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FARMERS' PRACTICES OF HERBICIDE USAGE: REFLECTION ON IMPORTANCE OF WEED MANAGEMENT PRACTICES

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ABSTRACT

Herbicide use in rice sector in Sri Lanka has increased tremendously in last decades. However, poor weed control, newly emerging weeds, herbicide-resistant biotypes of weeds, and environmental and human health issues related to herbicide use has become major drawbacks to the rice system. This study examined the current herbicide usage practices being used among the142 farmers in Hambantota district. Also, in-depth face to face interviews and focus group discussions were conducted among randomly selected farmers through which data was collected to augment the survey results. Fourteen herbicides were found in use in the study area. Sixty three percent of the respondents used Carfentrazone-ethyl 240g/1EC, while 27% used bispyribac sodium and the pre-mixed formulation of bispyribac sodium. Three main mode of actions herbicide group were identified, and 33% farmers used protoporphyrinogen oxidase-inhibitors (PPO), and 28% ALS-inhibiting herbicides. Meanwhile, 17% farmers used Acetyl CoA carboxylase (ACCase) inhibitors. *Cyperus difformis* and *Cyperus iria* is the most problematic weed species and 67% farmers complained that available herbicides are not effective on these weed species. Eighty seven percent farmers mix two or three herbicides together before application while 13% use as single spray. Majority (56%) of the respondents applied herbicides once and 43% farmers apply herbicides twice. Fifty three percent farmers not followed the recommended dosage of herbicides. Sixty six percent used hand sprayer while 34% farmers used power sprayer. Poor weed control efficacy of herbicides always couple with the mis-practice of herbicides such as, overuse, mixing and applying herbicides in violation of the scientific recommendations. There is a possibility to develop resistant weeds to most frequently use herbicides group, such as, ALS-inhibitors and use of same mode of action herbicides. This study recommends that training of farmers on the best practices on herbicide usage should be intensified and in-depth studies on weed science research should be given a high priority.

Key words: ALS-inhibitors, Herbicides, Mode of action, Resistant, Rice, Weeds.

INTRODUCTION

Sustainable rice production system requires critical consideration of agriculture technologies and identification of best practices. Herbicides are agricultural technologies that enable farmers to control weeds (Jansen and Dubois, 2014). Even with the availability of advanced technologies effective weed control has not been achieved the expected outcome in direct-seeded rice (DSR) in Sri Lanka. Herbicides are used as a tool in weed management in DSR and its' use likely to increase further with labour shortage. Herbicides have become dominant in the market where they contribute to 60% of total agrochemical imports (Abeysekera *et al*., 2015). However, farmers' over dependence on herbicides increases cost of production, enhances environmental pollution and accelerates the process of evolution of herbicide resistant weeds. In DSR, effective weed control requires proper herbicide application techniques, which are often not met, resulting in poor weed control.

In herbicide dominant system, overall weed control efficacy could be improved by selecting suitable herbicides with the combination of proper usage practices. Although herbicides are extremely effective tool for weed management, over reliance on a single herbicide (or group of herbicides with same mode of action) is a provision to result in development of herbicide resistant weed population. As an example, herbicides that target the enzyme Aceto Lactate Synthase (ALS) are among the most widely used mode of action in the world. Now, there are weed species that are resistant to ALS-inhibiting herbicides than to any other herbicides group (Heap, 2009; Tranel, 2002). ALS- inhibiting herbicides are the most popular herbicides group in Sri Lankan rice sector as well. The development of herbicide resistance is also a potential problem associated with prolonged usage of a single type of herbicide. Barnyard grass (*E. crus-galli*), the major troublesome grass weed in lowland rice cultivation in Sri Lanka was reported to have developed resistance to propanil (Marambe and Amarasinghe, 2002). *L. chinensis* has become a dominant weed with the use of bispyribac sodium (ALS –inhibiting herbicide) in Sri Lankan rice fields (Marambe and Amarasinghe, 2002). However, information on herbicide use and herbicide resistance is limited and

awareness on such is not satisfactory in Sri Lanka. Therefore, more attention should be given for proper herbicide usage in rice to achieve effective weed control while minimizing development of herbicide resistant weeds.

In addition to that, there is a high demand for herbicides in the country's current agricultural system. Selling outlets for herbicides have increased and farmers have easy access to them. Most of the times weed control in rice fields found to be very poor where rice farmers use the available herbicides without the knowledge of its mode of action. Conversely, practices of herbicide use of rice farmers are more complicated due to non-adherence to herbicide recommendations. Survey on practices of herbicide usage will be very important to gather information and thereby developing effective weed management approaches for the rice eco-system as well for directing future research and educational priorities. Thus, a survey was conducted to study the current practices on herbicide usage among the rice farmers, their awareness on herbicide usage and the recommendations.

MATERIALS AND METHODS

The study was conducted in six divisional secretariat divisions (Ambalantota, Belliatta, Hambantota, Tissamaharama,Walasmulla and Weraketiya) of Hambantota District which is one of the major rice growing areas in the country. A primary survey was conducted using randomly selected 142 farmers during 2016 *Yala* season. A questionnaire containing structured and semi- structured questions were designed to achieve the said objectives. Data were collected through a farmer survey by face-to-face interviews. Collected data include herbicides in use, type of herbicides, information on application of two or more herbicides together and their combinations, dose and frequency of herbicides applied, type of equipment used for application, most problematic weed flora in the system, remaining weed species after herbicide application and weed control efficacy of herbicides. Prior to the interview awareness programmes were conducted to make them aware on effective herbicide use and negative impact of improper use of herbicides. Data were subjected to analysis of using STAR for Windows version

2.1(IRRI, 2014). Descriptive statistics and chi-square (X^2) tests were used for quantitative data analysis.

RESULTS AND DISCUSSION

Hambantota district is located in the Low country Dry zone of Sri Lanka, where the major biological constraint to rice production is weed. Survey results revealed that, Sedges are the major problematic weed group in the District. Among the sedge weeds species, *Cyperus difformis* (66%) and *Cyperus iria* (58%) are the top rankers which are considered critically harmful in rice fields and according to the farmers as it is difficult to suppress (Figure 1). Second most problematic weed group in the study area is grass. *Ischaemum rugosum* (54%) grass species followed by *Echinochloa crus-galli* (53%) are the most critical grass species in the rice fields in Hambantota district. *Isachne globosa* ranked the third most critical in the grass group and becoming increasingly difficult to control due to its perennial nature. However, broadleaf weeds do not cause significant harmful impact on rice cultivations in Hambantota district.

Major crop establishment method found in the study area was direct-seeding (97%). The prominent method of weed control adopted by the 99% farmers was herbicide application along with the crop establishment. Results revealed that, fourteen types of herbicides are popular among farmers in the study area (Figure 2). However, sixty three percent of the respondents have used Carfentrazone-ethyl 240 g/1EC, while 27% have used bispyribac sodium and the pre-mixed formulation of bispyribac sodium. Majority of the farmers use Carfentrazone-ethyl 240 g/1EC herbicides. This might be due to the presence of high sedge weed pressure of the study area and Carfentrazone-ethyl 240 g/1EC might be showing good weed control efficacy than the available other broadleaf and sedge killer herbicides.

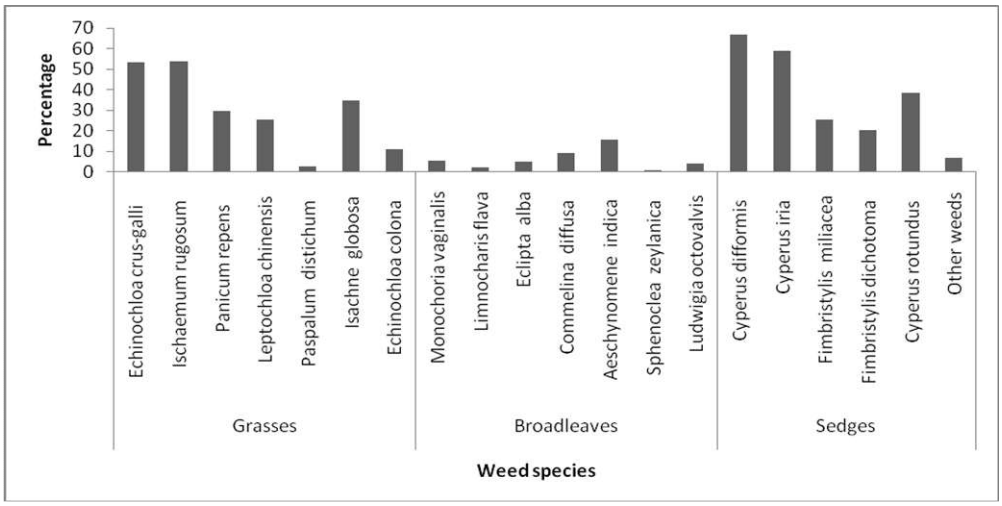

Figure 1. Percentage distribution of major troublesome weed species in Hambantota District.

In addition to the type of the herbicide distribution among the farmers, the mode of action of the herbicide is the other key area needs much attention. Considering the mode of action of herbicide distribution, three major groups are popular among the farmers. Thirty three percent of the farmers use protoporphyrinogen oxidase- inhibitors (PPO), 28% use ALS-inhibiting herbicides and 17% use Acetyl CoA carboxylase (ACCase) inhibitors (Figure 3). ALS inhibiting herbicides are among the most efficacious and widely used herbicides group in the world and it has been reported that high frequency of occurrence of resistant weed populations (Tranel, 2002). Therefore, knowledge on each herbicide's mode of action is important in selecting the proper herbicides to achieve effective weed control in rice. In this study use of herbicides with the same mode of action might be a reason to get poor weed control efficacy of the herbicides. Further, over-reliance of single mode of action places heavy selection pressure on weed population and may eventually select for resistant individuals. In addition 67% farmers have complained that, available herbicides are not effective to control weed, especially *Cyperus difformis* and *Cyperus iria.* This might be due to repetitive use of herbicides with the same mode of action which causes heavy selection pressure on weed population and may select for resistant individuals. The resistant individuals would multiply overtime and become dominant in the rice fields and resulting

particular herbicides no longer effective for weed control. Therefore, it is important not only rotate herbicide but also rotate herbicides with different modes of action of, along with other weed control method to achieve good weed controlling efficacy.

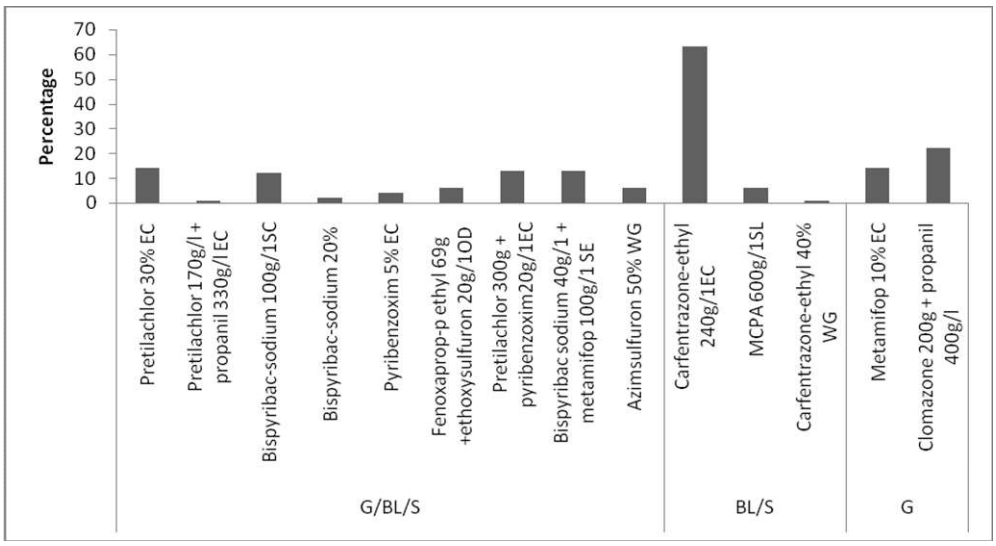

Figure 2. Percentage distribution of different herbicides use in the study area.

Additionally, herbicide mixing practice is more popular among the farmers in Hambantota district, where most farmers (87%) mix two-three herbicides before application, while 13% use as single spray (Figure 4). Herbicide mixtures help farmers to save time and labour and are considered to have a higher efficacy in weed control. However, label instructions do not cover mixtures of two or more herbicides and no information on the compatibility of chemicals. Further, unspecified tank mixing of herbicides are common practice with rice farmers in Hambantota district (Table 1).

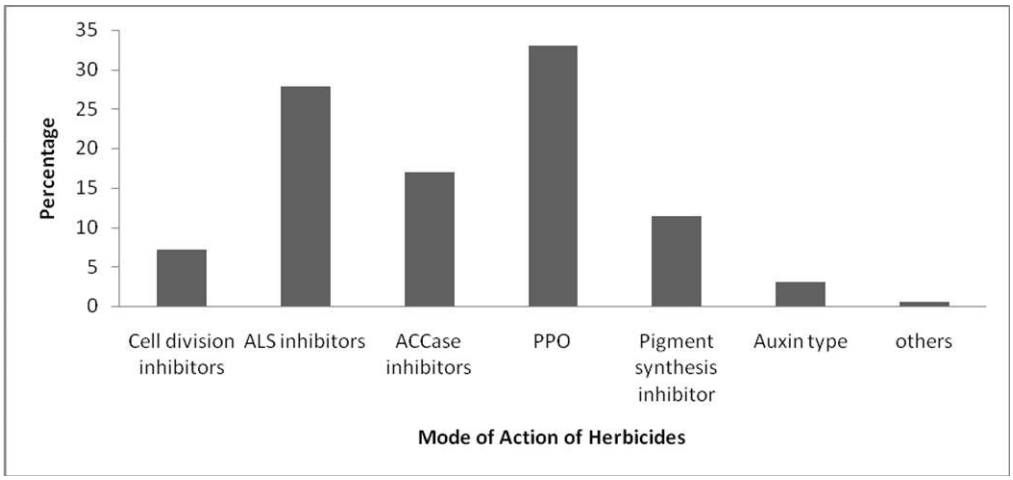

Figure 3. Percentage distribution of Mode of Action of herbicides in the study area.

Almost all the mixtures comprise with the Carfentrazone-ethyl 240 g/1EC herbicides, which is the most popular herbicides used in the system. (Bispyribac sodium 40 g/1 + metamifop 100 g/1 SE)+Carfentrazone-ethyl 240 g/1EC and Metamifop 10% EC + Carfentrazone-ethyl 240 g/1EC , two mixtures are the widely used (20.3%) mixture in the study area. Although 87% use herbicides mixture, they finally achieve poor weed control efficacy out of these mixtures. Results of the chi-square test proven that, herbicides mixtures not positively associated (X^2=28.09, p=0.256) with affectivity of herbicides on weed control. Therefore, results revealed that, over dependence of herbicides mixtures are always not effective to gain highly effective weed control.

Besides, farmers did not consider the negative impact of these mixtures on the crop, human health and environment. Herbicides mixing are guided by the retailer recommendation or common practice in the area. Mengistie *et al.* (2015) reported that, it is risky to mix two different formulas, for examples wettable powders (WP) with emulsified concentrates (EC). However, results showed that, most of mixtures comprise with the WP and EC formulas (Table 1). Results showed that 7% responded reported the phytotoxicity due to herbicide mixtures application. Therefore, application of different herbicides mixtures might be the reason for development of crop phytotoxicity, poor weed control efficacy and selection of some weed species with poor control.

Ngowi *et al*. (2007) reported that, interaction between different chemicals can influence the efficacy (more toxic, less efficient, neutralized or resistant) of pesticides, while some mixtures induced phytotoxicity.

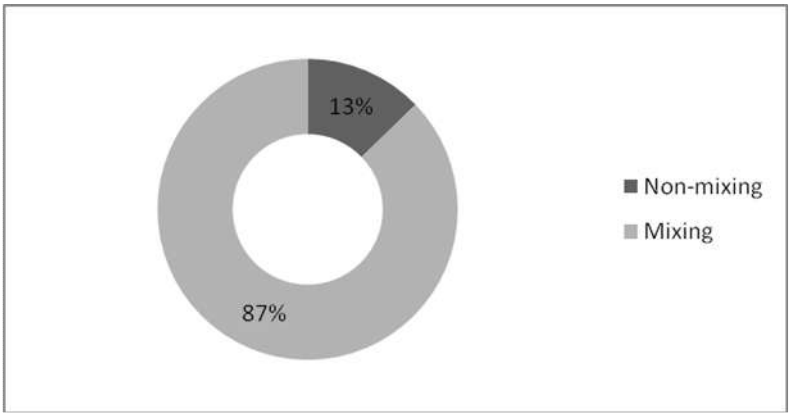

Figure 4. Farmer percentage of herbicide mixing in the study area.

In addition, herbicide dosage is the other important factor related to the herbicide efficacy. Generally, farmers use higher or lower dosage of herbicides than the recommendation, while 47 % farmers only used the recommended dosage (Table 2). However, dosage of herbicides positively associated (X^2=7.95, *P*=0.047) with the efficacy of weed control. Farmers believe that, high dose means better control of weeds and use of lower dose due to different mixtures usage. In addition to dosage, frequency of application of herbicides depending on the mixtures used and efficacy of herbicides applied. However, application of high dosage of herbicides than recommended dosage leads to high selection pressure and results would be development of resistant weed species.

Frequency of herbicide application is the other main factor needs much attention. Majority (56%) of the respondents applied herbicides once, while 43% farmers apply herbicides twice. The frequency of herbicides application depends on the type of herbicides used, whether mixtures use or not, cost of application and affectivity of herbicides. According to the view of the farmers, they prefer to apply herbicide once and as mixtures to reduce the cost of application without any instruction. As an example, Metamifop 10% EC + Carfentrazone-ethyl 240 g/1EC is the most popular mixture in the area.

However, Metamifop 10% EC is a grass killer herbicides and Carfentrazone-ethyl 240 g/1EC is a broadleaf and sedge killer herbicides and recommended to apply as single herbicides, but apply as a mixtures to reduce cost of application.

Table 1. Herbicides mixtures used among rice farmers in Hambantota district.

No	Herbicides Mixtures used	Percentage
1	(Bispyribac sodium 40g/1 + metamifop 100g/1 SE)+Carfentrazone-ethyl 240 g/1EC	20.3
2	Metamifop 10% EC + Carfentrazone-ethyl 240g/1EC	20.3
3	(Pretilachlor 300g + pyribenzoxim20g/1EC)+ Carfentrazone-ethyl 240 g/1EC	14.6
4	(Clomazone 200g + propanil 400g/l)+ Carfentrazone-ethyl 240 g/1EC	18.6
5	Bispyribac-sodium 100g/1SC + Carfentrazone-ethyl 240 g/1EC	4.8
6	Azimsulfuron 50% WG +Carfentrazone-ethyl 240 g/1EC	4.8
7	(Fenoxaprop-p –ethyl 69g + ethoxysulfuron 20 g/1OD)+Carfentrazone-ethyl 240g/1EC	3.3
8	Pyribenzoxim 5% EC +Carfentrazone-ethyl 240 g/1EC	1.6
9	Metamifop 10% EC + MCPA 600g/1SL	1.6
10	Metamifop 10% EC +Carfentrazone-ethyl 40% WG	1.6
11	(Pretilachlor 300g + pyribenzoxim20g/1EC)+ Carfentrazone-ethyl 40% WG	1.6
12	(Clomazone 200g + propanil 400g/l) + Carfentrazone-ethyl 240 g/1EC +Azimsulfuron 50% WG	1.6
13	Bispyribac-sodium 100 g/1SC + Carfentrazone-ethyl 240 g/1EC +Azimsulfuron 50% WG	1.6
14	Metamifop 10% EC + Carfentrazone-ethyl 240g/1EC+ Azimsulfuron 50% WG	1.6
15	Bispyribac-sodium 100g/1SC + Carfentrazone-ethyl 240g/1EC + Metamifop 10% EC	1.6

Majority of farmers use Hand operated knapsack sprayer (66%), while 34% farmers used power sprayer for the herbicide application (Table 2). According to the farmers' view, they use power sprayer for time saving and to reduce the cost of production. However, power sprayer is not recommended for the herbicide application. Power sprayer release the very small droplet of herbicides and which enhance the spray drift and which lead for poor weed

control efficacy than the hand operated knapsack sprayer. Although farmers totally depend on herbicides to control weeds in their filed and achieve poor weed control. However, majority (67%) of farmers complained that herbicides are not effective, while 33% farmers only achieve effective weed control with herbicide application. Obviously, poor efficacy of herbicides might be due to combining effect of the selection of proper herbicides, mis-usage, mis-practices of herbicides and other management practices adopted by the farmers.

Table 2. Herbicide use practices among the farmers.

Herbicide use practices	Variable	Percentage
Herbicides spraying equipment	Knapsack Sprayer	66
	Power Sprayer	34
Frequency of application	Once	56
	Twice	43
	Three times	1
Dose of Herbicides	Recommended	47
	High	37
	Low	16
Weed control efficacy with herbicides	Effective	33
	Not- effective	67
Uncontrolled weed group with herbicides	Grasses	21
	Sedges	79

Information on particular herbicides to use on weeds was obtained from the three sources. About 42% respondents had information of herbicides from agrochemical dealers while, 33% of them received information from colleague farmers. About 25% of them received information from agricultural extension officers. Therefore, these results revealed that, majority of the farmers depend on the dealers and colleague farmer's recommendation. Many of the farmers do not read the labels and instructions on herbicides before using them. Reason for this is not clear. However, it has been shown that farmers prefer to rely on herbicide sellers rather than reading instruction in the label.

Study shows that, rice farmers in Hambantota district practice improper use of herbicides in their cultivation. This observation confirms that the problem is not the herbicide itself but how farmers handle herbicides. Farmers apply herbicides indiscriminately in violation of the technical recommendation. However, these practices of herbicides use have implications for the sustainability of the rice system, the health of the farmers and environment. The study shown that, mixing of different herbicides results the poor weed control due to incompatibility of some mixtures and this encourages the resistant development process. Furthermore, use of same mode of action herbicides may cause the chance of resistant build-up. This problem can be attributing to farmers' lack of technical knowledge and lack of training on effective herbicide usage practices. Addressing the problem of herbicide misuse requires the active involvement of important stakeholders to provide training and technical support for farmers.

CONCLUSIONS

Cyperus difformis and *Cyperus iria* are the most problematic weed species in the Hambantota district and ALS-inhibiting herbicides and PPO herbicides, two of the most frequently used herbicides group and hence, there is a possibility to develop resistant weeds to ALS group. However, poor weed control is always coupled with the improper use of herbicides such as, overuse, mixing and applying herbicides against to scientific recommendations made by the DoA. Therefore, there is an urgent need to conduct awareness programs for all field level agriculture extension officials and farmers on correct use of herbicides.

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