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RESEARCH ARTICLE

Effect of herbicides in managing weeds and on *Gladiolus hybridus* Hort. growth and flowering

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ABSTRACT

An experiment was carried out to evaluate the efficacy of herbicides application in managing weeds and improving the gladiolus *(Gladiolus hybridus* Hort. cv. *Novalux)* growth and flowering. Treatments evaluated include: two doses each of atrazine, metribuzin, butachlor, pendimethalin and two controls, *viz*. weed free and weedy. All herbicide treatments significantly (p=0.05) affected the *G. hybridus* plant growth, flowering and associated weeds growth. Butachlor 1.0 kg/ha pre-emergence application (PE) recorded significantly greater plant height (90.23 cm), number of florets (12.46) while weed free control recorded significantly maximum spike length (60.64 cm) and floret size (7.58 cm). Metribuzin 0.25 kg/ha PE was at par with these treatments. All herbicide treatments caused significant reduction in weed density. Weed free control and metribuzin 0.25 kg/ha PE were most effective in reducing weed density, fresh and dry weed biomass with highest weed control efficiency and weed control index. Metribuzin at 0.25 kg/ha PE could be recommended for controlling the weeds and improving growth and flowering of *Gladiolus hybridus* cv. *Novalux.*

Key words: *Gladiolus hybridus* Hort., Herbicides, Metribuzin, Weed management

INTRODUCTION

Gladiolus (*Gladiolus hybridus* Hort.), known for its elegant spikes of different shapes and hues with excellent vase life is one of the most beautiful bulbous cut flowers in the floriculture industry and occupies fifth position in the international floriculture trade (Butt *et al.* 2015). Weeds are major constraints to the crop production as they directly affect crop growth and yield by competing for the essential growth resources or by releasing allelopathic substances which even results in crop failure (Pereira *et al.* 2011, Kumar *et al.* 2012, Rao *et al.* 2014). Weed control is difficult in Gladiolus as it is grown for cut flowers and corm production. Generally, 4-5 manual weedings are required in gladiolus cultivation which increases costly labour employment and increased cost of cultivation and moreover if not done properly may damage plants and corms. Hence resorting to chemical control would be ideal (Kumar *et al.* 2012.). Herbicides are economical, convenient and efficient in eradicating weeds and are considered viable option as they provide effective weed control without any phytotoxic effect on gladiolus (Leghari 2015; Queiroz *et al.* 2016) and with an enhancement in growth, flowering and production of corms (Swaroop *et al.* 2017). The herbicides like atrazine and metribuzin are found among the most widely used worldwide (Sattin *et al.* 1995) for effective weed control. The other herbicide like butachlor and pendimethalin are broad spectrum with low toxicity and soil persistence. These herbicides are selected for the present study because most of the weeds occurring in gladiolus field are broad-leaved weeds, hence these weedicides have broad spectrum and low toxicity. Thus, considering the above facts, the present study was undertaken to evaluate the effectiveness of different herbicides for manging weeds and to assess their effect on growth and production of *Gladiolus hybridus* cv. *Novalux*.

MATERIALS AND METHODS

The experiment was conducted during 2017-19 at Department of Floriculture and Landscaping, Punjab Agricultural University, Ludhiana. The weather data with maximum and minimum average temperature, rainfall and RH for the two years has been given in **Table 1**. The experiment consisted of ten treatments: pre-emergence application (PE) of atrazine at 1.0 and 1.5 kg/ha; metribuzin at 0.25 and 0.50 kg/ha PE; butachlor at 1.0 and 1.5 kg/ha PE; pendimethalin 0.75 and 1.0 kg/ha PE; weed free and weedy control. The corms of uniform size were planted during October and pre-emergence

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Table 1. Monthly meteorological data during the crop season 2017-2019 at PAU, Ludhiana

Months	Average temperature (^{0}C)	Relative Humidity (%)	Rainfall (mm)
September, 2017	29.89	29.6	0.0
October, 2017	25.66	26.1	0.0
November, 2017	20.12	20.5	0.0
December, 2017	14.47	16.3	0.0
January, 2018	12.5	75	18.4
February, 2018	16.0	64	27
March, 2018	21.6	61	0
April, 2018	27.8	43	10
September, 2018	28.0	75	250.6
October, 2018	24.2	64	0
November, 2018	19.3	63	2.6
December, 2018	13.9	68	0
January, 2019	12.3	70	66
February, 2019	14.7	75	95.6
March, 2019	18.6	67	7.4

herbicides were applied within 72 hours after planting the corms using sprayer fitted nozzle with working pressure of 30 psi using 600 liter of water per hectare. All cultural operations were followed as per standard package of practices. All treated plots were kept free of manual weeding except in weed free control, where weekly manual weeding was carried out.

The experiment was laid out in randomized block design (RBD) with three replications. At 60 days after planting (DAP) sampling was done using a quadrat of 50 × 50 cm placed randomly at two places in each plot to determine the weed density and fresh weight (fresh biomass) of different weeds. Weeds dry biomass was recorded by weighing after drying the weed samples at 60°C for 48 hours. The plant growth and floral parameters, corm yield, weed density and weed indices were recorded for two years and was analyzed statistically through ANOVA test (Steel *et al.* 1997) by CPCS1 software in which year was used as fixed factor and critical differences were worked out at five percent level. The pooled data was also statistically analyzed with two years considered as replications. Weed control efficiency and weed control index was worked out by using following formula (Mani *et al.* 1973, Mishra and Tosh 1979).

$$\text{Weed control efficiency} = \frac{\text{Weed density in control} - \text{Weed density in treated plot}}{\text{Weed density in control}} \times 100$$

$$\text{Weed control index} = \frac{\text{Weed biomass in control} - \text{Weed biomass in treated plot}}{\text{Weed biomass in control}} \times 100$$

RESULTS AND DISCUSSION

Gladiolus growth

The application of butachlor at 1.0 kg/ha PE resulted in significantly highest plant height (90.23 cm) which was at par with metribuzin at 0.25 k/ha and 0.5 kg/ha PE (88.60 and 87.97 cm) in pooled data of two years. (**Table 2**). Significantly lowest plant height was observed with atrazine at 1.0 kg/ha and 1.5 kg/ha PE (71.54 and 72.13 cm). The earliest flowering was recorded with butachlor at 1.5 kg/ha PE (107.88 days) which was significantly different from other treatments. The longest time to flowering was recorded with metribuzin at 0.25 kg/ha PE (113.50 days) which was at par with herbicidal treatments (**Table 2**). These results of delay in flowering with application of metribuzin are in conformity with earlier reports (Dhakar *et al.* 2016).

Gladiolus flowering and corm yield

The gladiolus floral characters and corm yield were significantly affected by herbicide treatments (**Table 2**). Significantly highest spike length was recorded in weed free control (60.64 cm) followed by butachlor 1.0 kg/ha PE (59.75 cm) and metribuzin 0.25 kg/ha PE (58.92 cm) which were at par amongst them. The minimum spike length was recorded with

Table 2. Effect of different treatments on plant growth and flowering parameters of gladiolus cv. *Novalux*

Treatment	Plant height (cm)			No. of leaves per plant			Days to flowering			Flowering duration (days)		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Atrazine 1.0 kg/ha PE	71.03	72.06	71.54	7.43	9.00	8.21	111.48	110.82	111.15	14.81	14.50	14.65
Atrazine 1.5 kg/ha PE	71.60	72.67	72.13	7.30	9.00	8.15	113.46	112.26	112.86	13.60	14.27	13.93
Metribuzin 0.25 kg/ha PE	87.20	90.00	88.60	9.11	9.16	9.13	113.00	113.32	113.16	13.83	15.50	14.66
Metribuzin 0.50 kg/ha PE	86.12	89.83	87.97	9.65	9.33	9.49	114.67	112.33	113.50	13.47	14.14	13.80
Butachlor 1.0 kg /ha PE	91.63	88.83	90.23	9.60	9.00	9.30	112.00	112.65	112.32	14.70	15.00	14.85
Butachlor 1.5 kg /ha PE	76.80	76.33	76.56	8.86	8.33	8.59	107.55	108.22	107.88	12.57	12.77	12.67
Pendimethalin 0.75 kg/ha PE	83.02	85.22	84.12	7.35	8.67	8.01	110.54	110.54	110.54	14.23	14.23	14.23
Pendimethalin 1.00 kg/ha PE	86.28	85.55	85.91	7.13	9.00	8.06	113.23	113.23	113.23	13.57	13.57	13.57
Control (weedy)	81.90	87.45	84.67	7.63	7.67	7.65	111.96	112.63	112.29	14.43	14.04	14.23
Control (weed free)	87.32	83.76	85.54	6.70	8.67	7.68	112.80	112.80	112.80	13.36	15.00	14.18
LSD (p=0.05)	9.37	8.09	4.55	NS	NS	NS	NS	NS	1.55	NS	NS	NS

*NS: Non-significant; PE: Pre-emergence application atrazine at 1.0 kg/ha and 1.5 kg/ha PE (42.55 and 42.86 cm). Metribuzin 0.25 kg/ha PE resulted in significantly highest rachis length (40.52 cm) followed by weed free control (39.32 cm), pendimethalin 1.00 kg/ha PE (39.03 cm) and metribuzin 0.50 kg/ha PE (39.01 cm) which were at par amongst them. The minimum rachis length was observed with atrazine 1.5 kg/ha and 1.0 kg/ha PE (31.23 and 32.34 cm). The highest number of florets per spike were recorded with butachlor 1.0 kg/ha PE (12.46) which was at par with metribuzin 0.50 kg/ha PE (12.19); metribuzin 0.25 kg/ha PE (12.09); pendimethalin 1.00 kg/ha PE (11.60); pendimethalin 0.75 kg/ha PE (10.86) and significantly different from other treatments. The largest floret size was recorded with weed free control (7.58 cm) which was at par with metribuzin 0.25 kg/ha PE (7.38 cm) and differed significantly from other treatments. Atrazine 1.5 kg/ha and 1.0 kg/ha PE resulted in smallest floret size (6.61 and 6.81 cm). The highest number of corms per plant was observed with atrazine 1.5 kg/ha PE (1.77) which was at par with weed free control (1.71) and differed significantly from metribuzin 0.50 kg/ha PE (1.60). The application of metribuzin resulted in reduced weed growth; therefore, the available nutrients were used by the crop which ultimately resulted in improved plant height, spike length, rachis length, and number of floret per spike and floret size with delay in flowering. The shorter plant height, spike length, rachis length and smaller florets observed with weedy control and atrazine was due to higher weed density resulting in greater weed competition (Burud *et al.* 2020).

Effect on weeds

The prominent weed species observed in experimental plots during both the years of study were *Cynodon dactylon, Cyperus rotundus, Parthenium hysterophorus, Chenopodium album, Phalaris minor* and others. Significantly lowest weed density and fresh weed biomass were recorded in metribuzin 0.25 kg/ha PE (95.51); pendimethalin 0.75 kg/ha PE (96.86) and metribuzin 0.50 kg/ha PE (102.06) which were at par amongst them (**Table 4**). The significantly highest weed density was recorded with weedy control (258.36) followed by atrazine 1.5 kg/ha and 1.0 kg/ha PE (187.20 and 157.29). The minimum weed dry biomass and maximum weed control efficiency (WCE) and weed control index (WCI) were recorded with metribuzin 0.25 kg/ha PE

Table 3. Effect of different treatments on floral characteristics and corm yield of gladiolus cv. Novalux

Treatment	Spike length (cm)			Rachis length (cm)			No. of floret/spikes			Floret size (cm)			Corms/corm			Corm diameter (cm)		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Atrazine 1.0 kg/ha PE	41.78	43.33	42.55	31.23	33.46	32.34	9.96	10.00	9.98	6.80	6.83	6.81	1.53	1.42	1.47	4.91	4.84	4.87
Atrazine 1.5 kg/ha PE	40.06	45.67	42.86	29.40	33.06	31.23	9.76	11.00	10.38	6.46	6.76	6.61	1.77	1.77	1.77	4.82	4.95	4.88
Metribuzin 0.25 kg/ha PE	57.85	60.00	58.92	43.00	38.05	40.52	12.35	11.83	12.09	7.42	7.34	7.38	1.54	1.39	1.46	4.87	4.77	4.82
Metribuzin 0.50 kg/ha PE	55.67	58.33	57.00	43.52	34.50	39.01	12.05	12.33	12.19	7.37	7.11	7.24	1.59	1.62	1.60	4.86	4.86	4.86
Butachlor 1.0 kg /ha PE	57.83	61.67	59.75	39.20	36.10	37.65	12.93	12.00	12.46	7.06	7.30	7.18	1.38	1.45	1.41	4.89	4.84	4.86
Butachlor 1.5 kg /ha PE	52.26	58.67	55.46	40.37	29.33	34.85	9.00	9.33	9.16	6.75	7.04	6.89	1.58	1.60	1.59	4.97	4.97	4.97
Pendimethalin 0.75 kg/ha PE	49.42	52.33	50.87	36.00	35.33	35.66	10.86	10.86	10.86	7.14	7.14	7.14	1.35	1.35	1.35	5.00	5.00	5.00
Pendimethalin 1.00 kg/ha PE	56.85	56.85	56.85	41.96	36.11	39.03	11.60	11.60	11.60	7.03	7.07	7.05	1.53	1.55	1.54	5.38	5.40	5.39
Control (weedy)	54.33	58.01	56.17	35.50	34.23	34.86	7.83	10.00	8.91	7.34	7.25	7.29	1.48	1.58	1.53	5.61	5.24	5.42
Control (weed free)	59.96	61.33	60.64	43.37	35.27	39.32	8.84	11.00	9.92	7.50	7.66	7.58	1.76	1.67	1.71	4.86	5.36	5.11
LSD (p=0.05)	11.21	10.32	3.11	NS	NS	1.68	2.45	2.44	1.68	NS	NS	0.29	NS	NS	0.12	NS	NS	0.34

*NS = non-significant

Table 4. Effect of different treatments on weeds in gladiolus cv. Novalux

Treatment	Weed density (no./m^2)			Weed fresh biomass (g/m^2)			Weed dry biomass (g/m^2)			WCE (%)	WCI (%)
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	Pooled	Pooled
Atrazine 1.0 kg/ha	164.33	150.26	157.29	44.67	76.00	60.33	25.35	38.23	31.79	39.10	77.20
Atrazine 1.5 kg/ha	203.88	170.53	187.20	91.00	87.33	89.16	26.00	39.21	32.60	27.50	76.83
Metribuzin 0.25 kg/ha	96.33	94.70	95.51	49.36	47.44	48.40	24.00	23.60	23.80	63.09	83.51
Metribuzin 0.50 kg/ha	100.20	103.93	102.06	52.00	70.33	61.16	22.50	25.93	24.21	60.49	83.06
Butachlor 1.0 kg/ha	118.30	97.93	108.11	198.33	95.00	146.66	59.00	55.33	57.16	58.13	60.53
Butachlor 1.5 kg/ha	121.46	111.07	116.26	310.00	149.00	229.50	91.70	69.00	80.35	54.98	45.29
Pendimethalin 0.75 kg/ha	95.36	98.37	96.86	245.00	191.00	218.00	72.00	54.44	63.22	62.50	56.94
Pendimethalin 1.00 kg/ha	101.93	102.90	102.41	356.80	202.00	279.40	77.36	56.77	67.06	60.45	54.40
Control (weedy)	257.03	259.70	258.36	396.00	311.22	353.61	164.70	128.40	146.55	0.00	0.00
Control (weed free)	0.00	0.00	00.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	100.00
LSD (p=0.05)	16.25	18.22	19.84	131.92	9.76	113.88	40.70	0.91	26.22	7.80	10.30

WCE: Weed control efficiency; WCI: Weed control index

(23.80 g/m^2) and metribuzin 0.50 kg/ha PE (24.21 g/m^2) which were at par amongst them. The maximum fresh (353.61 g/m^2) and dry weed biomass (146.55 g/m^2) was recorded with weedy control. The WCE and WCI were higher in all herbicide treatments compared to weedy check. All herbicidal treatments caused significant reduction in weed density (Chahal *et al*. 2013). Metribuzin 0.25 kg/ha PE reduced the weed density due to reduced germination and emergence of weeds which might be due to its control of weeds by inhibiting photosystem by disrupting electron transfer which results in death due to starvation in the target plant. The atrazine has same mode of action but metribuzin possesses higher solubility and lower absorption and persistence than atrazine (Vencill 2002), which implies a high potential for movement in soil and thus the effect differed. The minimum dry biomass with metribuzin application was due to better control of weeds and suppression of weed growth (Biradar and Yenag 1999) and at later stage; it might be due to longer persistence of this herbicide. The variability in weed densities in different treatments may be due to the fact that some herbicides are more effective for weed control than others (Khan *et al*. 2008) with lower herbicidal activity and were not able to control newly emerged weeds for longer periods (Patel *et al*. 2006). The higher WCE in herbicidal treatments was owing to lower weed dry biomass and due to effective control of complex weed flora (Priya and Kubsad 2013).

It was concluded that metribuzin at 0.25 kg/ha PE could be recommended for effectively controlling weeds and improving growth and flower quality of *Gladiolus hybridus* cv. Novalux.

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