Tropical Agricultural Research & Extension 22 (1 & 2): 2019

EVALUATION OF APPROPRIATENESS OF CURRENT WEED MANAGEMENT TECHNIQUES PRACTICED IN RICE CULTIVATION IN AKURESSA AND ATHURALIYA D.S. DIVISIONS

Susil Mendis AP, Wathugala DL* and Kumarasinghe HKMS

Department of Crop Science, Faculty of Agriculture, University of Ruhuna, Mapalana, Kamburupitiya, Sri Lanka

ABSTRACT

The present study was carried out to evaluate the appropriateness of different weed management methods practiced in rice cultivation in the Matara district. This study comprised of a survey conducted in rice fields cultivated with variety At 362 in Akuressa and Athuraliya D.S. divisions during 2016/ 2017 *Maha* season. The survey was carried out using a pretested questionnaire with the participation of randomly selected 100 farmers (69 from Akuressa and 31 from Athuraliya D.S. divisions). Primary data were gathered through several focused group discussions with Agricultural Instructors and using a structured questionnaire. Based on the data gathered a field experiment was conducted in the farmers fields to study the impact of various weed management methods practiced by farmers on weed density and growth and yield parameters of rice. Based on the data obtained on different weed control techniques farmer fields were divided into 4 categories such as single herbicide, herbicide mixtures, non-chemical (manual and/or mechanical) and both chemical with mechanical weeding. Growth and yield parameters of paddy and weed growth parameters were obtained at different stages of the rice growth. 't' test and Kruskal-Wallis were used to analyze the results. Descriptive and inferential statistics were employed to draw conclusions. The highest percentage of farmers used mixed herbicides (44%), while single herbicides, non-chemical and both chemicals with mechanical weeding were used by 20%, 16% and 20%, respectively. The weed count was negligible at 10 days after the application of weed management techniques indicating that the use of herbicide mixtures was ineffective. Method of weed control did not significantly alter the growth and yield parameters of rice except the use of herbicide cum mechanical weeder which showed positive effects on growth and yield of rice. The weed seed bank analysis showed higher sedges and broad-leaved weed populations in chemical applied fields while higher grass weed populations in non-chemical applied fields. Launching farmer awareness programmes at the field level are found to be more important for a better understanding of the rational use of herbicides in rice cultivation.

Keywords: Growth and yield of rice, Herbicides, Weeds, Weed control

INTRODUCTION

Paddy (*Oryza sativa* L.) is one of the main productions and staple foods of Sri Lanka (Ekanayake 2009). It is estimated that on average 722,626 ha are cultivated during *Maha* and 480,662 ha during *Yala* seasons making the average annual extent sown with rice to about 1,253,288 ha contributing 4.8 million tons yield in annual rice production (Department of Census and Statistics 2015). The most popular rice variety grown in Matara District is At 362, which occupied about 52% of the paddy cultivated area in the district (Department of Census and Statistics 2016). Transplanting and direct seeding by hand or machines are the two major rice establishment methods used by the farmers. Similar to the other rice growing countries in the world, weed is one of the major causes for yield reduction in rice cultivation in Sri Lanka. It accounts for 30 to 40 percent of yield losses (Abeysekera 2001). Farmers use various weed control strategies like use of single herbicide or herbicide mixtures,

*Corresponding author: wgdlakmini@crop.ruh.ac.lk

hand weeding, mechanical weeding or combined method of these to overcome negative effects arisen from weeds. Among them, most of the farmers still rely on chemical weed control due to various marketing strategies of powerful chemical companies and easiness of application (Ekanayake *et al*. 2017). However, number of reports have shown various malpractices in herbicide application such as overuse, mixing and applying herbicides violating recommendations (Herath *et al.* 2017). In the Matara district also paddy farmers practice various methods to control weeds in their fields. A study has not been done to evaluate the effectiveness of different weed control methods practiced by farmers on weed control and the yield on rice. Therefore, the major objective of this study was to evaluate the appropriateness of different weed management techniques practiced in rice cultivation in Athuraliya and Akuressa D.S. Divisions in terms of their impact on growth and yield performances of rice variety At 362 and the efficacy of weed control.

MATERIALS AND METHODS

This study was conducted with the participation of farmers in Athuraliya and Akuressa divisional secretariat divisions (agro-ecological regions WL_{2a} and WL_{2b}, respectively) during the 2016/2017 *Maha* season. The total sample of 100 paddy farmers, together with their field in which 69 farmers from Akuressa and 31 farmers from Athuraliya were randomly selected for the survey.

Primary and secondary data were gathered using a structured questionnaires and that information pertaining to the certain socioeconomic status of farmers and agronomic aspects of paddy cultivation were categorized. Several focused group discussions and direct field observations were also used to collect some data.

The growth and yield (number of tillers, number of productive tillers per bush, leaf dry weight, number of grains per panicle, 1000 grain weight and yield per ha) data of rice were obtained 60 and 95 days after field establishment and weed parameters such as number of weeds/m^2 and weed type were collected from all selected farmer fields using $1m^2$ quadrate at about 10 days after the application of weed management method and 60 days after field establishment. Because herbicides are normally applied 7-14 days after rice establishment and their effects will remain another 1-2 weeks. Therefore, the first weed count was taken 10 days after the application of the weed management method. At the milking stage (about 60 days after establishment) again weeds can highly affect the yield of rice. Therefore, 60 days after rice establishment second set of weed data were taken.

Within two weeks after harvesting, soil weed seed bank was analyzed from farmer fields' which applied different weed management techniques. An experiment was arranged in a completely randomized design with three replicates. Five weeks after laying the experiment, the number of weeds and weed types (grass, broad leaves, sedges, and ferns) were collected.

The collected growth and yield parameters of paddy were analyzed using a statistical package named "statistix". Data of all weed control methods and weed seed banks were analyzed by using Kruskal- Wallis test.

RESULTS AND DISCUSSION

Akuressa and Athuraliya Divisional secretariat's divisions are located within the agro-ecological regions WL_{2a} and WL_{2b}, respectively. The average annual rainfall of this area is about 2250 mm and the average day time temperature ranges within 22-29^{0}C with relative humidity of 80%. In 2015, the rice cultivated extent in Matara district was 29,191.91 ha and out of it, At 362 was cultivated in 15,224.92 ha (Department of Census and Statistics 2015). Common weeds observed in the area have been listed in Table 1. Both transplanting and broadcasting were used as major crop establishment methods in the study area. Out of the 100 farmers selected for the study, 51 farmers practiced transplanting and 49 followed broadcasting. Other management practices like land prepara-

tion, irrigation, fertilization…etc were similar among farmers in the area. Weed control employing chemicals was the popular weed control method in the study area (84% farmers). Herbicide mixing practice is popular among the farmers in the area, where most farmers (44%) two or three herbicides are cocktail before application. Twenty percent of farmers used a single herbicide for weed control and few of them (20%) used mechanical weeding apart from herbicide application. Interestingly, 16% of farmers follow only mechanical weeding or manual weeding (non-chemical). Results revealed that 8 types of single herbicides and 12 types of herbicide mixtures were popular among farmers in the area (Table 2). Azimsulfuron 50% WG was the most common single herbicide used by farmers. The mixture of Clomazone 200g + Propanil 400g/l with Carfentrazone ethyl 240g/l EC was the most popular herbicide mixture in the area. Farmers spray these single herbicides or herbicide mixtures within 7-14 days after seed establishment as a single spray. The main objectives of farmers in mixing herbicides over the use of single herbicides were the reduction in production cost by saving time and labour and to kill a broad spectrum of weeds or an extension of the frequency of weeding.

However, the weed count taken 10 days after the application of weed management methods identified in the area showed more than 95% effectiveness. Therefore, herbicide mixing can be identified as an ineffective practice. Although hand weeding or non-chemical weed control method showed similar results as chemical applications, it is obvious that other factors such as labour availability, cost, time should be taken into account in non-chemical weed management methods. Similarly, environmental and health impacts caused by long term chemical application should also be considered. The density of the weeds is again critical at the milking stage (about 60 days after establishment) of the rice. Therefore, a weed count was taken from each field 60 days after field establishment. The mean number of weeds per m^2 recorded was 43.21, 44.36, 39.62 and 15.45 for single herbicide, herbicide mixtures, non-chemical and both chemical with mechanical methods applied fields, respectively at that stage. Both chemical and weeder applied fields gave the lowest weed density implying integration of weed management methods were more beneficial rather than depending on a single herbicide application. The similar weed count was observed in single herbicide and herbicide mixture sprayed fields again implying the ineffectiveness of herbicide mixtures.

The result of herbicide mixtures may be additive, synergistic, or antagonistic. It is obvious that in the case of antagonism, where the bio-efficacy of the mixture is reduced and greater dosages are required. Whereas, in the case of synergism enhanced bio-efficacy of the mixture can be achieved thereby application rates can be reduced. In general, antagonism has been found in mixtures where companion herbicides belong to different chemical groups (Damalas 2004). These chemicals probably have a greater chance to interact at the site of

Table 1: Common weed species found in the study area

Grasses	*Echinochloa glabrescenns, Echinochloa colonum, Echinochloa crusgalli, Panicum repens, Ischaemum rugosum, Isachne globosa, Oryza sativa, spontanea*
Sedges	*Cyperus iria, Cyperus difformis, Fimbristylis dichotoma, Fimbristylis miliacea, Scirpus supinus*
Broadleaved	*Ludwigia perennis, Eclipta alba, Eichnornia crassipes, Commelina diffusa, Murdannia nudiflora, Aeschynomene indica*
Ferns	*Marsilea quadrifolia*

action and form an inactive complex, as those chemicals have different chemical structures, modes of action and pathways of metabolism. Therefore, mixing herbicides before application should be done with a better understanding of the behavior of herbicide alone or in a mixture. In the study area herbicide mixing was guided by the retailer.

Because of the higher weed control efficiency, it can be suggested that there was no competition for resources from weeds on growth and yield variations of paddy in those fields. The growth and yield variations observed might be attributed to other factors such as type of chemicals or their combinations, application methods, application time, dose, etc.
A pairwise comparison between different weed control methods on some growth and yield parameters of paddy has been done and results are shown in Table 3.

Tillering is an important agronomic trait for rice population, quality and grain production (Counce and Wells 1990; Ling 2000). This is because excess tiller production results in a dense canopy, which provides a moist microenvironment favorable for pests and diseases, whereas a very few tillers result in insufficient numbers of panicles (Cu *et al.* 1996). On the other hand, such a dense canopy is caused to mitigate the weed growth underneath rice plants due to shading. However, in this study, the number of tillers per m^2 was not significantly affected by any of the weed management techniques. Similarly, 1000 grain weight was also not significantly affected by weed management technique. Whereas, the number of effective tillers was significantly increased in single herbicide treatment compared to that of chemical+ mechanical weeding and hand weeding, while leaf dry weight was significantly lower in single herbicide treatment than chemical with mechanical weeding method. The number of grains/panicle was significantly higher in chemical with mechanical weeding than single herbicide and herbicide mixture methods. The non-chemical technique also gave higher grains per panicle than single herbicide treatment. However, yield/ha significantly higher only in chemical with mechanical weeding and herbicide mixtures than sin-

Table 2: Herbicide mixtures used by farmers in the study area

No	Herbicide mixtures used	Percentage (out of hundred farmers)
1	Azimsulfuron 50% + Carfentrazone-ethyl 240g/l	2
2	Azimsulfuron 50% + 2-methyl-4chlorophenoxyacetic acid	3
3	(Thiobencarb 400g/l + Propanil 200g/l) +2-methyl-4chlorophenoxyacetic acid	5
4	(Bispyribac sodium 40g/l + Metamifop) + Carfentrazone-ethyl	1
5	(Bispyribac-sodium 40g/l + Metamorfoos) + 2-methyl-4chlorophenoxyacetic acid	2
6	Bispyribac sodium 100g/l + Carfentrazone-ethyl	3
7	(Pretilachlor 300g/l + Pyribenzoxim 20g/l) + Carfentrazone-ethyl	1
8	(Clomazone 200g + Propanil 400g/l)+ Carfentrazone-ethyl	15
9	(Clomazone 200g + Propanil 400g/l)+ 2-methyl-4chlorophenoxyacetic acid	8
10	Femoxaenap-p-ethyl + Ethoxysulfuron + 2-methyl-4chlorophenoxyacetic acid	1
11	Bispyribac sodium 100g/l + 2-methyl-4chlorophenoxyacetic acid	1
12	(Pretilachlor 300g/l + Pyribenzoxim 20g/l) + 2-methyl-4chlorophenoxyacetic acid	2

gle herbicide application. The significantly lower leaf dry weight in herbicide mixtures at 95 days after planting indicates early dry matter partitioning from leaf to grains and that allows a longer duration for sink filling. It may be the reason for the higher yield obtained in herbicide mixture applied fields. However, early dry matter partitioning implies stress conditions experienced by the rice plant and it might cause by the application of a mixture of herbicides. Under unfaourable weather condition these kinds of stresses may result in lower yields.

Some research studies have amply demonstrated that there is a positive correlation between the weeder use and crop growth and yield. Senthilkumar (2003) observed 10.9% enhanced grain yield and increased plant height in the treatment weeder along applied compared to the manual weeding. Vijayakumar *et al*. (2004) also found a significant yield increase of 9.7% (20 x 20 cm plant den-

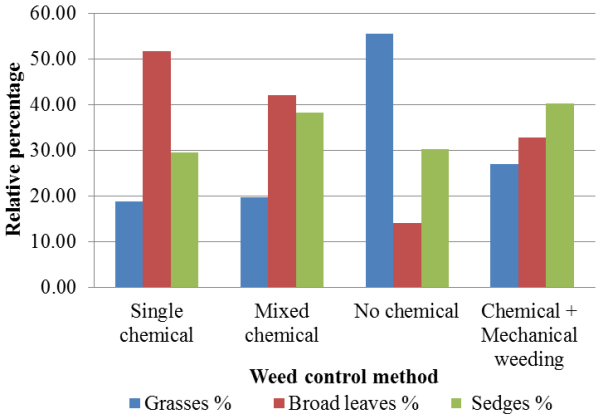

Figure 1: The relative percentage of grass, broad leaves and sedges under different weed control methods after harvesting.

Table 3: Pairwise comparison of different weed control methods on growth and yield of paddy

Pair of weed control methods compared	Mean difference					
	NT/m^2 at 60 DAE	NET/m^2 at 95 DAE	LDW (g/m^2) at 95 DAE	NG/P	Y (t/ha)	1000 GW (g)
Single herbicide *vs* Herbicide mixtures	2.85 ^{NS} (486.40, 483.55)	40.75 ^{NS} (421.95, 381.20)	94.04** (295.31, 201.27)	1.05^{NS} (122.25, 121.20)	-0.54** (2.87,3.41)	0.06^{NS} (21.96,21.89)
Single herbicide *vs* Non-chemical	63.77 ^{NS} (486.40, 422.63)	106.76** (421.95, 315.19)	37.17 ^{NS} (295.31, 258.14)	-34.06** (122.25, 156.31)	-0.18^{NS} (2.87,3.05)	0.19^{NS} (21.96,21.76)
Single herbicide *vs* Chemical + mechanical weeding	-6.20 ^{NS} (486.40, 492.60)	90.95** (421.95, 331.00)	-147.65** (295.31, 442.96)	-30.20** (122.25, 152.45)	-0.88** (2.87,3.74)	-0.02^{NS} (21.96,21.97)
Non-chemical *vs* Herbicide mixtures	-60.92 ^{NS} (422.63, 483.55)	-66.01 ^{NS} (315.19, 381.20)	56.87** (295.31, 201.27)	35.11** (156.31, 121.20)	-0.36^{NS} (3.05,3.41)	-0.13^{NS} (21.76,21.89)
Non-chemical *vs* Chemical + mechanical weeding	-69.97 ^{NS} (422.63, 492.60)	-15.81 ^{NS} (315.19, 331.00)	-184.82** (295.31, 442.96)	3.86^{NS} (156.31, 152.45)	-0.70^{NS} (3.05,3.74)	-0.21^{NS} (21.76,21.97)

(Note: DAE- Days after establishment, NS- Not significant, **- Significant ($p \leq 0.05$), NT- number of tillers, NET- number of effective tillers, LDW – Leaf dry weight, NG/P- number of grains per panicle, Y- total yield and 1000GW- 1000 grain weight. The mean difference of each comparison is indicated in each column and its mean values are included within brackets)

sity) and 11.1% (25 x 25 cm plant density) due to the weeder use when compared to conventional weeding (herbicide + hand weeding). Ramamoorthy (2004) found that the weeder use has a sort of earthing up effect and the plants produce new roots which probably help in additional nutrient uptake. Therefore, the application of weeders in paddy cultivation cannot only manage weeds but also to loosening soil thereby enhancing crop growth through facilitating root growth.

The weed population after harvesting paddy has been studied taking soil samples from each field. The relative percentages of three categories of weeds against each weed control method are presented in Fig.1.

Sedges and broad-leaved weeds were the prominent weeds in all chemical applied fields. But in non-chemical applied fields the main weed type was grasses. Generally, prominent weed types in chemical applying paddy fields are grasses and sedges while broad-leaved weeds are prominent in paddy fields which are applied manual weeding methods since grasses and sedges can rapidly develop resistance to herbicides. However, the results observed in this study suggested that the herbicides and their mixtures use by farmers in the area are capable enough to kill grasses than broadleaf weeds. Therefore, the method of weed management used several years back should be analyzed to understand the composition of weed population in the paddy fields after harvesting.

CONCLUSION

Results of this study showed that the application of either a single herbicide or a mixture of herbicide has no significant effect on weed control efficacy since more than 95% weed-free fields were observed in the study period. Hence there is no need to apply herbicide mixtures. The use of mechanical weeders along with chemical weeding achieves some promising weed control thereby positive increase in growth and yield of rice. Conducting awareness programmes at the field level to educate farmers about the rational application of herbicides together with alternative weed management strategies will help in the path towards smart agriculture.

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