this process if there is any kind of adverse impacts, likewise. To address these issues, objective of this study is to explore how paddy farmers in Anuradhapura District utilize herbicides and factors affecting herbicide usage.

Methodology

Both descriptive and inferential statistics were used to analyze the data. Data were collected by using a structured questionnaire. The questionnaire was structured to measure three components regarding chemical usage namely: specific herbicide usage practices in cultivation; alternative methods of controlling weeds and extension & other information on herbicide usage. Data collection was done in January 2015 to March 2015 targeting 2014/2015 *maha* season. Initial stages were carried out by conducting focus group discussions and in depth interviews with heads of the farmer organizations and herbicide retailers. The study was carried out by partnering with the farmer organizations in the Anuradhapura District by covering four district secretaries namely: Nochchiyagama (n=68) and Thabuththegama (n=62) representing major irrigation scheme; Galenbidunuwewa (n=60) and Kahatagasdigiliya (n=60) representing minor irrigation scheme. Total of 250 paddy farmers were proportionately selected randomly for interviews and also for live demonstrations in the field.

Data were analyzed by using the SPSS 16.0 version. Multiple linear regression approach was used for the data analysis process. This model attempts to account for the variation of the independent variables in the dependent variable synchronically (Uyanik & Guler, 2013). Multiple linear regression is a technique to show case relationship between two or more variables and it is one of the most widely used statistical technique (Bakar & Tahir, 2009). The dependent variable, level of weedicide used by the farmer was measured by a ratio of actual amount of pesticides used to recommended level. The farmers' level of weedicide usage was hypothesized to depend on various socio economic variables. Such information is not only useful for a better understanding of farmers' behavior on weedicide usage, but also useful for deciding suitable strategies on improving present weedicide management techniques. For the population represented by the sample, variables that are being hypothesized to be affected on usage of weedicides take the form:

$$Y=f(x_1,x_2,x_3,x_4,x_5,x_6,x_7,x_8) \qquad [1]$$

Where, Y is the level of weedicide used by the farmer was measured by a ratio of actual amount of pesticides used to recommended level; Xs are socio-economic variables affecting level of weedicide used by farmers. These socio-economic variables namely: age of the farmer in terms of years(x_1); farming know-how (experience) in terms of years (x_2); extension received in terms of frequency of visits per particular season (x_3); education level of the farmer (x_4); number of family members (x_5); degree of understanding the label attached to herbicide container (x_6); land extent in terms of acres (x_7) and number of crops per particular season (x_8) are assumed to have a relationship with the level of weedicide used by a particular farmer. Extension received (x_3) was derived through formal extension services for a particular season from its inception to end measures in terms of number of visits by an agriculture research and production assistant (ARPA). Education level of farmer (x_4) is divided into four categories namely: uneducated (not attend to school); primary education level (from grade 1 to 5); secondary education level (from grade 6 to advanced level) and tertiary education level (Diploma or degree level or above).

Degree of understanding the label attached to herbicide container (x_6), is divided into three categories namely: poor understandability (<25% of understandability of information on label of herbicide container which are brand name and usage guidelines); average understandability (26%-50% of understandability of information on label of herbicide container which are first category plus, hazardous label and dosages) and clear understandability (>51% of understandability of information on label of herbicide container which are both first and second categories plus chemical name, units and effects). Recommended herbicide dosage may identify by the farmers who fall into second and third categories.

Results and Discussion

Out of total 250 subjects, majority (88%) were males. The average age of a household head was 45 years with having 29 years of farming experience. From the total sample, 51% mainly engaged in the rice cultivation and the rest engaged in vegetable (26%), maize (16%) and other field crop (7%) cultivation apart from paddy. Primary source of income of 93% of the sample was farming. Sample was dominated by the secondary educated (46%) farmers and very few (2%) has had higher education qualification.

About 56% of farmers solely depending on inorganic type of weedicides and none of the farmers relied only on organic measurements to eradicate weeds. This revealed the current level of adaption to the inorganic weedicides by farmer groups. This was due to easiness of application and high effectiveness against weeds. Furthermore, 66% from the total sample was reading the labels that attached to the chemical containers. Among them 78% had average understandability about the information on the label including the recommended dosage, common names, important dates and the hazardous signs to some extent.

Further, 10% from the label reading category was completely aware about the full information regarding the chemicals and 12% were not able to get any idea about labels. Even though, 12% could not read labels they apply herbicides according to their previous experience and also with the recommendation of sellers. The study revealed that more than 60% of farmers irrelevant to their understandability, apply chemicals using their prior experience or by simply following neighboring farmers.

Main source of information (39%) regarding weedicides generated from word of mouth scenario; that is through farmer to farmer communication (Figure 2). Farmers preferred to know information on herbicides and other chemicals through their neighboring farmer. It is observed that farmers tend to use new chemical types frequently from season to season. However, according to farmers' view, main herbicide types such as Glyphosate is a critical chemical and there are no other alternatives. The seller was another significant character in the farmer society regarding both information distribution as well as for the extension services. Spot meetings (10%), Leaflets (8%) and farmer organizations (7%) were not much effective as an information source on weedicides.

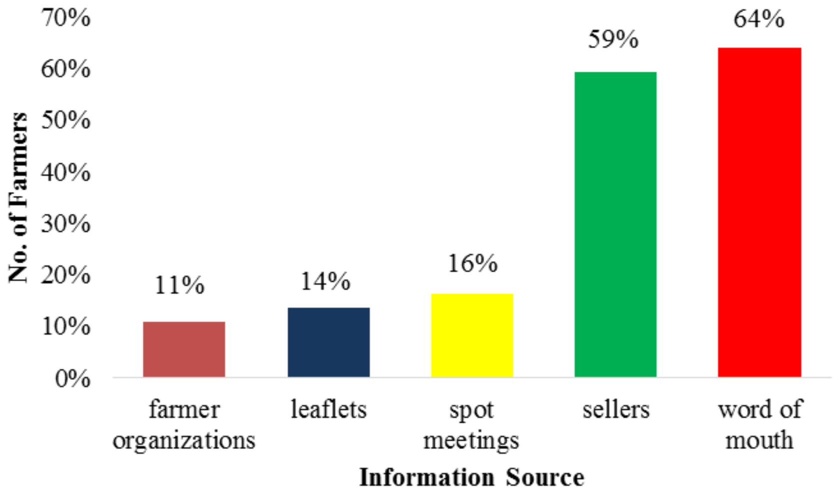

Figure 2: Source of Information on Weedicides
Source: Survey Data, 2014/15 maha season

Figure 3 illustrates all sources of formal and informal extension services that were available to farmers. Sellers contribute as the highest (36%) share that provides extension on weedicides. Extension services provided by sellers, particularly retailers were considered as informal extension services due to its biasness. However, agricultural officers were the second highest (20%) category that provided information on herbicides. Agriculture Research and Production Assistants (ARPAs) and Agriculture Instructors (AIs) were the major agricultural officers who provided extension services to farmers. Further, these extension services were considered as formal extension services since these officers are well trained. On contrary, farmers tend to neglect these formal extension services due to strict regulation on chemical usage. Furthermore, agro-chemical sellers regularly provide sensitive information of chemicals such as effective period, easiness and range (total weed killing ability), and thus, farmers always prefer these sellers for obtaining information.

Therefore, the target category regarding awareness on weedicides should always not be the farmer level, but it should also include the sellers' category as well. Simultaneously by strengthening the farmer organizations and agricultural officers by giving them sufficient and updated information regarding chemicals are the next best alternative to control over usage. It is revealed that the farmers tend to obtain methods of applying chemical and even the quantity of chemicals to be used via immediate retailer. Therefore, it is necessary to aware immediate retail agro chemical sellers regarding agro chemical products. In that sense, private companies which distribute agro chemicals should take the direct responsibility. Government should play a supervisory role to make it happen.

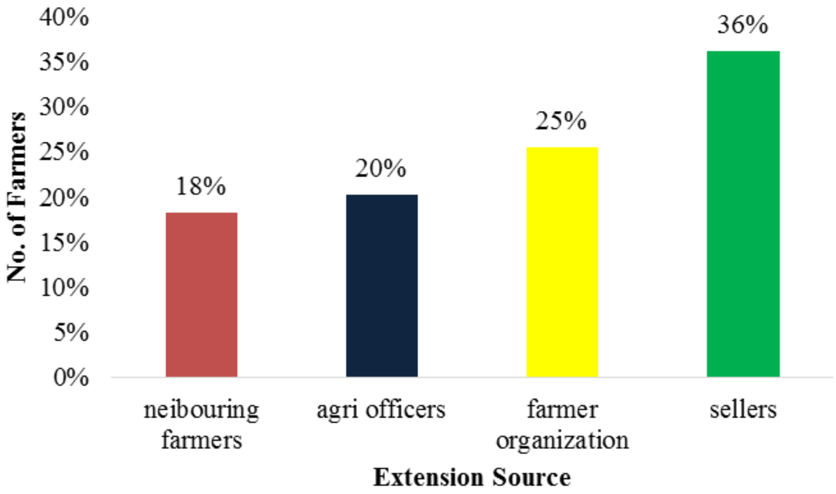

Figure 3: Source of Formal and Informal Extension on Weedicides

Source: Survey Data, 2014/15 Maha season

Among nine different chemicals, most widely (32%) used chemical was the Glyphosate (Figure 4). The second chemical was the MCPA (23%) and both were highly overused by the subjects. From the sample, 93% of farmers overused the Glyphosate chemical and furthermore, the study has estimated that excess amount would be 26.64g per acre on the average. Estimated excess amounts for MCPA, Bispyribac-Sodium and Clomazone + Proponil were 32.23g, 10.15g and 30.12g respectively per acre by a farmer. Farmers used these four chemical types more frequently in 2014/15 *maha* season than any other herbicide types. As mentioned earlier farmers are compelled to apply Glyphosate since, there aren't any alternative. Although the amounts were less, this will be a threat to the environment. Especially the agriculture sector has to play a vital role in ensuring the safety of the drinking water as it is the sector heavily dependent on the agro chemicals and fertilizer that can potentially harm the safety of the drinking water (Kodithuwakku, 2013).

Glyphosate is a non-selective, systemic herbicide and belongs to phosphorous group of compounds. Glyphosate is recognized for its effectiveness against perennial, deep-rooted, grass and broad leaf weeds, as well as woody bush problems in crop and non-crop areas. It can be applied at any stage of plant growth or at any time of year, with most types of application equipment. Its mechanism of action appears to be the inhibition of the synthesis of aromatic amino acids, which results in the inhibition of nucleic acid metabolism and protein synthesis (Ware, 1983).

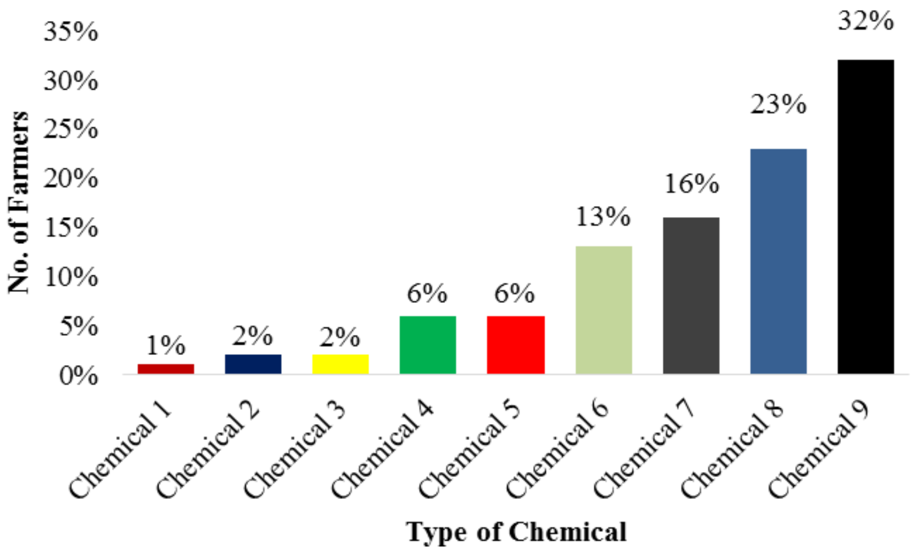

Figure 4: Various Types of Chemical Compositions Used by the Farmers

Source: Survey Data, 2014/15 maha season

*Note:	*Chemical 1 - Fenoxaprop-p-Ethyl-Ethoxysulfuron*	*Chemical 2 - Carfentrazone-Ethyl*	*Chemical 3 - Azimsulfuron*
	Chemical 4 - Topramezone	*Chemical 5 - Quinclorac*	*Chemical 6 - Clomazone + Proponil*
	Chemical 7 - Bispyribac-Sodium	*Chemical 8 - 2-Methyl-4 Chorophenoxyacetic Acid*	*Chemical 9 - Glyposate*

Majority (27%) of Glyphosate users purchased the product due to unavailability of an alternative. About 26% highly rely on Glyphosate because of the better performance against all types of weeds. MCPA chemical was preferred by farmers due to its high effectiveness. Unlike Glyphosate, MCPA is used as a selective herbicide and also there are various kinds of alternative for MCPA. Even though, Bispyribac-Sodium and Clomazone + Proponil show characteristics of non-selective weed killer, according to farmers' view these two chemicals were less effective than Glyphosate.

Farmers in the studied area used minimum protective clothing (21%) during handling and spraying of weedicides. The common dress was long sleeve shirts either with sarong or trousers. From that 15%, 2% and 2% used gloves, masks, caps and boots respectively. Only a very few (2%) used safety mix (gloves, masks, caps and boots). It is estimated that the average spraying duration was 3.5 hours per acre and the average land extent for individual farmer was 5.5 acres. So the vulnerability for toxicity was very high among the farmers. Betel chewers had totally avoided that habit during spraying. Farmers were highly negligent in proper disposal of empty containers; only 23% were burying the empty containers, 24% burnt and more than 50% were disposed containers to the field bunds, to the water or dump in bush areas adjoining their field.

Impact of Socio-Economic Factors on Weedicide Application

The overall R^2 of 0.54 is a good enough since the data used in the study was cross sectional. Regression model was highly significant (p value <0.000). According to the results of the regression analysis socio-economic factors such as farmer age, farming experience, extension services received, secondary education and good understanding of the information on the label of chemicals were significant on amount of herbicides used by the farmer for the 2014/15 *maha* season. Interestingly, when farming experience of a farmer increases by one year subsequently chemical usage also increases by six units. Farmers tend to use herbicides using their accumulated knowledge over the years. If a farmer applied a certain amount of herbicides in the previous season, farmer always tries to apply more amounts in the next season. This was a common practice observed in the studied area. However, results also revealed that if a farmer received proper extension services in a given season herbicide usage decreases approximately by 25 units. Another factor that affects herbicide usage is the secondary education. Farmers who had secondary education tend to use more chemicals with referred to uneducated farmers. Farmers who were having a good understanding on information about labels tend to use less herbicide in a given season with referred to the farmers who were having a less understandability regarding labels.

Table 1: Multiple Linear Regression Results for the Selected Socio-Economic Variables

Variables	Coefficients	P-value
Constant	157.70***	0.008
Age (x_1)	-15.90**	0.039
Farming know-how (x_2)	6.62***	<0.000
Extension received (x_3)	-25.51***	<0.000
Education Level (x_4)		
Primary education	9.63	0.671
Secondary education	35.34**	0.041
Thirtiary education	-66.82	0.271
No. of Family Members (x_5)	2.13	0.811
Understandability of the label (x_6)		
26%-50% of understandability	10.23	0.671
>51% of understandability	-17.12**	0.037
Land extent (x_7)	1.76	0.731
No. of Crops (x_8)	-1.46	0.973

***Significant at 1% level, **Significant at 5% level, * Significant at 10% level

On contrary, when farming experience increased by one unit, chemical usage amount increased by 6g per acre (Table 1). Also, when age of the farmer increased by one unit, chemical usage amount decreased by 15g per acre. Study revealed that, theses farmers did not use measurement cups, instead they used whatever the equipment that can be useful to take liquid out and feed it to the 16L tank according to their experience of pre-decided dosage. This pre-decided amount was estimated from the previous season and it was always higher than the previous. This practice was done almost in every season. However, variables such as number of family members, land extent and number of additional crops apart from paddy were not significant on usage of herbicides. Farmers also cultivated maize, low country vegetables and other field crops other than paddy.

Extension received on chemicals was negatively affected for the over usage. When extension received by a farmer increased by one unit, chemical over usage would decrease up to 25%. Farmers need at least average five to six sessions of extension services in cultivation season to achieve this target. However, these extension services should conduct in an effective way to communicate the best intention. Otherwise, if these services are more general, then the farmer community tends to skip those advices and do as they practiced. Continuous extension procedure during spraying season was much more effective, than giving separate training sessions. Having a tertiary education was a natural advantage to reduce the over usage of the chemicals. This resulted 66% reduction of over usage. Also, clear knowledge and understandability about facts on the labels that attached to the containers catered to reduce the over usage by another 28%. Since there were very few (2%) farmers that had tertiary education, proper and continuous extension is the key to control over usage.

As previously described, the extension services should provide for farmers as well as the agro-chemical retailer and distributors. Since private bodies have considerable share in agro-chemical industry, ethical conducting procedure is a must for them. As a regulatory body government should include agro-chemical retailers and distributors for regular extension sessions.

Conclusions

This study clearly depicted that the amount of herbicides used by farmers are far beyond the recommended dosage. Findings revealed that the preliminary action of retailer awareness is much more effective to disseminate the correct guidelines to the paddy farmer community regarding the agro-chemicals. Rather than natural factors such as clear understandability and higher education levels, continuous extension services would be the key to govern the herbicide usage. Conditions regarding the handling of safety practices were very poor among the farmers. It's remaining only as an explicit knowledge and therefore, requirement of strict policy regarding this matter is a must. There should be a continuous inspection on both safety and care. Not only the public bodies, but also the private bodies should involve in this procedure to achieve the ultimate target of reduction of chemical usage. Most possible and realistic solution would be; at least these procedures should follow at the time of spaying season.

The consequence of excessive use of agrochemicals has now reached alarming proportions. However, long term adoption of herbicide does envisage many issues such as buildup of herbicide resistance, heavy metal accumulation, harmful residue in food, threats on human health and probable threats on biodiversity and aquatic fauna. Therefore, the long term usage of herbicides by the third parties should be effectively address through adoption of strict regulatory measures, proper management options and continuous monitoring and judicious to maintain the sustainability for future generations. This study focused only on herbicides. A complete analysis regarding other agro-chemicals should be done in order to ascertain the full impact over health, environment and for the society. Furthermore, findings have implications for agro-environmental policies for the studied area.

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