Planta Daninha

Journal of The Brazilian Weed Science Society

<http://www.sbcpd.org>

ISSN 0100-8358 (print)
1806-9681 (online)

Research Article

Optimizing efficacy of acetochlor + atrazine and dicamba at various doses to manage *Conyza stricta* L. in sugarcane

Arif Hussain[a]*, Abdul A. Khakwani[a], Asif Tanveer[b], Ejaz A. Khan[a], Mohammad S. Baloch[a]

[a] Faculty of Agriculture, Gomal University, Dera Ismail Khan, KPK, Pakistan; [b] Faculty of Agriculture, University of Agriculture Faisalabad, Punjab Pakistan.

Article Information

Received: March 6, 2019
Accepted: May 31, 2019

Keywords:
dry weight
persistence index
biological yield
sugarcane

***Corresponding author:**
<marifagronomy@gmail.com>

Cite this article:
Hussain A, Khakwani AA, Tanveer A, Khan EA, Baloch MS. Optimizing efficacy of acetochlor + atrazine and dicamba at various doses to manage *Conyza stricta* L. in sugarcane. Planta Daninha. 2020;38:e020220829.
https://doi.org/10.1590/S0100-83582020380100080

Conflict of Interest:
The authors declare that there is no conflict of interest regarding the publication of this manuscript.

Highlights

- *C. stricta* problem in sugarcane.
- Acetochlor + atrazine and dicamba controlled this weed in sugarcane.
- Increase in sugarcane yield.

Abstract

Background: *Conyza stricta* L. (Horse weed) is an annual problematic weed in an agricultural ecosystem and considerably decreases the crop yield and quality.
Objective: To determine the most effective pre and post emergence herbicides and their dose to control *C. stricta* in sugarcane crop.
Methods: A two years field study comprised of six herbicides treatments along with weedy check and hand weeding. The design of study was RCBD with three replications.
Results: Hand weeding recorded more leaf area index (LAI), crop growth rate (CGR) and net assimilation rate (NAR), biological and stripped yield. However, greater LAI, CGR and NAR, biological and stripped yield were recorded by acetochlor + atrazine at the rate of 2,715 g ha^{-1} (pre emergence) and dicamba at the rate of 466 g ha^{-1} (post emergence). All the treatments produced statistically comparable harvest index except weedy check, which produced less harvest index. Minimum *C. stricta* density and dry weight were recorded for acetochlor + atrazine at the rate of 2,715 g ha^{-1} and dicamba at the rate of 466 g ha^{-1}. Acetochlor + atrazine at the rate of 2,715 g ha^{-1} (pre emergence) and dicamba at the rate of 466 g ha^{-1} (post emergence) gave better *C. stricta* control with high herbicides efficiency index.
Conclusion: Acetochlor + atrazine at the rate of 2,715 g ha^{-1} (pre emergence) or dicamba at the rate of 466 g ha^{-1} (post emergence) may be used for efficient control of *C. stricta* in sugarcane.

1 Introduction

Sugarcane (*Saccharum officinarum* L.) is grown successfully in the tropics and subtropics of the world (Zhao and Li, 2015). In Pakistan, sugarcane is an important cash crop after cotton and it has significant importance for sugar based industries of the country (Anonymous, 2018). It occupies a significant position in national economy of Pakistan by its share in agriculture value addition (3.6%) and gross domestic product (0.7%). In Pakistan, average stripped cane yield (61.7 t h^{-1}) is much lower than world's leading sugarcane growing countries (Anonymous, 2018). Low sugarcane yield and sucrose content have different reasons at farmer's fields especially in developing countries. Costly inputs, unbalance and under dose application of fertilizers (Ehsanullah et al., 2011), insect, pests and diseases (Zafar et al., 2015; Hussain et al., 2018), lacking of irrigation water, imperfect ratoon crop management, less support price and high weed invasion are main reasons of low sugarcane yield (Malik and Gurmani, 2005; Neto et al., 2019).

Weeds are undesirable plants, which considerably affect our agriculture production because of their specific characteristics i.e. they produce large quantity of seed, fast seedlings growth, early maturation, sexual and asexual mode of reproduction and environmental plasticity (Zimdahl, 1999; Kholi et al., 2004). These mentioned characteristics of weeds like high nutrients uptake, allelopathic potential, drought tolerance etc., make weeds more harmful for agriculture. In agro-ecosystem, weeds uptake significant portion of soil moisture, mineral nutrients, intercept solar radiations occupy space and may release allelopathic chemicals (Abbas et al., 2017) that harm the crops and reduce yield of crops (Christoffoleti et al., 2006; Huang et al., 2018; Neto et al., 2019). Sugarcane yield loss due to weeds infestation is about 24 to 52% depending upon the species of weed and their density level (Khan, 2015; Fontenot et al., 2016). Weeds are generally handled by manual, biological, mechanical and chemical methods. Manual weed control is difficult as it consumes more time, weather dependent and bad smell from hands during weeds uprooting. Mechanical weed control can cause injury to crop plants, redistribution of weeds seeds in fields and soil erosion problems (McErlich and Boydston, 2013). Biological weed control has various constraints such as it decreases pest's population very slowly than pesticides or herbicides. Furthermore, it requires specific biological agents at a specific time interval to kill or suppress the specific weed/organism (Bale et al., 2008).

Weed control through chemicals is comparatively more resourceful and reasonable due to entrance of novel chemistry and herbicides (Kahramanoglu and Uygur, 2010; Khan, 2015). Thus, it is important to know and select a compound that is the most effective in controlling weed in sugarcane in order to reduce the operational cost of weed management.

Conyza stricta L. (Horse weed) is an annual weed belongs to *Asteraceae* family (Sunflower family). Many species of *Conyza* are also perennial rarely shrubs, growing to 1-2 m tall. The native area of the weed is warm temperate and tropical regions throughout the world (Paula et al., 2017). This weed has multi-stems near base and these stems are full of long white hairs. Leaves are thin, narrow, stalkless and become further smaller towards the top of plant (Santos et al., 2014; Paula et al., 2017). Inflorescence is branched and nearly 35 cm long and produces pale yellow flowers in September-October on short, thickly hairy pedicels. It competes with crop for nutrient, moisture and space and significantly influences the crop due to its allelopathic potential. Since this weed is usually observed to form thick, dense and almost pure stands, which is logical to think that allelopathy could be involved in the suppression of other plants in the vicinity. Shaukat et al. (2003) tested the allelopathic potential of *Conyza* species (*C. canadensis* L). They reported that *C. canadensis* reduced root and shoot growth of the test crop species to varying degrees and shoot growth was usually influenced to a greater extent than the root growth. The *Conyza* species have a high competency of adaptability, which allows them to exit in various soil and climatic conditions (Santos et al., 2013). *C. bonariensis* caused 25.9% yield reduction soybean (Agostinetto et al., 2017). *C. stricta* has an invasive potential and thought in difficult to control due to resistance to herbicides (Paula et al., 2017). There is little research on *C. stricta* in Pakistan and elsewhere. Therefore, the present research was conducted to determine the most effective pre and post emergence herbicides and their dose to control *C. stricta* in sugarcane crop.

2 Materials and Methods

The experiment was started in experimental area of Department of Agronomy, Faculty of Agriculture, Gomal University, Dera Ismail Khan, Pakistan (31.49° N, 70.54° E and 165 m ASL) during spring season 2014-15 and 2015-16. The trial was designed in randomized complete block design (RCBD) with four replicates. The net plot size was 4.5 m × 8.0 m. The experiment was comprised of six treatments of herbicides combination: H_1 = acetochlor + atrazine at the rate of 905 g a.i. ha^{-1} (Click at the rate of 1,250 mL ha^{-1}) pre-emergence spray, H_2 = acetochlor + atrazine at the rate of 1,810 g a.i. ha^{-1} (Click at the rate of 2,500 mL ha^{-1}) pre-emergence spray, H_3 = acetochlor + atrazine at the rate of 2,715 g a.i. ha^{-1} (Click at the rate of 3,750 mL ha^{-1}) pre-emergence spray, H_4 = dicamba at the rate of 233 g a.i. ha^{-1} (Commit at the rate of 500 mL ha^{-1}) post-emergence spray, H_5 = dicamba at the rate of 349.50 g a.i. ha^{-1} (Commit at the rate of 750 mL ha^{-1}) post-emergence spray and H_6 = dicamba at the rate of 466 g a.i. ha^{-1} (Commit at the rate of 1,000 mL ha^{-1}) post-emergence spray. Control (weedy check) and hand weeding practice were also included.

For good seed bed preparation, two ploughing and four cultivations followed by planking were performed. Sugarcane variety CPF246 was planted in first week of March, 2014 and 2015 applying seed rate of 8 t ha^{-1} by manual hand sowing at 75 cm row spacing. Sugarcane was sown in that field where heavy infestation of *C. stricta* was observed previous year. All the weeds except *C. stricta* were eliminated when they emerged during experiment. Moreover, *C. stricta* plants more than set density levels were also pulled out during study. The recommended doses of nitrogen, phosphorus and potash at the rate of 170-110-110 NPK kg ha^{-1} were applied, respectively. All the phosphorus, potash and 1/3 quantity of nitrogen were used during crop sowing while remaining dose of nitrogen was used in to 2 equal portions; at germination completion and tillering. Irrigations were given according to crop requirement by tube well. Crop reached to cut out stage on 15th (2015) and 23th December (2016).

Growth, agronomic, yield and sugar related parameters of sugarcane were recorded during study. For leaf area, randomly five plants were selected and their leaf area was noted by following the method of Hunt (1978) and then changed into LAI. For crop growth rate (g m^{-2} day^{-1}), 10 plants were randomly harvested from each plot and chopped into small pieces dried at 80 °C. CGR was noted by method of Hunt (1978). Net assimilation rate (g m^{-2} day^{-1}) was also calculated by following method of Hunt (1978). Sugarcane length (cm) was noted at crop harvesting time, 10 sugarcane plants were chosen indiscriminately from every plot of each replication and their height was measure with a meter rod then averaged.

Number of millable canes at time of harvest (m^{-2}) was recorded. Millable cane means cane whose trash and top has been removed and it has gained usual length and girth. At harvest, 1 meter^{-2} was chosen indiscriminately from each plot and millable canes were noted. Cane girth (cm) was measured from bottom, mid and upper portion of cane using Vernier caliper. For stripped cane yield (t ha^{-1}), unit area was marked randomly and entire millable canes were weighed. Harvest index (%) was also calculated by dividing stripped cane yield over unstrapped or biological yield. To measure brix (%), 10 plants were harvested randomly from each plots and chopped, their juice was extracted and packed in glass tubes. Using Brix hydrometer, the readings of juices were observed. Schmitz's table (Meade, 1996) was used to correct observed values of brix.

Total sugar (t ha^{-1}) was measured as:

$$\frac{\text{Stripped cane yield (t ha}^{-1}\text{)}}{\text{Pol \%} \times 100}$$

Density, dry weight of *C. stricta* (m^{-2}) and herbicides related parameters were also recorded. At 30 days after herbicides application and at sugarcane harvesting, density of *C. stricta* plants were counted from a unit area (0.5 m × 0.5 m) randomly selected from three places of each plots and then averaged. For dry weight (g), *C. stricta* plants were removed from 0.5 meter^{-2} of each plot of a replication near ground surface, chopped and sun dried. After sun-drying, weed plants were placed in the oven at 80 °C and then dry weight was recorded.

Percent *C. stricta* control over weedy check (%) was calculated as.

$$\text{Percent control} = \frac{\text{W weedy check - W treatment}}{\text{W weedy check}} \times 100$$

where W-weedy check means fresh or dry mass of plants noted in weedy check plots. W-treatment shows fresh or dry mass of plants from herbicide applied plots.

Weed persistence index (WPI) was recorded by following Misra and Misra (1997):

$$\frac{\text{Dry matter of weed in treated plot}}{\text{Dry matter of weed in control plot}} \times \frac{\text{Weed count in control plot}}{\text{Weed count in treated plot}}$$

Similarly, herbicide efficiency index (HEI) was also recorded by following Misra and Misra (1997) as given below:

$$\text{Herbicide efficiency index} = \left(\frac{YT - YC}{YC} \times 100\right) \Big/ \left(\frac{DMT}{DMC} \times 100\right)$$

where YT mean yield gained from herbicide treated plants whereas YC exhibits yield gained from control plants while DMT indicates dry matter given by treated plants while DMC denotes dry matter produced by control plants.

3 Results and Discussion

3.1 Effect of pre and post emergence herbicides on the growth and yield components of sugarcane

Different pre (acetochlor + atrazine) and post emergence (dicamba) herbicides greatly improved the growth, yield and yield components of sugarcane crop during both years of years study (Table 1). Outcomes showed that maximum leaf area index (LAI), crop growth rate (CGR) and net assimilation rate (NAR) of sugarcane were recorded in hand weeding practice while the lowest values were observed in weedy check plots (control). Among different herbicides, pre-emergence herbicide, acetochlor + atrazine at the rate of 2,715 g ha^{-1} and post emergence (dicamba at the rate of 466 g ha^{-1}) significantly improved LAI, CGR and NAR followed by acetochlor + atrazine at the rate of 1,810 g ha^{-1} and dicamba at the rate of 349.50 g ha^{-1}. While acetochlor + atrazine at the rate of 905 g ha^{-1} and dicamba at the rate of 233 g ha^{-1} recorded less LAI, CGR and NAR during both years of study (Table 1).

Sugarcane plots where *C. stricta* was controlled through hand weeding produced greater biological, stripped cane yield and total sugar followed by acetochlor + atrazine at the rate of 2,715 g ha^{-1} (pre emergence) and dicamba at the rate of 466 g ha^{-1} (post emergence) during both experimental years (Table 2). Overall, less biological, cane yield and total sugar production was noted in weedy check sugarcane plots followed by acetochlor + atrazine at the rate of 905 g ha^{-1}. Results regarding harvest index depicted that all the herbicide treatments produced similar harvest index except weedy check plots, which had significantly less harvest index (Table 2). While pre and post emergence herbicides did not affect brix and commercial cane sugar contents of sugarcane during experiments.

3.2 Efficacy of pre and post emergence herbicides to control *C. stricta*

Acetochlor + atrazine at the rate of 2,715 g ha^{-1} (pre emergence) significantly reduced *C. stricta* density followed by dicamba at the rate 466 g ha^{-1} (post emergence) at 30 days after spray compared to

Table 1 - Effect of pre and post emergence herbicides on leaf area index, crop growth rate, net assimilation rate, cane length, millable canes and cane girth

Treatment	Leaf area index		Crop growth rate (g m^{-2} day^{-1})		Net assimilation (g m^{-2} day^{-1})		Cane length (cm)		Millable canes (m^{-2})		Cane girth (cm)	
	2014-15	2015-16	2014-15	2015-16	2014-15	2014-15	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
H_1	6.2 d	6.3 d	7.9 d	8.1 d	1.7 c	1.9 c	201c	205 d	9.2e	9.8 d	7.0 e	7.1 c
H_2	6.8 c	6.8 c	8.6 c	8.9 c	2.0 b	2.1 b	221 bc	222 c	10.2c	10.8 c	7.7 c	7.7 b
H_3	7.2 b	7.3 b	9.1 b	9.4 b	2.1 a	2.2 a	234 ab	238 b	10.7b	11.4 b	8.1 b	8.2 a
H_4	6.5 c	6.6 cd	8.3 c	8.5 c	2.0 b	2.0 bc	212 bc	218 c	9.7d	10.4 c	7.4 d	7.4 bc
H_5	6.8 c	6.9 c	8.6 c	8.8 c	2.0 b	2.1 b	219 bc	223c	10.1c	10.7 c	7.6 c	7.7 b
H_6	7.2 b	7.3 ab	9.1 b	9.4 b	2.1 a	2.2 a	234 ab	239 b	10.8b	11.4 b	8.2 b	8.2 a
H_7	3.4 e	3.5 e	4.2 e	4.4 e	0.9 d	1.0 d	107 d	111e	4.7f	5.3 e	3.6 f	3.8 d
H_8	7.5 a	7.6 a	9.6 a	9.9 a	2.2 a	2.3 a	245 a	250 a	11.2a	12.0 a	8.5 a	8.5 a
LSD	0.31	0.33	0.39	0.41	0.12	0.11	22.60	10.46	0.28	0.52	0.23	0.34

There is significant variation among means of two columns at P 0.05 having different letters.
T_1 = Acetochlor + Atrazine at the rate of 905 g ha^{-1}, T_2 = Acetochlor + Atrazine at the rate of 1,810 g ha^{-1}, T_3 = Acetochlor + Atrazine at the rate of 2,715 g ha^{-1}, T_4 = Dicamba at the rate of 233 g ha^{-1}, T_5 = Dicamba at the rate of 349.50 g ha^{-1}, T_6 = Dicamba at the rate of 466 g ha^{-1}.

Table 2 - Effect of pre and post emergence herbicides on biological yield, stripped cane yield, total sugar, harvest index, brix and commercial cane sugar

Treatment	Biological yield (t ha^{-1})		Stripped can yield (t ha^{-1})		Total sugar (t ha^{-1})		Harvest index (%)		Brix (%)		Commercial cane sugar (%)	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
H_1	96.3 e	97.6 e	74.7 e	76.7 e	9.4 d	9.9 e	77.5 a	78.6 a	20.0	20.0	11.7	11.8
H_2	105.9 c	106.9 c	82.6 c	84.4 c	10.4 c	10.9 c	78.0 a	78.9 a	20.0	20.1	11.7	11.8
H_3	111.7 b	113.1 b	88.3 b	89.0 b	11.0 b	11.5 b	78.0 a	78.7 a	19.9	20.0	11.6	11.8
H_4	101.2 d	102.4 d	79.1 d	80.6 d	10.0 c	10.5 d	78.1 a	78.7 a	19.9	20.0	11.6	11.7
H_5	105.1 c	106.5 c	81.8 cd	83.7 c	10.3 c	10.8 c	77.8 a	78.6 a	20.0	19.7	11.7	11.5
H_6	111.8 b	113.2 b	88.4 b	89.1 b	11.0 b	11.6 b	79.0 a	78.7 a	20.2	20.2	11.8	11.8
H_7	50.7 f	49.7 f	37.7 f	38.2 f	5.1 e	4.9 f	74.4 b	76.8 b	19.9	20.0	11.6	11.6
H_8	117.0 a	117.7 a	92.2 a	93.2 a	11.5 a	12.1 a	78.8 a	79.1 a	20.2	20.2	11.8	11.9
LSD	3.04	3.32	2.94	2.41	0.48	0.30	1.86	1.06	Ns	Ns	ns	ns

There is significant variation among means of two columns at P 0.05 having different letters.
T_1 = Acetochlor + Atrazine at the rate of 905 g ha^{-1}, T_2 = Acetochlor + Atrazine at the rate of 1,810 g ha^{-1}, T_3 = Acetochlor + Atrazine at the rate of 2,715 g ha^{-1}, T_4 = Dicamba at the rate of 233 g ha^{-1}, T_5 = Dicamba at the rate of 349.50 g ha^{-1}, T_6 = Dicamba at the rate of 466 g ha^{-1}.

other herbicide treatments (Table 3). Alike, *C. stricta* density at crop harvesting was also less in acetochlor + atrazine at the rate of 2,715 g ha^{-1} and dicamba at the rate of 466 g ha^{-1} treated plots while more *C. stricta* density was recorded where acetochlor + atrazine at the rate of 905 g ha^{-1} and dicamba at the rate of 233 g ha^{1} were used (Table 3). Similar, trend was also observed in dry weight of *C. stricta*. More dry weight of *C. stricta* at 30 days after spray was depicted in weedy check plots while significantly less in acetochlor + atrazine at the rate of 2,715 g ha^{-1} and dicamba at the rate of 466 g ha^{-1} treated plots (Table 3). Whereas in case of herbicides treated plots, more dry weight was recorded where acetochlor + atrazine at the rate of 905 g ha^{-1} and dicamba at the rate of 233 g ha^{-1} were applied during both experimental years (Table 3).

Hand weeding practice gave 100% control of *C. stricta* while among herbicides, acetochlor + atrazine at the rate of 2,715 g ha^{-1} (pre emergence) and dicamba at the rate of 466 g ha^{-1} (post emergence) showed 86% *C. stricta* control. However, acetochlor + atrazine at the rate of 1,810 g ha^{-1} also showed comparable weed control to acetochlor + atrazine at the rate of 2,715 g ha^{-1} and dicamba at the rate of 466 g ha^{-1} during 2015-16 (Table 3). While, less *C. stricta* control was recorded for acetochlor + atrazine at the rate of 905 g ha^{-1} and dicamba at the rate of 233 g ha^{-1} (Table 3). Data discloses that maximum herbicide efficiency index was noted in acetochlor + atrazine at the rate of 2,715 g ha^{-1} (pre-emergence) and dicamba at the rate of 466 g ha^{-1} (post emergence). Least herbicide efficiency index was recorded for acetochlor + atrazine at the rate of 905 g ha^{-1} whereas less herbicide efficiency index was noted for acetochlor + atrazine at the rate of 905 g ha^{-1} during both years of study (Table 3). High value for weed persistence index was observed in acetochlor + atrazine at the rate of 1,810 g ha^{-1} and then by dicamba at the rate of 349.50 g ha^{-1} while least herbicide persistence index was noted in acetochlor + atrazine at the rate of 2,715 g ha^{-1} and dicamba at the rate of 466 g ha^{-1} (Table 3).

Herbicides decreased weeds density and their dry weight. As a consequence, sugarcane plants produced larger leaves, secured more growth rate as their resource capturing competitors (weeds) were suppressed effectively by herbicides. Our outcomes support the results of Khaliq et al. (2013 and 2014) who documented that different herbicides decreased weed growth effectively and improved LAI of wheat of plants. Likewise, Mehmood et al. (2013) used different herbicides in corn to manage weeds. They reported minimum weed growth in sprayed plots. They recorded maximum LAI of corn where herbicides were used. Alike, Hassan et al. (2010) reported that herbicides significantly increased crop growth due to suppression of weeds. It was noted that sugarcane length and number of millable canes greatly increased by hand weeding practice compared to all other treatments while minimum all these traits were observed in weedy check (control) plots. However; among various herbicides, acetochlor + atrazine at the rate of 2,715 g ha^{-1} (pre-emergence) and dicamba at the rate of 466 g ha^{-1} (post emergence) considerably enhanced length of sugarcane, number of millable canes, girth of canes (Table 1). *C. stricta* infested sugarcane plots showed minimum plant height and length of sugarcane due to severe competition by *C. stricta* with sugarcane. These results are in line with findings of Sundararajan et al. (1991) who compared oxyfluorfen 100-500 g ha^{-1} with two hands weeding along with weedy check plots.

Table 3 - Effect of pre and post emergence herbicides on density, dry weight of *C. stricta*, percent *C. stricta* control over weedy check, herbicides efficiency index and herbicides persistence index

Treatment	*C. stricta* density 30 days after spray (m^{-2})		*C. stricta* density at crop harvest (m^{-2})		Dry weight at 30 days after spray (m^{-2})		Percent *C. stricta* control over weedy check (%)		Herbicides efficiency index		Herbicides persistence index	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
H_1	4.3 b	4.0 b	4.3 b	4.0 b	22.6 b	20.3 b	59.9 d	74.2 d	2.4 c	2.8 c	1.4 bc	1.5 bc
H_2	2.6 c	2.6 c	1.6 d	2.3 cd	12.6 c	13.3 c	62.6 c	84.9 c	3.2 b	3.3 b	3.6 a	3.3 a
H_3	2.0 c	2.3 c	1.0 d	1.3 d	8.3 d	8.6 c	86.0 b	90.9 b	9.6 a	9.7 a	1.0 c	1.1 c
H_4	4.0 b	4.3 b	4.0 b	4.0 b	21.9 b	21.6 b	59.9 d	76.0 d	2.7 bc	2.8 bc	1.5 bc	1.6 bc
H_5	2.5 c	2.6 c	2.6 c	2.6 c	12.8 c	13.3 c	61.7 cd	84.6 c	3.1 bc	3.3 bc	2.6 ab	2.6 ab
H_6	2.0 c	2.2 c	1.0 d	1.6 d	8.3 d	8.7 d	86 b	86 bc	9.6 a	9.7 a	1.0 c	1.0 c
H_7	16 a	16. a	16 a	16 a	79.0 a	80.0 a	100 a	100 a	-	-	-	-
H_8	0.0 d	0.0 d	0.0 e	0.0 e	0.00 e	0.00 d	-	-	-	-	-	-
LSD	1.20	1.32	0.94	0.84	2.76	2.80	2.60	4.44	0.61	0.65	1.35	1.33

There is significant variation among means of two columns at P 0.05 having different letters.
T_1 = Acetochlor + Atrazine at the rate of 905 g ha^{-1}, T_2 = Acetochlor + Atrazine at the rate of 1,810 g ha^{-1}, T_3 = Acetochlor + Atrazine at the rate of 2,715 g ha^{-1}, T_4 = Dicamba at the rate of 233 g ha^{-1}, T_5 = Dicamba at the rate of 349.50 g ha^{-1}, T_6 = Dicamba at the rate of 466 g ha^{-1}.

They noted greater length of sugarcane in herbicide sprayed plots compared to weedy check plots. Similarly, Kaur et al. (2015) reported an improvement in plant height/length of cane where herbicides were used. Due to more number of leaves and leaf area, there was an improvement in number of tillers and millable canes because of better solar radiation interception by leaves. Similar results were reported by Zafar et al. (2010) and Buragohain (1993) who reported greatest millable canes and sugarcane yield where herbicides (atrazine etc.) were applied. Zafar et al. (2010) and Millhollon (1993) depicted that weed severely reduced girth and diameter of sugarcane.

Higher biological, sugarcane yield and total sugar production from herbicides applied plots might be due to better control of *C. stricta* density, which resulted in ease of access of more plant mineral nutrients, moisture, etc. to sugarcanes plants. In other hand, more *C. stricta* biomass in weedy check plots exhibited dangerous effects and competed severely with sugarcane plants. As a result, sugarcane growth decreased and ended with lower yield (Jain et al., 2006; Walia and Brar, 2006). Similar outcomes were also depicted by Rahman et al. (1989) who recorded highest suagrcane yield in gizapex combi, stomp and tribunil applied plots compared to weedy check. Zafar et al. (2010) also noted maximum sugarcane yield, stripped yield and total sugar production where weeds were controlled through herbicides. Harvest index shows the biological competency of plants to send photo-assimilates towards their economic parts. Thus lower harvest index indicates that weed infested with plant and caused poor photo-assimilates translocation to words economic parts of plant. Similar results are also mentioned by Zafar et al. (2010) who recorded maximum HI in sugarcane where herbicides were used. Herbicides did not influence the brix and sucrose content of sugarcane and these results are with Sinha et al. (1990) who also reported non-significant effect of herbicides on sucrose % in sugarcane.

Results showed that acetochlor + atrazine at the rate of 2,715 g ha^{-1} (pre emergence) and dicamba at the rate of 466 g ha^{-1} (post emergence) herbicides significantly reduced the density and dry weight of *C. stricta*. These results are in line with Alam (2000) who noted that various combination of herbicides declined fresh mass and dry weight of *C. stricta*. Similarly, Masood (2000) found that application of gizapex reduced branches, leaves, fresh and dry weight of *C. stricta* plants. Honyal and Yandagoudar (1999) reported that herbicide (atrazine) exhibited least weed number and dry mass at harvest. Chauhan and Singh (1993) revealed that all the treatments decreased fresh and dry weight of weeds. Alike, Das and Borthakur (1991) compared gramoxone, atrazine, atrazine + 2, 4-D, atrazine + dicamba, 2,4-0, saturn and taurus for weed control in sugarcane. All the herbicides reduced weeds infestation but atrazine + dicamba gave the best weed control (73, 36%) and highest sugarcane yields. Johari and Singh (1991) reported that herbicides decreased dry weight of weeds and improved number of millable canes. Mehra et al. (1995) reported better weed control in sugarcane through application of herbicides. Shali et al. (1994) reported 75%, 70%, 40% and 17% weed control for gesapax combi 80 WP, Basta 205 L and U- 46-0 fluid, respectively.

Higher value for herbicide efficiency index in acetochlor + atrazine at the rate of 2,715 g ha^{-1} and dicamba at the rate of 466 g ha^{-1} is most likely because of efficiency of herbicides against *C. stricta* than other combination of herbicides. Our results corroborate the findings of Millhollon (1993) who reported that mixture of pendimethalin with metribuzin or terbacil gave more herbicide efficiency index. Alike, Khaliq et al. (2011) documented 94% herbicide efficiency index. Similarly in another study of Khaliq et al. (2014) where they accounted least weed persistence index for iodosulfuron + mesosulfuron methyl.

4 Conclusions

Study conclusion shows that pre-emergence (acetochlor + atrazine) and post emergence dicamba) herbicides recorded better control of *C. stricta* L. in sugarcane. The herbicide acetochlor + atrazine at the rate of 2,715 g ha^{-1} (pre-emergence) and dicamba at the rate of 466 g ha^{-1} (post emergence) decreased maximum density of *C. stricta*, its dry weight and improved sugarcane growth and final sugarcane yield. Thus, application of acetochlor + atrazine at the rate of 2,715 g ha^{-1} (pre-emergence) and/or dicamba at the rate of 466 g ha^{-1} (post emergence) can be used for *C. stricta* control in sugarcane under agro-ecological conditions of D.I. Khan, Pakistan.

5 Contributions

AH: conceived the idea, conducted the research and prepared the draft. AAK: planned and supervised the research and experiments. AT: co-supervised the research. EAK: guided during writing of manuscript. MSB: gave valuable suggestions how to record the observations and data during experimentation.

6 ACKNOWLEDGEMENTS

Authors acknowledge the Gomal University, Dera Ismail Khan, KPK, Pakistan.

7 REFERENCES

Abbas T, Nadeem MA, Tanveer A, Syed S, Zohaib A, Farooq N, et al. Allelopathic influence of aquatic weeds on agro-ecosystems: a review. Planta Daninha. 2017;35:e017163146.

Agostinetto D, Silva DRO, Vargas L. Soybean yield loss and economic thresholds due to glyphosate resistant hairy fleabane interference. Arq Instit Biol. 2017;84:1-8,e0022017.

Alam M. Comparative study of different materials to control *Conyze stricte* weed in sugarcane crop. [thesis]. I. Khan: Gomal University; 2000. p.31-35.

Anonymous. Pakistan economic survey. Economic advisor's wing, finance division. Islamabad: Government of Pakistan; 2018. p.89-92.

Bale SJ, Goodman K, Rochelle PA, Marchesi JR, Fry JC, Weightman AJ, et al. Desulfovibrio profundus barophilic sulfate-reducing bacterium from deep sediment layers in the Japan Sea. Int J Syst Bact. 2008;47:515-21.

Buragohain SKR. Integrated weed management in spring planted sugarcane. Coop Sugar. 1993;25(1-2):39-40.

Chauhan RS, Singh G. Integrated weed management in spring planted sugarcane. Indian Soc Weed Sci. 1993;3:188-91.

Christoffoleti PJ, Borges A, Nicolai M, Carvalho SJP, López-Ovejero RF, Monquero PA. Carfentrazone-ethyl applied in post -emergence to control *Ipomoea* spp. and *Commelina benghalensis* is in sugarcane crop. Planta Daninha. 2006;24(1):83-90.

Das TK, Borthakur. The effects of combining modified sowing methods with herbicide mixtures on weed interference in wheat crops. Int J Pest Manag. 1991;52:314-21.

Ehsanullah, Jabran K, Jamil M, Ghaffar A. Optimizing the sugarcane row spacing and seeding density to improve its yield and quality. Crop Envir. 2011;2:1-5.

Fontenot DP, Griffin JL, Bauerle MJ. Bermudagrass (*Cynodon dactylon*) competition with sugarcane at planting. J Am Soc Sugar Cane Technol. 2016;36:19-30.

Hassan G, Tanveer S, Khan N, Munir M. Integrating cultivars with reduced herbicides rates for weed management in *Zea mays*. Pak J Bot. 2010;42:1923-9.

Honyal SC, Yandagoudar BA. Studies on yield and growth parameters of sugarcane as influenced by application of herbicides for weed control. J Maharashtra Agric Univ. 1999;24(1):86-7.

Huang YK, Li WF, Zhang RY, Wang XY. Color illustration of diagnosis and control for modern sugarcane diseases, pests, and weeds. 1st ed. Springer: Singapore; 2018. p.420.

Hunt R. Plant growth analysis. UK: Edward Arnold; 1978. p.26-38.

Hussain S, Khaliq A, Mehmood U, Qadir T, Saqib M, Iqbal AM, et al. Sugarcane production under changing climate: effects of environmental vulnerabilities on sugarcane diseases, insects and weeds. [Online First], IntechOpen, 2018. DOI: 10.5772/intechopen.81131.

Jain N, Mishra JS, Kewat ML, Jain V. Effect of tillage and herbicides on weed seed bank dynamics in wheat (*Triticum aestivum*) under transplanted rice-wheat system. Ind J Weed Sci. 2006;38:112-14.

Johari D, Singh G. Chemical weed control in spring planted Sugarcane. Bhamitiya Sugar. 1991;16(7):51-5.

Kahramanoglu I, Uygur FN. The effects of reduced doses and application timing of metribuzin on redroot pigweed (*Amaranthus retroflexus* L.) and wild mustard (*Sinapis arvensis* L.). Turk J Agric Forestry. 2010;34:467-74.

Kaur T, Kaur S, Bhullar MS. Testing of new brand formulations of sulfonylurea herbicides for control of mixed weed flora in wheat. J Krishi Vigyan. 2015;4:5-9.

Khaliq A, Gondal MR, Matloob A, Ullah E, Hussain S, Murtaza G. Chemical weed control in wheat under different rice residue management options. Pak J Weed Sci Res. 2013;19:1-14.

Khaliq A, Hussain M, Matloob A, Tanveer A. Weed growth, herbicide efficacy indices, crop growth and yield of wheat are modified by herbicide and cultivar interaction. Pak J Weed Sci Res. 2014;20(1):91-109.

Khaliq A, Matloob A, Tanveer A. Reduced doses of a sulfonylurea herbicide for weed management in wheat fields of Punjab, Pakistan. Chilean J Agric Res. 2011;71:424-9.

Khan MZ. Weeds and weed control methods in sugarcane: a case study of Khyber Pakhtunkhwa Pakistan. Pak J Weed Sci. 2015;21:217-28.

Kholi RK, Singh HP, Batish DR. Allelopathy in agroecosystems. New York: Food Products Press; 2004.

Malik KB, Gurmani MH. Cane production guide. Dewan City, District Thatta, Sind Pakistan: Dewan Farooque Sugarcane Research Institute; 2005. p.38-41.

Masood S. Comparative study of different chemicals to control *Conyza stricta* weed in sugarcane crop. MSc. (Hons.) [thesis]. D. I. Khan: Gomal University; 2000. p.35-9.

McErlich AF, Boydston RA. Current state of weed management in organic and conventional cropping systems. Lincoln, NE: Agricultural Research Service; 2013.

Meade JA. Growth and development of yellow foxtail and giant foxtail. [S.l. : s.n.]; 1996. p.139-42.

Mehmood A, Iqbal J, Chattha MB, Azhar GA. Evaluation of various herbicides for controlling grassy weeds in wheat. Mycopathology. 2013;11:39-44.

Mehra SP, Brar LS, Sharma KK. Weed management in spring planted sugarcane. J Res. 1995;32(1):1-H8.

Millhollon RW. Pre-emergence control of itch grass and Johnson grass in sugarcane. Weed Sci. 1993;41(4):621-6.

Misra M, Misra A. Estimation of IPM index in jute, a new approach. Indian J Weed Sci. 1997;29:39-42.

Neto CDG, Sanches IDA, Neves AK, Prudente BHR, Körting TS, Picoli MCA, et al. Assessment of texture features for Bermuda grass (*Cynodon dactylon*) detection in sugarcane plantations. Drones. 2019;3(2):36. Avaiable at: https://doi.org/10.3390/drones3020036

Paula JM, Pinto-Maglio, CAF, Pinto, LR. Morphological analysis and DNA methylation in *Conyza bonariensis* L. cronquist (Asteraceae) phenotypes. Bragantia. 2017;76(4):480-91.

Rahman HU, Zada K, Rahman S, Khan GS. Weed control in sugarcane. Pak J Weed Sci Res. 1989;2:20-8.

Santos G, Francischini AC, Blainski E, Gemelli A, Machado MFPS. Aspectos da biologia e da germinação da buva. In: Constantin J, Oliveira Junior RS, Oliveira Neto AM, editores. Buva: fundamentos e recomendações para manejo. Curitiba: Omnipax; 2013. p.11-26.

Santos G, Junior O, Constantin RS, Francischini J, Osipe JB. Multiple resistance of *Conyza sumatrensis* to chlorimuron-ethyl and to glyphosate. Weed. 2014;32:409-16.

Shali M, Afghan S, Shah M, Mahmood. Screening of herbicides for weeds in sugarcane at post-emergence stage. Pak Sugar J. 1994;8(1):9-12.

Shaukat SS, Munir N, Siddiqui IA. Allelopathic responses of *Conyza canadensis* (L.) Cronquist: a cosmopolitan weed. Asian J Plant Sci. 2003;2(14):1034-9.

Sinha UP, Sinha SS, Choub HN, Kumar S. Studies on cultural and chemical methods of weed control in sugarcane. Bharathya Sugar. 1990;16:17-20.

Sundararajan R, Tomilselvan S, Valliapran T. Bio efficacy and residue of oxyfluorfen in sugarcane. Indian J Agric Sci. 1991;61(5):356-8.

Walia US, Brar LS. Effect of tillage and weed management on seed bank of *Phalaris minor* Retz. in wheat under rice-wheat. Ind J Weed Sci. 2006;38:104-7.

Zafar M, Tanveer A, Cheema Z, Ashraf M. Weed-crop competition effects on growth and yield of sugarcane planted using two methods. Pak J Bot. 2010;42:815-23.

Zafar M, Tanveer A, Majeed MA, Safdar ME, Ali HH, Javaid MM. Reducing herbicide dose in sugarcane by application of plant water extract. Herb. 2015;15:1-7.

Zhao D, Li, YR. Climate Change and sugarcane production: potential impact and mitigation strategies. Int J Agron. 2015;ID547386.

Zimdahl RL. Fundamentals of weed science. New York: Academic Press; 1999.