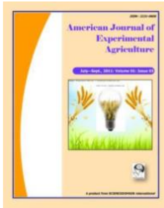

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Integrating Mechanical and Chemical Control Treatments to Manage Invasive Weed *Chromolaena odorata* (L.) R. M. King and H. Robinson in Grassland Area

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Author's contribution

All this work, from designing the study, writing the protocol, writing the first draft of the manuscript, reviewing the experimental design and all drafts of the manuscript, managing the analyses of the study, identifying the plants, performing the statistical analysis, reading and approving the final manuscript was carried out by author MR.

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ABSTRACT

An experiment was conducted on *Chromolaena odorata* dominated grassland to determine the efficacy of integrated mechanical and chemical control on regrowth of *Chromolaena odorata* and other weeds and to determine their botanical composition at 30, 60 and 90 days after treatment application. Treatments were spraying of glyphosate (Roundup) onslashed *Chromolaena odorata*, spraying of glyphosate on normal *Chomolaena odorata*, spraying of triclopyr (Garlon 4) on slashed *Chromolaena odorata* and spraying of triclopyr on normal *Chromolaena odorata*. Efficacy was assessed on the basis of dry weight of weeds yielded at 30, 60and 90 days after herbicide applications. Both herbicides were more effective when sprayed on normal than on slashed *Chrmolaena odorata*. Regardless of slashing, triclopyr was more effective than glyphosate in suppressing weeds. In glyphosate sprayed plots, *Chromolaena odorata* and other weeds were the dominant plants, whereas in triclopyr sprayed plots, herbage was the dominant plant, however

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dominance of *Chromolaena odorata* progressively increased over time. The results suggest that the interval between slashing and spraying of herbicides is an important factor to determine the efficacy of integrating slashing and herbicide to control *Chromolaena odorata*.

Keywords: Chromolaena odorata; integrated slashing and herbicidal control; weed suppression; botanical composition.

1. INTRODUCTION

Chromolaeana odorata (L.) King and H. Robinson (hereafter called *Chromolaena*), a species of *Asteraceae* family is a perennial shrub native to subtropical and tropical America [1,2]. It has been reported as one of the world's most invasive species; it is considered to be a serious weed problem in Africa, India, Pacific island and South East Asia [3]. It was introduced to India in the 1840s as an ornamental plant from where it spreads to South East Asia and since the Second World War; it has been spreading rapidly throughout Indonesia. It is considered as the most noxious weed in pasture areas because it reduces grazing area for livestock and hinders biodiversity conservation by changing the botanical composition of pasture [4].

In the pasture area owned by the Faculty of Animal Science Hasanuddin University in Enrekang regency, the weed has covered more than 50% of pasture area thus severely reducing carrying capacity of pasture. Lacks of forage because of reducing carrying capacity generally occur during dry season and during the season; many cattle grazing on the pasture were die because of starvation. *Chromolaena* leaves are not eaten by livestock because it is unpalatable when fed fresh to animals [5]. The weed is also toxic to animals because of high levels of nitrate (5 – 6 times above toxic levels) [6]. As all parts of the plant contain alkaloid that is bitter tasting, livestock will avoid it. Because of these reasons, presence of the weed in grassland area needs to be controlled.

The control of *Chromolaena* is difficult because of its ability to thrive in a wide variety of soils, rapid attainment of reproductive maturity, large production of easily dispersible seeds, a significant proportion of seeds persisting in the soil more than one year and strong ability to resprout after burning [7].

Chromolaena can be controlled by mechanical, chemical, cultural, biological and integrated methods. Mechanical control includes uprooting and slashing that have been the most widely used control measure against the weed. However, to be effective in the long term, the weed must be slashed frequently until its carbohydrates reserve content is exhausted. Escalating labor cost makes this method is prohibitively expensive. Integration with other control methods such as chemical control may be effective and economical.

Many reviews on the use of herbicides for the control of *Chromolaena* are available [8,9]. Herbicides are quicker, cost effective and disturb the soil less where erosion may be of concern. A wide range of herbicides have been evaluated for the control of *Chromolaena*. These include 2,4-D amine, picloram, tebuthiuron, imazapyr, glyphosate and triclopyr. In Indonesia, glyphosate, next to paraquat, are commonly used herbicides to control *Chromolaena* in grassland area. Triclopyr, although effective to control of *Chromolaena* [10], is rarely used in grassland area. There is a paucity of information concerning the efficacy of use of glyphosate and triclopyr in grassland area. The present study was aimed at determining integration of slashing and herbicidal (glyphosate and triclopyr) control method on regrowth suppression of *Chromolaena* and other weeds and observing their botanical composition after treatments applied in grassland area.

2. MATERIALS AND METHODS

2.1 Study Site

The experiment was conducted during the dry season in a pasture owned by the Faculty of Animal Science Hasanuddin University. The site was located at Maiwa, Enrekang regency South Sulawesi Indonesia from July to November 2012 (3º33'57" S, 119º47'31"E) at about 1300 m above sea level. The climate of the area is tropical monsoon characterized by one rainy season (November to June) and one dry season (July to November). The annual average rainfall was 2426 mm with a daily average temperature of approximately 27.34ºC. The soil texture was silty clay loam. The area was heavily infested by combinations of *Chromolaena*, *Stachytarpheta* *jamaicensis*, *Borreria* sp and some other weeds and herbage species.

2.2 Experimental Design and Treatments

The study was conducted on a *Chromolaena* dominated pasture with density of 300 – 500 stems/plot and height 1 – 2 m. Community coefficient values indicated homogeneity among the plant communities were 60 – 70%.The herbicides used were glyphosate and triclopyr. A knapsack sprayer fitted with a fan jet nozzle was used for spraying the herbicides.

The experimental design was a split plot in time design with four integrated chemical and mechanical controls as sub plots and three slashing times after application of herbicide as the main plots. There were three replications for each treatment. The four integrated chemical and mechanical control treatments were: T1 spraying of glyphosate (Roundup) on slashed *Chromolaena* and other plants, T2 spraying of glyphosate on unslashed *Chromolaena* and other plants, T3 spraying of triclopyr on slashed *Chromolaena* and other plants, and T4 spraying of triclopyr on unslashed *Chromolaena* and other plants. Spraying of herbicides was conducted at two weeks after slashing of *Chromolaena* with the slashing height of 10 cm above soil surface. Plot sizes were 5.0 x 5.0 m and a 1 m space between plots was allotted to prevent treatment effects of one plot to other plots. The study area was fenced off using barbed wire to height of 2,0 m to keep out animals and unauthorized persons. The fenced area measured 50 x 40 m. A 100 m wide area outside the fences was ring-weeded using a motorized brush cutter to prevent accidental burning.

Glyphosate and triclopyr were applied at the rates of 2.4 kg a.i./ha and 1.23 kg a.i./ha with concentrations of 10 g and 4 g L^{-1}, respectively. The form of triclopyr used was butoxy ethyl ester (Garlon 4). Application of herbicides was conducted on day 15 days after slashing of *Chromolaena*. The efficacy of treatment was determined by measuring dry matter weight of surviving weeds at 30, 60 and 90 days after herbicide application. More dry matter of weeds yielded indicates that the treatment was the less effective. Dry matter weight of regrowth was taken randomly from cutting of plants inside the plots at 10 cm above soil surface in quadrants measuring 1 m x 1 m. To determine dry matter content, the fresh samples obtained were dried in oven at 70ºC for 72 h. The botanical composition was calculated as dry matter yield of species comprising the pasture during experiment.

2.3 Statistical Analysis

This experiment was conducted using split plot in time design with three times of sampling (30, 60 and 90 days) as main plot and four integrated mechanical and chemical control treatments as sub-plot. SPSS program version 15 was used to conduct all statistical analysis. Differences among each treatment were analyzed using least significant difference (LSD) method.

3. RESULTS AND DISCUSSION

3.1 Efficacy of Integrated Chemical and Mechanical Control Treatments

Dry matter yield of weeds at 30, 60 and 90 days after herbicide application (DAHA) are shown in Table 1. Average dry matter yield of weeds sprayed with herbicides on normal *Chromolaena* was significantly lower than when herbicides sprayed on slashed *Chromolaena*. This indicated that the effective treatment to suppress the regrowth of *Chromolaena* and other weeds was spraying of herbicideon normal growth of *Chromolaena* and less effective when the herbicides were applied on slashed *Chromolaena*.

Slashing treatment followed by herbicide application is widely used to control the regrowth of weeds. Slashing of shrub plants reduces their biomass, forces the plants to tap their food reserve in roots or stem base to fuel regrowth and provides more succulent leaves which are more readily penetrated by herbicides. Slashing lowers reserve carbohydrate levels and by timing the herbicide application with the low total non-structural carbohydrate storage, efficacy of herbicide can be maximized [11]. This strategy has been reported to be successfully in suppressing the regrowth of *Chromolaena* in India where 2,4-D herbicideis used [12]. In Swaziland, [13] also reported that slashing followed by spraying of Roundup was more effective in controlling *Chromolaena* than slashing only.

Table 1. Dry matter yield of *Chromolanea* and other weeds (g/plot) as influenced by integrated mechanical and chemical control methods

		Days after herbicide application			
Treatment	**Plants**	**30**	**60**	**90**	**Mean**
T1	*Chromolaena*	495,00	1798,35	2053,35	1448.90
	Other weeds	424,00	885.85	1613.30	974.38
	Total	919.00	2684.20	3666.65	2423.16d
T2	*Chromolaena*	133.35	456.65	1067.32	552.44
	Other weeds	310.67	647.03	1052.70	670.13
	Total	444.02	1103.68	2120.02	1222.57b
T3	*Chromolaena*	223,35	1120.35	1430.00	924,56
	Other weeds	663.66	1190.00	1545.00	1132.89
	Total	887.01	2310.35	2975.00	2057.45c
T4	Chromolaena	15.00	213.35	695.65	308.00
	Other weeds	81.35	458.26	974.35	504.65
	Total	96.35	671.61	1670.00	812.65a
Mean	*Chromolaena*	216.68	897.18	1311.58	808.48
	Other weeds	369.92	795.29	1296.34	820.52
Mean	Total weeds	586.88a	1542.47b	3257.75c	

Mean of total weeds at the same row and column sharing different letter are significantly different (P< 0.05)

A possible reason why both herbicides were less effective in controlling regrowth of *Chromolaena* in slashed plots was the blocking of downward translocation of absorbed herbicides influenced by the too short interval between slashing of weeds and application of herbicides. This was in agreement with [14] that when the plants are in early flushing, translocation of carbohydrates upward from roots or stem bases to a new flush prevents the downward translocation of foliar applied herbicide to the roots. The maximum height of slashed *Chromolaena* when sprayed with herbicides in this study rarely attained a height of 20 cm and this value might be too low to obtain effective results. [8] Stated that efficacy of various foliar applied herbicides such as triclopyr and glyphosate to *Chromolaena* was high when herbicide was sprayed to actively growing regrowth of 0.5 – 1.0 m tall.

The higher efficacy of both herbicides sprayed on normal *Chromolaena* might be attributed to the high translocation of carbohydrates downward from leaves to roots when herbicides were sprayed, that is after the head and seed had been formed. This was in line with the results of [15] that foliar systemic phloem mobile herbicides have a good efficiency when application were made at post-flowering stages which coincide with translocation of carbohydrates to the roots. This efficiency can reach maximum when the application of herbicides is done in stages where emigration of carbohydrates to the root system is fast.

Average dry matter yields of *Chromolaena* and other weeds in both the slashed and unslashed plots were lower when plants were sprayed with triclopyr than those of glyphosate sprayed plots. The higher efficacy of triclopyr over glyphosate on *Chromolaen a*re growth was also reported by [16,17]. [17] reported that by using triclopyr, an acceptable level of control could be obtained with 1.8 – 1.9 dm^3/ha, whereas by using glyphosate, between 3.5 and 4.3 dm^3/ha was required for effective control. This indicated that in grassland area, triclopyr is more suitable to be used to control *Chromolaena* and other weeds than glyphosate. The selective properties of triclopyr give this herbicide is advantage over other herbicides. Vegetation tolerant to triclopyr remains in place and can compete with other plants, increase biodiversity, and reduces the dependency of repeat herbicide application.

3.2 Botanical Composition

Botanical composition as influenced by integrated mechanical and chemical control treatments are shown in Fig. 1.

There were 24 species of weeds and herbage recorded in this study. About 80% of total plant species comprised only seven species, namely, *Chromolaena odorata, Stachytarpheta jamaicensis, Borreria latifolia, Borreria laevis, Borreria ocymoides, Cynodon dactylon and Axonopus compressus.*

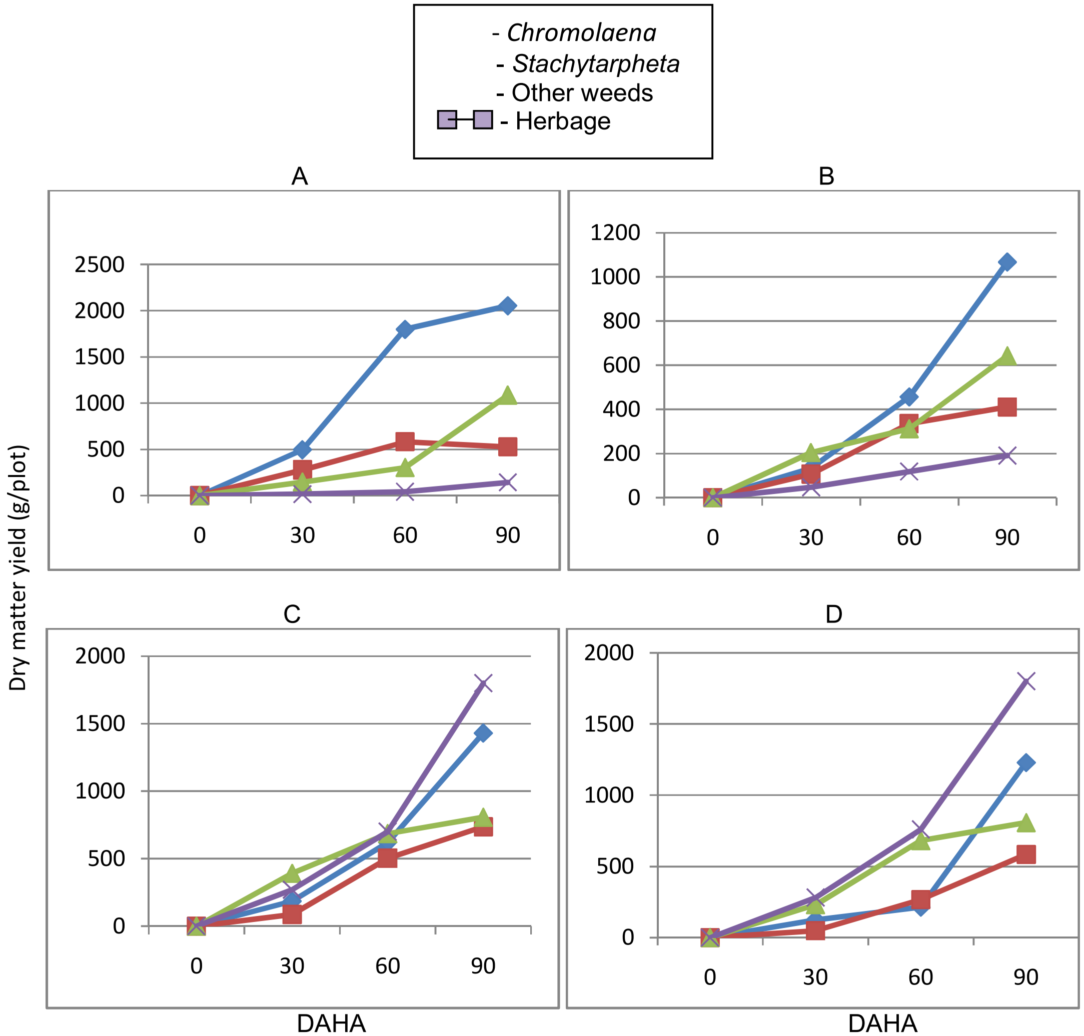

Fig. 1. Changes in dry matter yield of slashed, glyphosate sprayed plants (A), unslashed, glyphosate sprayed plants (B), slashed, triclopyr sprayed plants (C) and unslashed, triclopyr sprayed plants (D)

In slashed *Chromolaena* plots sprayed with glyphosate, *Chromolaena* began to be the most dominant species at 30 DAHA and continued to increase until the end of study, but in normal *Chromolaena* plots sprayed with glyphosate, dominance of *Chromolaena* began at 60 DAHA until the end of study. This might be attributed to low efficacy of Roundup sprayed on slashed *Chromolaena* than sprayed on normal *Chromolaena*. In both slashed and unslashed plots, the lowest botanical composition was herbage species. This lowest botanical composition of herbage indicated that glyphosate was unsuitable to control *Chromolaena* in pasture area. This may be attributed to mode of action of glyphosate that is, non selective and kills all plants, including grasses [18]. Conversely, in triclopyr sprayed plots, herbage was always the most dominant plant, conversely, at 30 and 60 DAHA, botanical compositions of *Chromolaena* were low, comparable to *Stachytarpheta*, however at 60 DAHA, *Chromolaena* was dominant again. The highest botanical composition of herbage in triclopyr sprayed plots may be attributed to differential effects of triclopyr on the regrowth of plant species that reduced regrowth of *Chromolaena* and other herbaceous broad-leaves species but leave grass species unharmed [19]. Thus, spraying triclopyr on *Chromolaena* dominated pasture is very beneficial because it suppresses regrowth of *Chromolaena* and other broadleaf plants but do not kill grasses. However efficacy of Triclopyr was not lasting because at 90 DAHA, *Chromolaena* began to dominate grassland area again this indicated that herbicides application is not lasting and to achieve a 100% success in controlling regrowth, repeated application of herbicide is needed and this makes this method is prohibitively expensive. This was in agreement with [19] that chemical control of *Chromolaena* is not economically feasible and it is unlikely that it would be economic in the extensive grassland.

4. CONCLUSION

Spraying triclopyr on normal *Chromolaena* and other weeds is recommended as a suitable control method to suppress the weed in grassland area, because besides providing the highest efficacy of control, it does not kill grasses. However, application of triclopyr and glyphosate on normal *Chromolaena* is not lasting and may require a high cost outlay to achieve a complete control.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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