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BIOEFFICACY OF TANK MIXED POST-EMERGENCE HERBICIDES FOR CONTROLLING WEED IN FORAGE MAIZE (*ZEA MAYS* L.)

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ABSTRACT

Background Weed infestation is one of the major problems in the successful cultivation of maize. Thus, to realize the optimum yields weed management is considered very critical. Hence, chemical weed control is more feasible, less laborious, cost effective and economical in maize.

Methodology A field trial was carried out to test the bio-efficacy of tank mixed post-emergence herbicides to control weeds in maize forage (*Zea mays* L.) at the Research Area, University of Agriculture Faisalabad. The treatments were: helosulfuron @ 40 g a.i. ha^{-1} tank mixed with carfentrazone-ethyl @ 10 g a.i. ha^{-1} or atrazine @ 296 g a.i. ha^{-1} or bromoxynil + MCPA @ 750 g a.i. ha^{-1}. Weedy check (control) and hand weeding treatment was also included for comparison. The experiment was conducted with four replications in randomized complete block design. The data regarding weeds, and yield components of forage maize was recorded using standard procedures. The lowest total weed density (25.50 m^{-2} 15 DAT and 22.00 m^{-2} at harvest) was recorded in plots where helosulfuron was tank mixed with bromoxynil + MCPA @ 750 g a.i. ha^{-1}. Tank mixed application of helosulfuron with carfentrazone-ethyl @ 10 g a.i. ha^{-1} gave maximum (74.47 %) control of *C. arvensis* at harvest. While, the minimum density (9.5 m^{-2}) of *E. crus* galli was noted in plots where foliar application of helosulfuron @ 40 g a.i. ha^{-1} + atrazine @ 296 g a.i. ha^{-1} was done.

Results The highest values of plant population (22.00 m^{-2}) plant height (230.00 cm), stem diameter (1.4 cm) of maize plant, number of green leaves (11.70) per plant and forage yield (80.06 t ha^{-1}) of maize was recorded with the foliar application of helosulfuron @ 40 g a.i. ha^{-1} + bromoxynil + MCPA @ 750 g a.i. ha^{-1}.

Conclusion It is concluded that post–emergence application of helosulfuron @ 40 g a.i. ha^{-1} + bromoxynil + MCPA @ 750 g a.i. ha^{-1} performed best and gave maximum control of weeds and increase forage yield of maize.

INTRODUCTION

Maize is an imperative member of family poaceae which majorly contributes in agricultural economy of the world. For livestock feed, maize is cultivated on wide range of soil type both in irrigated and rainfed areas of the temperate, tropical and sub-tropical agro-ecological regions (Muhammad et al. 1995). In Pakistan, although the soil and climatic conditions are favorable for maize cultivation but its fodder yield per unit area is near to ground as compared to other countries known for maize production (Aslam et al. 2011). Many factors contribute towards low yield of fodder maize like limited resources, imperfect resource management and non-adaptation of technological advancements. Among these weed management is considered one of the key factors which caused severe reduction (58-68.2%) in fodder yield by limiting plant growth, height and stem diameter of maize plant (Singh and Prasad, 1994; Arif et al. 2007). Although, a number of weed species are relished by animal sand these also have higher nutritive

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nutritive value and palatability. But despite of the higher nutrient uptake ability of weeds, these are not as much productive as the fodder crops. In other words; by utilizing grater amount of added inputs weeds produce less biomass then the expanses of yield loss caused by their infestation in fodder crops. Weed management by use of cultural, biological and mechanical methods is getting much expensive due to continuous increasing cost of fuel and labor. On the other hand the chemical methods for controlling weeds show quick response, save time and also require less labor which ultimately reduces the cost of production. The level of yield decline due to infestation of grassy weeds, non-grassy weeds and sedges alone has been testified around 84.4, 31.7 and 21%, respectively. So the control of all types of weed species becomes important to explore the yield potential of a crop (Pandey et al. 1999). The narrow weed killing spectrum of presently available herbicides and absence of their pre mixed formulations restricts their use for controlling mix weed flora infestation in a field. The separate application of two different herbicides for different weed species is also not economical because it may requires extra fuel, labor and time to repeat the herbicide application procedure which ultimately increases the cost of production. On the other hand; application of same herbicide or usage of herbicides with similar mode of action again and again over several years definitely eliminate sensitive weed species but also results in gradual buildup of herbicide tolerant weed population. In this situation tank mixing of herbicides with multiple mode of actions offer broad spectrum weed control and also a better technique to overcome the problem of herbicide tolerance of weeds (Markovic et al. 2008; Singh et al. 2012). In an experiment results in gradual buildup of herbicide tolerant weed population. In this situation tank mixing of herbicides with multiple mode of actions offer broad spectrum weed control and also a better technique to overcome the problem of herbicide tolerance of weeds (Markovic et al. 2008; Singh et al. 2012). In an experiment of herbicide tank mixing for controlling weeds in maize; the WCE of metolachlor increased to 82% when use in mixture (1:1) with alachlor. In the same way an increase of 28% in WCE of metribuzin was observed when half dose of both metribuzin and metolachlor was used in mixture (Patel et al. 2006). Use of herbicides in combination is helpful to increase herbicides persistence enough to give full season weed control. The proper experimentation of herbicide tank mixing is helpful in the preparation of pre-mix herbicide formulations for the easiness of farmers. The present study was therefore, planned to manipulate the tank mixed potential of post-emergence herbicides for controlling mix weed flora and to study the forage yield response by controlling weeds in autumn planted maize.

MATERIALS AND METHODS

The planned research was conducted as field experiment at Student Research Area, University of Agriculture, Faisalabad. Experiment was arranged with four replications by using Randomized Complete Block Design. The net plot size was 6 m × 1.2 m. The Pak–afgoyee variety of maize was sown in the month of July after fine seedbed preparation. Seed rate 100 kg ha^{-1} was used. The sowing was done in 30 cm spaced rows using hand drawn single row seed drill. Nitrogen at 120 kg ha^{-1} and phosphorus at 100 kg ha^{-1} were applied as urea and DAP, respectively. Whole of phosphorus and half of nitrogen were applied by broadcast method just before sowing of crop, whereas, remaining amount of nitrogen was applied in standing crop just before the application of first irrigation. All the agronomic operations except under study kept normal and uniform. Detail of herbicide treatments is given in Table 1. The herbicides were applied after emergence of weeds and maize crop using hand operated Knapsack sprayer fitted with flat fan nozzle. The sprayer was calibrated before spraying and water was applied at 250 L ha^{-1} to spray herbicide. Herbicides were mixed at the time of application. Hand hoeing was done in 3rd week after sowing using hand hoe (kasula) in selected plots of each replication. The data on density and dry weight of weeds (g) was recorded from area of one square meter, ten plants were selected at random to record plant height (cm),

Table 1 Detail of experimental treatments

Treatments	Common name	Time of application	Dose (g a.i. ha^{-1})
Weedy check (Control)	--	--	--
Hand weeding (one)	--	--	--
Orcus-80WDG + Aim-40DF	Helosulfuron+ carfentrazone-ethyl	post-emergence	40 + 10
Orcus-80WDG + Clarkplus-80WDG	Helosulfuron+ atrazine	post-emergence	40 + 296
Orcus-80WDG + Buctril super 60EC	Helosulfuron + bromoxynil+MCPA	post-emergence	40 + 750

a.i: Active ingredient of weedicides

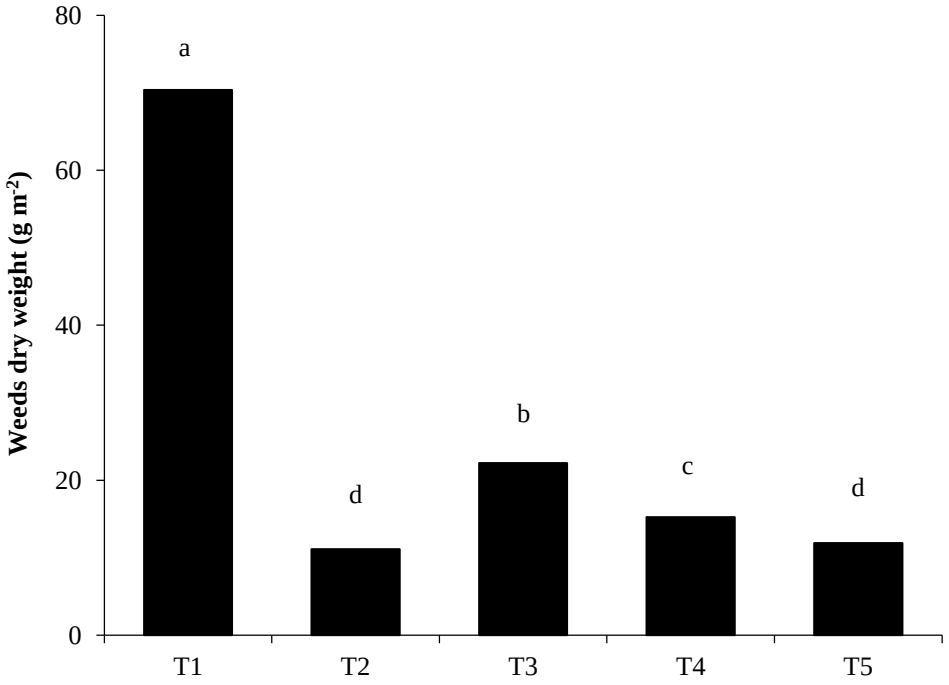

Figure 1 Total weeds dry weight (g m^{-2})

Table 2 Weed density affected by different weed control treatments

Treatments	Weed density (m^{-2})									
	T. portulacastrum		***C. arvensis***		***E. Colona***		***C. rotundus***		**Total**	
	15 DAT	AH	15 DAT	AH	15 DAT	AH	15 DAT	AH	15 DAT	AH
WC	46.50 a	47.75a	11.25a	11.75a	26.75a	29.0a	23.25a	30.0a	107.75a	118.50a
HW	4.50c	5.0d	3.25c	3.75c	3.75d	5.0d	6.75b	7.75b	18.25d	21.50d
H+C	11.00 b	13.50b	3.75c	3.0c	13.25b	12.75b	6.50b	6.75b	34.50b	36.00b
H+A	11.00 b	9.75bc	6.25b	5.50b	9.50c	9.25c	5.25bc	4.0c	32.00b	28.50c
H+B+MCPA	6.0c	5.75cd	4.75bc	3.75c	10.25c	9.5c	4.50c	3.0c	25.50c	22.00d
LSD value	2.71	4.21	1.51	1.31	2.44	3.04	1.83	2.52	4.18	5.36

WC: Weedy check, HW: Hand weeding, H+C: Helosulfuron + carfentrazone-ethyl, H+A: Helosulfuron + atrazine, H+B+MCPA: Helosulfuron + bromoxynil + MCPA, DAT: Days after treatment, AH: At harvest

stem diameter (cm), number of green and dry leaves per plant, fresh and dry weight per plant (g). The green forage yield of maize was recorded on per plot basis and was converted t ha^{-1}. Fisher's analysis of variance technique was used for analyzing the collected data and least significant difference test was performed for comparison of treatment means (Steel et al. 1997).

RESULTS AND DISCUSSION

Weed density

Tank mixed herbicides caused significant reduction in weed density over weedy check (Table 2). Among the herbicide treatments the minimum weed density (6.0 m^{-2} 15 DAT and 5.75 m^{-2} at harvest) of *T. portulacastrum* was recorded with application of helosulfuron tank mixed with bromoxynil + MCPA. While the mortality (66.67% 15 DAT and 74.47% at harvest) of *C. arvensis* was higher in those plots where helosulfuron was tank mixed with carfentrazone–ethyl, however, it was statistically similar with tank mixed application of helosulfuron with bromoxynil + MCPA. But the foliar spray of herbicides tank

mixes of helosulfuron + atrazine and helosulfuron + mixes of helosulfuron + atrazine and helosulfuron + bromoxynil + MCPA gave good control of both *E. colona* and *C. rotundus* and caused maximum reduction (61-68 % and 77-90%, respectively) in their density over weedy check (Figure 3). Lowest total weed density was recorded in hand weeding and with foliar application of tank mixed helosulfuron + bromoxynil + MCPA and it was significantly different than rest of the treatments (Table 2). Hand weeding and herbicide treatments caused mortality of weeds and results in significant reduction in weed density over weedy check. This statement is also supported by Markovic et al. (2008) who found that the post-emergence application of atrazine + acetochlor (0.75 + 1.6 kg ha^{-1}) gave effective control of weeds in maize and results in enhancing crop yield. Sing et al. (2012) also described that the post-emergence application of tembotrione @ 120 g ha^{-1} is much effective in controlling narrow leave weeds particularly *E. colona* in maize field.

Dry weed biomass

The minimum dry weight (2.39 g m^{-2}) of *T. portulacastrum* and maximum reduction in dry biomass (84.21%) of *C. arvensis* was recorded with the application of helosulfuron + bromoxynil+MCPA and helosulfuron + carfentrazone-ethyl, respectively (Figure a, b, c and d). While, the lowest dry weight (3.48 g m^{-2}) of *E. colona* was weighted from those plots where foliar spray of helosulfuron + atrazine was done and it was statistically similar with that of helosulfuron + bromoxynil + MCPA. The highest value of dry weight (2.09 g m^{-2}) of *C. rotundus* was noted from those replicates where tank mixed application of helosulfuron + carfentrazone-ethyl was done to control the weeds density. The lowest weed dry weight (11.10 g m^{-2}) was recorded in hand weeding treatment and it was statistically at par with similar to the total dry weight (11.88 g m^{-2}) of weeds weighted from those replicates where foliar application of helosulfuron + bromoxynil + MCPA was done (Figure 1). In weedy check the maximum dry weight of weeds was because of higher weeds population and unrestricted growth throughout the growing season. The mortality of weeds in hand weeding and with herbicide application decreased their density which resulted in reduction of weeds biomass. These results are supported by those of Quddus et al. (2012). They observed significant reduction in dry weight of weeds in spring planted maize with the application of formasulfuron tank mixed with isoxadifen-ethyl @ 1125 g a.i. ha^{-1}. Rastgordani et al. (2013) reported that the foliar application of a herbicide combination of rimsolfuron + nicosolfurona @ 175 g a.i. ha^{-1} was very effective for controlling weeds and also reduced the dry weight (82.72 %) of weeds as compared to weedy check.

Forage yield and yield components of maize

The maximum values of plant height (230.00 cm), stem diameter (1.4 cm) and number of green leaves (11.70) per plant of maize was recorded in those plots where weeds were controlled manually which, however was statistically similar to those of application of helosulfuron tank mixed with atrazine and bromoxynil + MCPA (Table 3). The higher values of these parameters caused significant increase (25-29%) in per plant fresh weight of maize which ultimately results in higher fodder yield. The minimum value of fresh weight (334.25 g) per plant of maize was recorded in weed check. This reduction in fresh weight might be due to reduction in plant height, stem thickness and number of green leaves in weedy check plots. This reduction in yield related attributes in weedy check treatment can be described because of restricted plant growth in the presence of stressed conditions created due to nutrient and water consumption by weeds. Among herbicide treatments significantly lower green fodder yield (69.61 t ha^{-1}) was recorded in those plots where helosulfuron was tank mixed with carfentrazone-ethyl to control the weeds (Table 3). The lowest green forage yield of maize (52.17 t ha^{-1}) was recorded in weedy check. These results are in similarity with Arif et al. (2007) who reported minimum forage yield (54 t ha^{-1}) of maize in those plots where no weed control measures were taken. Ali et al. (2003) and Abdullah et al. (2007) concluded that the application of herbicides minimize the weed crop competition and ensures maximum uptake of nutrients by crop plants which results in maximum plant biomass production and ultimately increased crop yield.

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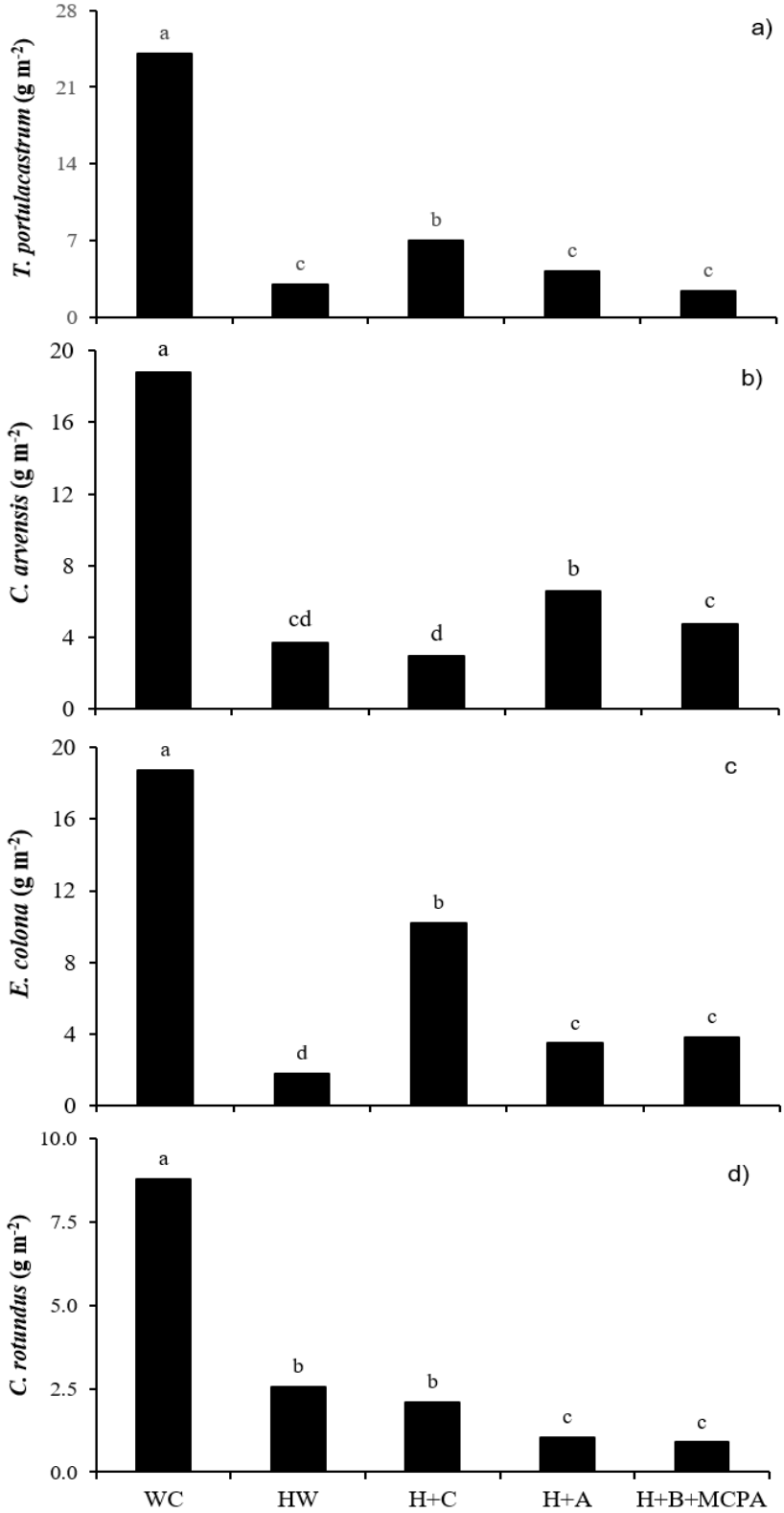

Table 2 Dry weed biomass affected by different weed control treatments at harvest. WC: Weedy check, HW: Hand weeding, H+C: Helosulfuron + carfentrazone-ethyl, H+A: Helosulfuron + atrazine, H+B+MCPA: Helosulfuron + bromoxynil + MCPA, DAT: Days after treatment, AH: At harvest

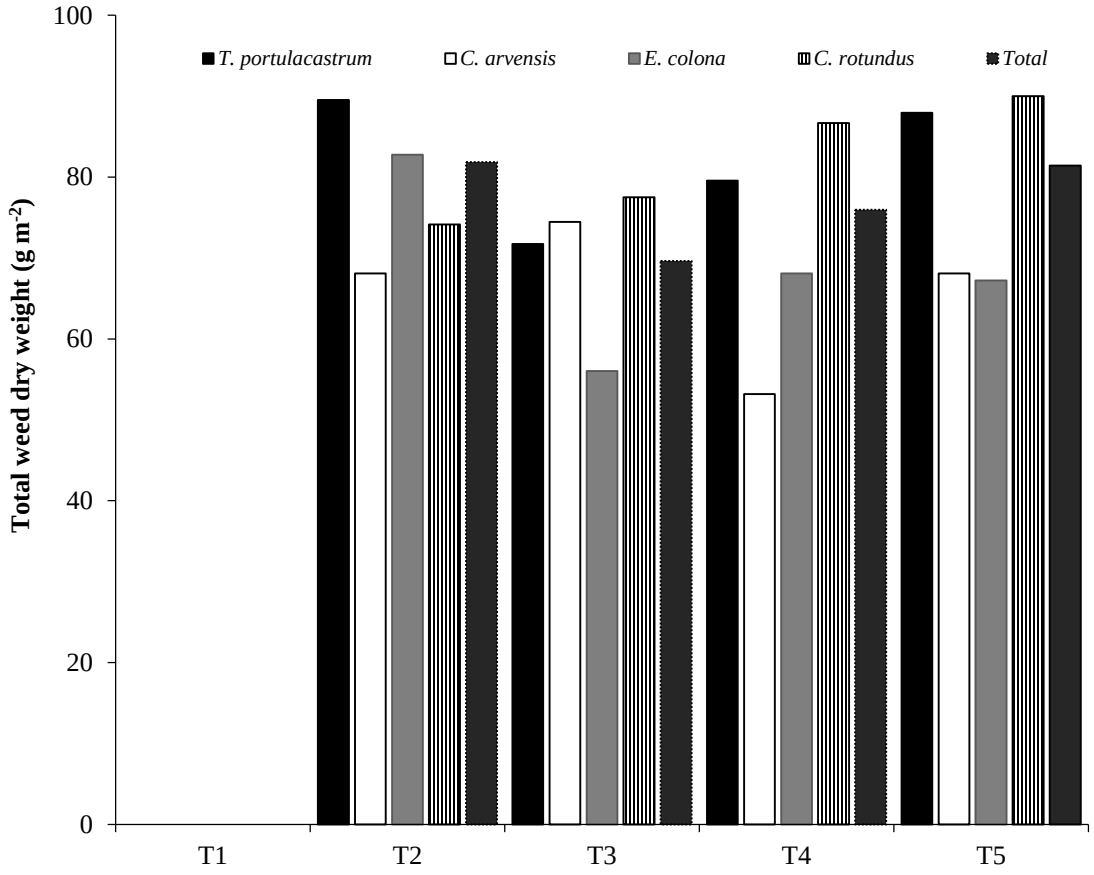

Figure 3 Weed control efficiency (WCE %), LSD value: 3.34

Table 3 Yield components and forage yield of maize as affected by various weed control treatments

Treatments	Yield components				FY
	PH (cm)	SD (cm)	NGL (plant^{-1})	FWP (g)	(t ha^{-1})
WC	186.50c	1.23 c	10.0 c	334.25 c	52.17d
HW	234.0 a	1.43 a	11.85 a	430.25 a	82.68a
H+C	202.25bc	1.30 bc	10.75 b	374.0 b	69.61c
H+A	213.50ab	1.35 ab	11.40 ab	403.00 ab	76.38b
H+B+MCPA	230.0 a	1.40 ab	11.70 a	419.50 a	80.06ab
LSD value	22.60	0.12	0.67	30.45	4.21

PH: Plant height, SD: Stem diameter, FWP: Fresh weight per plant, FY: Fodder yield, NGL: Number of green leaves, WC: Weedy check, HW: Hand weeding, H+C: Helosulfuron + carfentrazone-ethyl, H+A: Helosulfuron + atrazine, H+B+MCPA: Helosulfuron + bromoxynil + MCPA

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