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Research Article

Influence of Various Weed Management Practices on Growth, Flowering and Corm Production of Gladiolus cv. 'Nova Lux'

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ABSTRACT

The present investigation was conducted during 2018-19 at Centre for Quality Planting Material, RDS Seed Farm CCSHAU, Hisar, Haryana. The experiment comprised of 16 treatments i.e. nine herbicidal treatments, five mulch treatments and one treatment of hand weeding and weedy check as control, laid out in simple randomized block design with three replications. Polypogon monspeliensis, Phalaris minor, Cyperus rotundus and Cynodon dactylon among monocots and Chenopodium murale, Convolvulus arvensis, Fumaria parviflora and Coronopus didymus in dicots were the dominant weeds. Among the application of herbicides or mulch materials either alone or in combinations, black polyethylene mulch (T_{13}) was found highly effective in controlling weeds followed by pendimethalin 1000 g fb HW + pendimethalin 1000 g (T_{12}). Amongst the herbicidal treatments, pendimethalin 1000 g fb HW + pendimethalin 1000 g (T_{12}) was found comparatively more efficient in controlling weeds without any phytotoxic effect on crop. Interestingly, the applications of oxyfluorfen as a pre-emergence and metsulfuron-methyl as a post-emergence in different herbicidal combinations caused phytotoxicity in crop plants, and the phytotoxic effect of metsulfuron-methyl was more than the oxyfluorfen. At 30 DOP the maximum level of phytotoxicity (1.70) was recorded with the pre-emergence application of oxyflurofen 500 g fb HW + oxyflurofen 500 g (T_3), whereas at 90 DOP and 120 DOP, it was recorded highest (i.e. 2.73 and 2.97, respectively) with the application of oxyfluorfen 500 g fb metsulfuron-methyl 5 g (T_2) and it was followed by post-emergence application of metsulfuron-methyl 5 g in combinations with pre-emergence application of other herbicides (T_8 & T_{11}). Overall, the application of mulch materials (either alone as a black polyethylene sheet of 100µ or paddy straw @ 10 tonnes ha^{-1} in the combination with HW or pendimethalin 1500 g ha^{-1}) was found very effective with the aspect of weed control in gladiolus.

Keywords: *Gladiolus, Weed management, Herbicidal treatment, Phytotoxicity, DOP (days of planting), HW (hand weeding), fb (followed by)*

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INTRODUCTION

Gladiolus (*Gladiolus x hybrida*), generally called "Glad" belongs to family Iridaceae and originated from South Africa. The word Gladiolus is derived from a Latin word 'Gladius' meaning sword, so it is also known as 'Sword Lily' due to its sword shaped leaves. It is herbaceous bulbous plant which develops from axillary buds on the corm. Being an important bulbous ornamental plant, it occupies a prime position among commercial flower crops which have high demand in both domestic and international markets. It occupies eighth position in the world's cut flower trade and has a global history (Ahmad et al., 2008). Gladiolus is very much liked for its majestic spikes, which contain attractive, elegant and delicate florets. These florets open in sequence over longer duration and hence have good keeping quality. There is a wide range of colours *i.e.* single or bicolour, with or without central mark, varying from white to dark crimson. The spikes of gladiolus are mainly used for display in gardens, interior decoration and for making bouquets. In India, the commercial cultivation of gladiolus is being undertaken around big cities and the cut spikes are being sold @ Rs. 12-40/ dozen, depending upon the variety, and corms are also being sold @ Rs. 36-60/ dozen as planting material in the market. Now it has become an important cut flower in domestic flower markets of Hyderabad, Bangalore, New Delhi, Kolkata and Mumbai (Rao et al., 2014). In year 2013-14, area under gladiolus cultivation was 11670 ha in India and 370 ha in Haryana with the production of 142200 tonnes and 6260 tonnes cut spikes, respectively (Anonymous, 2014).

For successful cultivation of this crop, several cultural operations are required. Out of which weed management plays an indispensable role as its lacunae directly affect the production in terms of quality and quantity. The competition caused by weeds in this crop results in either short or long stressful periods during the growth and development of crop plant (Leghari et al., 2015). Further, weeds also serve as host plant for different pests and diseases, causing phyto-sanitary problems. Generally, growers utilize manual labour to remove weeds which is not only time consuming but also costly and cumbersome. Moreover, availability of manual labour is not assured during the peak period of crop-weed competition which may leads to heavy yield losses; hence it becomes necessary to use herbicides that may provide effective weed control without any phytotoxic effect on gladiolus (Leghari et al., 2015). Further, the different types of mulch materials are already being used for controlling weeds effectively in various horticultural crops. Natural mulches include straw, dead leaves and compost which had been used since last century. Black polyethylene sheet is also used as a mulch material in many horticultural crops. Mulching retards the losses of soil moisture by intercepting the upward movement of capillary water by shading the soil, regulates soil temperature fluctuations, suppresses weed growth and on decaying enhance the soil fertility level.

In India, previous experiments by several scientific brains on weed management practices in gladiolus field also revealed the effectiveness of mulch materials and/or herbicides in controlling the weeds as well as promotion in growth, flowering and production of the corms (Kumar et al., 2012; Chahal et al., 2013; Rao et al., 2014; Swaroop et al., 2017). In recent years, several new cultivars of gladiolus with the range of colours have been developed to fulfil market demand and the cultivar 'Nova Lux' is also one of them. This variety is commonly grown in surrounding areas of Delhi and Ludhiana. It has deep yellow colour florets and requires near about four months for flowering. In Haryana and adjoining areas, very less information is available on the effectiveness of mulching and herbicides for controlling weeds in this crop and the enhancement in various growth parameters of this cultivar.

Keeping in view the importance of the crop and this particular cultivar, the present investigation was undertaken to study the effect of various weed management practices

on growth, flowering and corm production of gladiolus.

MATERIALS AND METHODS

The experiment was conducted at demonstration farm of the Centre for Quality Planting Material, RDS Seed Farm, CCS HAU, Hisar (Haryana) during the cropping season of year 2018-2019. The experimental site has a semi- arid subtropical climate with hot, dry and desiccating winds during summer season and severe cold during winter season. Newly developed and commercialized gladiolus cultivar 'Nova Lux' was selected to conduct this experiment and except weed management practices, other agronomical practices were applied according to the "Package of practices for horticultural crops" as recommended by CCSHAU, Hisar. According to layout-plan, healthy and uniform sized corms (diameter 4.0-5.0 cm) were planted in 2nd week of November on well prepared flat beds (1.50 x 1.50 m) with row to row distance of 30 cm and plant to plant distance of 20 cm. The experiment comprised of 17 treatments laid out in simple randomized block design with three replications i.e. nine herbicidal treatments [viz. oxyfluorfen @ 500 g/ha, pendimethalin @ 1000 g/ha, butachlor @ 1000 g/ha, carfentrazone @ 30 g/ha and metsulfuron-methyl @ 5 g/ha in combinations of pre and pre/post-emergence application at 50 DOP (days of planting) after the HW (hand weeding) or without HW], five mulch treatments (*viz*. mulching of black polyethylene sheet of 100 µ alone, and the paddy straw mulching @ 10 tonnes/ha in combinations with HW at 75 DOP or pre-emergence application of Pendimethalin @ 1000, 1250 & 1500 g/ha), and one treatment of hand weeding/hoeing (at 25, 50 & 75 DOP), weed free (HW as and when required) and weedy check (no weed was uprooted) as a control. The experimental field, in which trial was conducted was fallow from last six months and well ploughed and levelled before preparation of experimental plots. A basal dose of well rotten Farm Yard Manure (50 tonnes/ha) w as uniformly mixed in the soil one week before planting of corms. The recommended dose of nitrogen (Urea @ 600 kg/ha), phosphorus (SSP @ 625 kg/ha) and potassium (MOP @ 160 kg/ha) was applied in each plot. Half dose of nitrogen and the full dose of phosphorus and potassium was mixed in soil just before the planting of corms, and the second & third doses of nitrogen (one fourth each) were applied as top dressing at 3-5 leaves stage and at the time of spike emergence, respectively.

The calculated quantity of herbicides was dissolved in water @ 500 litres/ha and applied with the help of hand operated knapsack compressor sprayer with a flat fan nozzle having rectangular spray pattern. Butachlor, oxyfluorfen and pendimethalin were applied as a pre-emergence of weeds, and carfentrazone and metsulfuron-methyl were applied post-emergence of weeds at 50 DOP. Second dose of pre-emergence herbicides was applied at 50 DOP after the hand weeding operation in T_3, T_9 and T_{12} plots. Mulching treatments with paddy straw (10 tonnes/ha) in T_4, T_5, T_6 & T_{14} and black polyethylene sheet of 100 µ in T_{13} were continued from planting up to the harvesting of corms. In case of weed-free plots, hand-weeding was done as and when required, and in hand weeding (HW)/hoeing plots this operation was done at 25, 50 and 75 DOP. In weedy check (control) no weed was uprooted till the harvesting of corms. Various horticultural operations namely staking, harvesting of spikes & corms, and plant protection measures were adopted according to the "Package of practices for flower crops" as recommended by nearby SAUs and ICAR Institutes for this crop. Corms were dug out in first week of May when all the plants had dried up and after digging the corms and cormels were cleaned, washed and dipped in carbendazim (0.1 %) plus mancozeb (0.2%) solution for half an hour as a precautionary treatment against storage diseases, and then shade-dried and kept in cloth bags for storage in a cool place as a planting material for the cultivation of next season crop.

For recording data on visual control of weeds (%), all the experimental plots (T_1 to T_{17}), except $T_{16,}$ were critically observed from planting up to the harvesting of daughter corms at monthly intervals to collect the information on effectiveness of various weed management practices in the suppression of monocot or dicot weeds and expressed in percentage. For recording data on crop parameters, outer two plants in each row of each plot were considered as guard row plants. The sprouting percentage data was recorded on 25 plants, while the days taken for sprouting were recorded on first appearance of sprouts on 10 selected corms in each plot. For rest of the crop parameters, the observations were recorded on 5 healthy competitive plants as selected in each plot. Sprouted corms in each plot were counted at the interval of 3 days and the percentage of sprouted corms was calculated with the help of mathematical formula, and expressed for 9, 12, 15 and 18 DOP.

The days taken for sprouting of corms were counted from date of planting to the time of appearance of cotyledonary leaf above the soil surface and the total number of sprouts per plant were counted at flowering stage and then averaged. Plant height excluding spike (cm) from soil surface to the tip of the tallest leaf of each sprout and the plant height including spike (cm) from soil surface to the top most floral bud of each spike was measured with the help of a meter scale and then averaged. Further, the total number of leaves at flowering stage in each sprout of the 5 selected plants were counted in each plot and then averaged. For average leaf area, sampling was done at flowering stage and five sprouts, out of 5 marked plants in each plot, are selected randomly and 3 leaves from different height of each sprout were taken, pressed and the total area of these 15 leaves from each plot was determined with the help of digital Leaf Area-Meter model no. CL-203, and then the average leaf area per sprout (cm^2) was worked out.

For recording data on days taken up to spike emergence, the total number of days taken from planting date up to the spike emergence in each sprout; days taken up to colour break in basal floret, the total number of days taken by each sprout from the planting date to colour break in basal floret of each spike; and for days taken up to the opening of basal floret, the total number of days taken by each sprout from the planting date of corm to the complete opening of basal floret in each spike, were counted and then averaged for each parameter. Duration of flowering (days) was calculated by counting the number of days from first floret open to the wilting of last floret in each spike and then averaged. The length of each spike (cm) was measured from starting point where the stalk emerged from the joint of 3^{rd} leaf to the top most bud of the spike and then mean was calculated, and the length of rachis (cm) was measured from first basal floret to the most apical floret in each spike and then averaged. The total number of florets on each spike and the total number of spikes in each plant were counted for 5 representative plants and then averaged. The minimum and maximum diameters (cm) of basal 2^{nd} and 3^{rd} florets at fully opened stage in each spike were measured with the help of a scale and then the mean diameter (size) of floret (cm) was calculated. At the end of flowering period, the total number of marketable spikes produced by 10 selected plants in each plot were counted on the basis of spike length (>45cm), rachis length (>25cm) and number of florets (≥10) in each spike.

Further, the data on number of corms per plant was recorded by counting the total number of daughter corms produced by 5 selected plants and then averaged. The minimum and maximum equatorial diameter of 5 corms was measured with the help of Digital Vernier Caliper and then the mean diameter (size) of corm (cm) per plot was calculated, and the weight of individual corm (g) was measured with the help of Digital Weighing Balance and then the average of 5 corms per plot was calculated. Further, the total number of cormels produced by the 5 selected plants were counted and weighed, and then the average number of cormels and their weight per plant was calculated. After the harvesting of corms, total number of

marketable daughter corms produced by the 10 selected plants in each plot were counted on the basis of diameter (>3.5 cm) and weight (>30 g) of each corm.

The recorded data on different parameters were statistically analysed by applying the Analysis of variance (ANOVA) technique and the treatment differences were tested by 'F' test of significance on the basis of null hypothesis (Cochran and Cox, 1963). Statistical analysis was done by using OPSTAT statistical software design developed by CCSHAU, Hisar to find out the significance of variation resulting from the experimental treatments. All tests of significance were made at 5% level of the significance.

RESULTS AND DISCUSSION

Control of weeds on visual basis (%)

The highest control of monocot weeds (table 1 & figure 1) as visually noticed was under T_{13} (polyethylene mulching) at all stages of crop growth which was followed by application of pendimethalin, hand weeding and other mulch treatments at different stages of crop growth. These results are might be due to better suppression of monocot weeds with the application of these treatments. These results are in confirmative with Chahal et al. (1994) who reported that the application of mulch material (3" local grasses) was found more effective in controlling monocot weeds as compared to herbicidal applications in gladiolus field.

However, the highest control of dicot weeds at different stages of crop growth was visually seen under different treatments (table 1 & figure 2). At 30 DOP (98.33 %), 120 DOP (93.33 %) and at harvesting stage (94.33 %), the highest control of dicot weeds was noticed under T_{13}, whereas at 60 DOP (91.66 %) and 90 DOP (96.33 %), it was observed under T_{15} (hand hoeing) and T_{12} (pendimethalin 1000 g *fb* HW + pendimethalin 1000 g), respectively. Such results might be due to effective control of dicot weeds by the HW operations done at 25 & 50 DOP and the pre-emergence applications of pendimethalin after the planting and at 50 DOP.

Effectiveness of pendimethalin in controlling dicot weeds in gladiolus crop has already been reported by Bhat and Sheikh (2015) and Qadeer et al. (2016). The results of polyethylene mulch (T_{13}) are in confirmative with Khan et al. (2015) who reported that among the various mulching treatments, plastic mulch was found most effective for inhibiting the weed germination in gladiolus field.

Crop Performance against weed management practices

Sprouting percentage and days taken for sprouting of corms

Sprouting percentage of corms was significantly affected by mulching and herbicidal treatments at 9 DOP and 12 DOP, whereas at 15 DOP & 18 DOP, it was observed non-significant (table 2). The higher percentage of sprouting at 9 DOP (46.67 %) and 12 DOP (82.67 %) was recorded with black polyethylene mulch (T_{13}) and it was closely followed by paddy straw mulch in combinations with HW (T_{14}) or the pre-emergence applications of pendimethalin (T_5, T_4 & T_6), Similarly (table 2), the minimum number of days taken by corms to sprout (11.27 days) were recorded in T_{13} (black polyethylene mulch) which was followed by T_{14} (mulching of straw *fb* HW) and ultimately this effect of mulching resulted in earlier and uniform sprouting of corms in these plots. Interestingly, corms under most of the pure herbicidal treated plots took more number of days in sprouting as compared to other treatments.

Early sprouting in mulched plots was might be due to increase in soil temperature and conservation of soil moisture by mulch material, and such favourable conditions also resulted in earlier flowering and longer flowering period under mulched plots as compared to without mulching plots. These results are in conformity with Chahal (1991) who recorded the highest sprouting percentage (77.78%) at 65 DOP under mulch (3" local grasses) treatment which was significantly higher than rest of the treatments in this crop.

Table 1: Control of monocot and dicot weeds (%) with different weed management practices on visual basis

Treatments		Monocot Weeds					Dicot Weeds				
		30 DOP*	60 DOP	90 DOP	120 DOP	Harv. stage	30 DOP	60 DOP	90 DOP	120 DOP	Harv. stage
Oxyfluorfen 500g *fb* carfentrazone 30g	T1	90.33	72.00	95.0	88.66	87.33	85.38	78.83	86.80	80.91	78.88
Oxyfluorfen 500g *fb* metsulfuron-methyl 5g	T2	87.66	75.00	94.33	85.67	86.66	84.20	79.90	85.80	78.34	76.38
Oxyfluorfen 500g *fb* HW+oxyfluorfen 500g	T3	86.00	71.00	95.33	85.33	82.33	85.16	77.57	92.33	84.51	82.44
Pendimethalin 1000g+straw mulch	T4	93.33	82.33	77.00	80.00	80.00	92.58	85.21	80.16	78.87	76.62
Pendimethalin 1250g+straw mulch	T5	94.67	84.66	79.66	82.00	82.00	94.40	88.95	82.22	80.67	78.21
Pendimethalin 1500g+straw mulch	T6	97.33	86	81.33	84.33	80.33	96.48	90.04	83.68	81.93	80.19
Butachlor 1000g *fb* carfentrazone 30g	T7	82.67	31.33	92.00	88.33	87.00	59.07	54.65	80.04	76.19	73.66
Butachlor 1000g *fb* metsulfuron-methyl 5g	T8	85.00	37.66	91.00	84.00	83.00	61.16	52.83	79.14	74.68	71.77
Butachlor 100g *fb* HW+butachlor 1000g	T9	85.33	41.66	85.33	79.33	76.00	60.60	53.92	80.74	75.83	73.31
Pendimethalin 1000g *fb* carfentrazone 30g	T10	92.33	77.66	96.00	85.66	79.67	91.83	81.43	91.70	82.54	80.96
Pendimethalin 1000g *fb* metsulfuron-methyl 5g	T11	93.66	76.33	94.00	84	79.00	92.53	80.79	87.55	80.89	79.02
Pendimethalin 1000g *fb* HW+ pendimethalin 1000g	T12	93	76.00	96.33	90.33	90.00	92.11	80.53	95.15	90.29	89.08
Mulching of black poly-ethylene sheet (100 µ)	T13	98.33	89.33	92.33	93.33	94.33	98.22	96.63	95.05	93.16	92.76
Mulching of straw (10 t) *fb* HW (75 DOP)	T14	90.00	78.33	90.67	87.33	88.00	89.68	84.91	93.78	87.03	84.79
Hand weeding/hoeing at 25, 50 & 75 DOP	T15	96.33	91.66	88.33	88.33	79.33	96.75	92.76	90.13	83.28	81.87
Weedy free (HW as and when required)	T16	-	-	-	-	-	-	-	-	-	-
Weedy check (control)	T17	-	-	-	-	-	-	-	-	-	-

* Days of planting

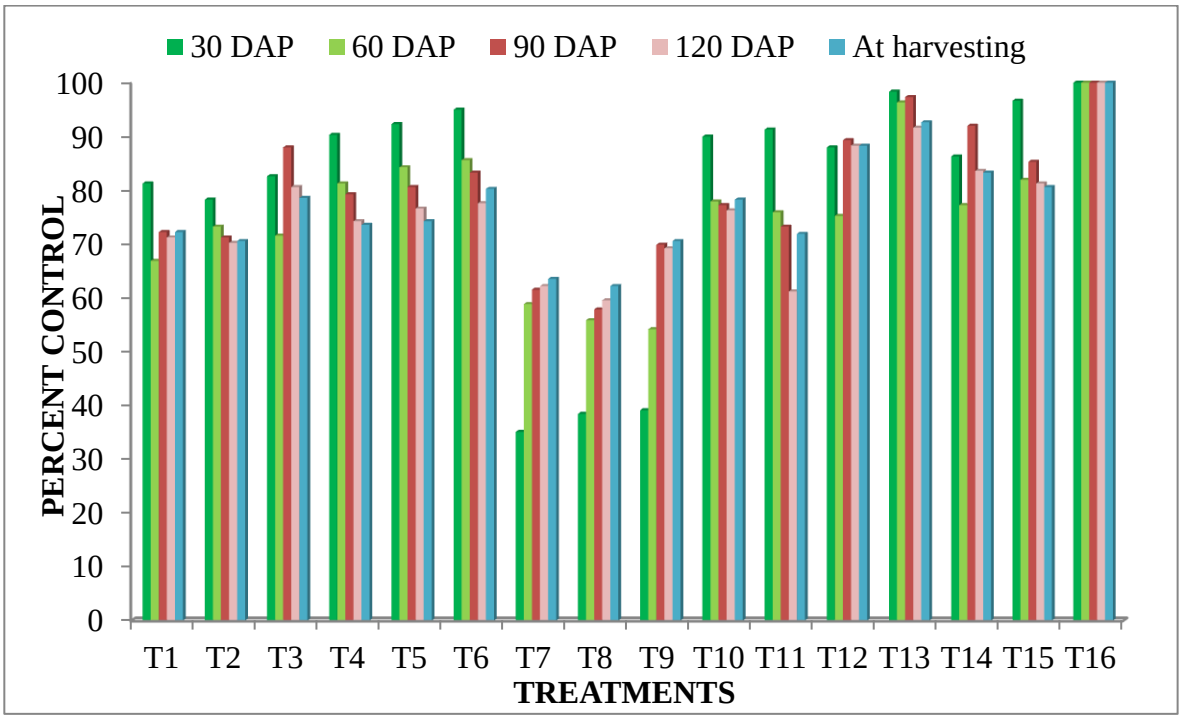

Fig. 1: Visually observed control of monocot weeds by weed management practices (T_1 to T_{16} 'weedy check') except weed free at different stages of crop

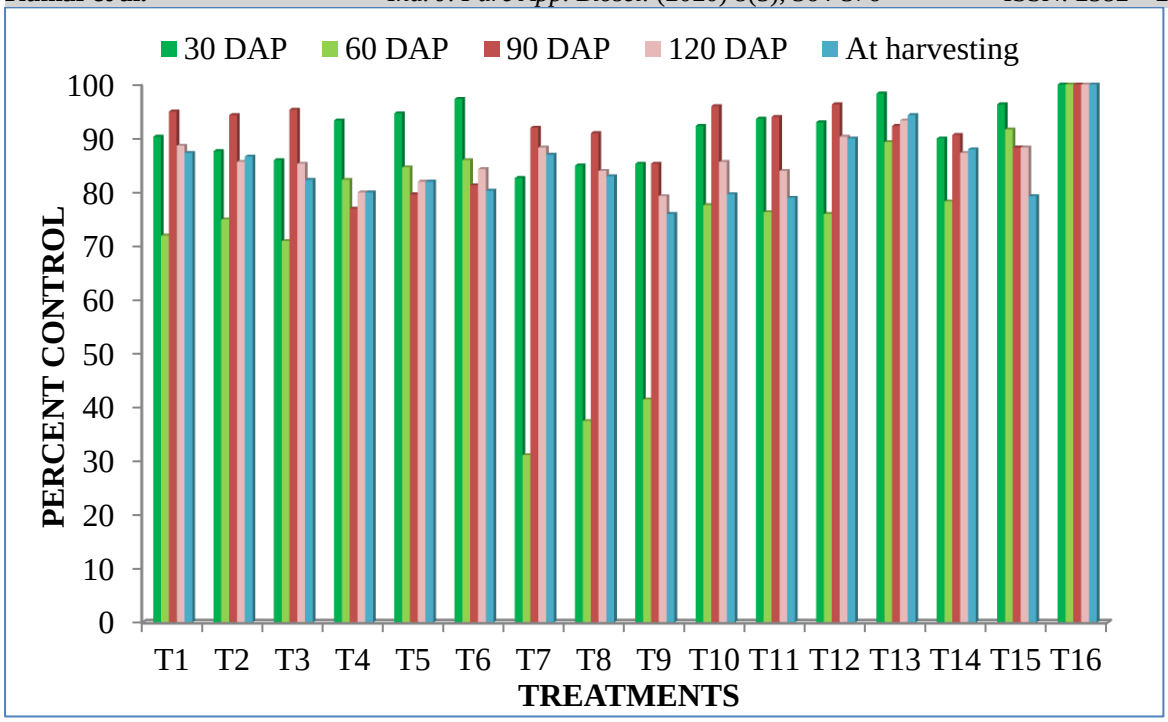

Fig. 2: Visually observed control of dicot weeds by weed management practices (T_1 to T_{16} 'weedy check') except weed free at different stages of crop

Table 2: Effect of weed management practices on sprouting of corms in Gladiolus cv. 'Nova Lux'

Treatments		Sprouting (%)				Days taken by corms to sprout	No. of sprouts/plant
		9 DOP*	12 DOP	15 DOP	18 DOP		
Oxyfluorfen 500g *fb* carfentrazone 30g	T1	10.67	44.00	85.33	94.67	14.47	1.80
Oxyfluorfen 500g *fb* metsulfuron-methyl 5g	T2	14.67	41.33	73.33	96.00	14.60	2.00
Oxyfluorfen 500g *fb* HW+oxyfluorfen 500g	T3	18.67	40.00	82.67	82.67	14.53	1.93
Pendimethalin 1000g+straw mulch	T4	42.67	78.67	87.33	96.00	13.13	2.07
Pendimethalin 1250g+straw mulch	T5	46.67	78.67	93.33	98.67	12.93	2.13
Pendimethalin 1500g+straw mulch	T6	41.33	73.33	93.33	100.00	12.87	2.20
Butachlor 1000g *fb* carfentrazone 30g	T7	12.00	38.67	82.67	96.00	14.80	1.93
Butachlor 1000g *fb* metsulfuron-methyl 5g	T8	8.00	48.00	85.33	94.67	14.67	1.87
Butachlor 100g *fb* HW+butachlor 1000g	T9	14.67	50.67	81.33	94.67	14.80	1.87
Pendimethalin 1000g *fb* carfentrazone 30g	T10	20.00	54.67	85.33	93.33	14.47	1.93
Pendimethalin 1000g *fb* metsulfuron-methyl 5g	T11	18.67	50.67	88.00	93.33	14.07	1.93
Pendimethalin 1000g *fb* HW+ pendimethalin 1000g	T12	20.00	54.67	84.00	90.67	13.53	1.87
Mulching of black poly-ethylene sheet (100 µ)	T13	44.00	82.67	94.67	98.67	11.27	2.27
Mulching of straw (10 t) fb HW (75 DOP)	T14	40.00	78.67	86.67	97.33	12.47	2.20
Hand weeding/hoeing at 25, 50 &75 DOP	T15	30.67	54.67	85.33	98.67	12.67	2.27
Weed free (HW as and when required)	T16	22.67	58.67	86.67	94.67	12.72	2.20
Weedy check (control)	T17	29.33	53.33	78.67	89.33	12.83	1.6
CD @ 5%		6.80	8.00	NS	NS	0.60	NS

*Days of planting

Effect on vegetative growth characteristics

Studies on weed management practices in gladiolus revealed the tremendous improvement in plant height excluding spike, plant height including spike and average leaf area with the applications of most of the weed management practices, even though, results obtained with polyethylene mulch (T_{13}) and hand weeding/hoeing (T_{15}) were only comparable with weed free (T_{16}) treatment in which these parameters were observed the maximum (table 3). The above results are might be due to adequate effect of mulches on plant microclimate by changing the soil energy balance and reducing evaporation from the soil. However, the number of sprouts per plant and number of leaves per sprout were observed non-significant which may be due to the varietal characteristics which had already been observed by several workers during their studies in gladiolus crop. Rathod and Venugopal (2017) also observed various growth and flowering parameters better under weed free treatment as compared to other treatments in tuberose crop. In contrary to number of sprouts per plant, Sihombing and Handayati (2017) reported the maximum number of plant shoots per clump (15.86) with the mulch treatment as compared to un-mulched treatment (6.22) in tuberose. Further. with the application of black polyethylene mulch, the tremendous improvement in vegetative parameters of gladiolus, tuberose and rose have already been reported by Messar et al. (2016), Jeevan et al. (2016) and Singh et al. (2019), respectively.

Effect on floral characteristics

All the treatments (table 4) markedly reduced the days taken for spike emergence, days taken for colour breaking in basal floret and days taken up to the opening of basal floret, and enhanced the duration of flowering, spike and rachis length, number of florets per spike, diameter of floret and number of marketable spikes over control (T_{17}). The minimum number of days taken for spike emergence, colour breaking in basal floret and opening of basal floret were recorded in T_{16} (weed free), and T_{13} (polyethylene mulching) and T_{15} (three HW/hoeing) were observed at par with T_{16}. Further, the maximum duration of flowering was also recorded under T_{16}, but it was closely followed by T_{13}, T_{15}, T_4 (pendimethalin 1000 g + straw mulch), T_5 (pendimethalin 1250 g + straw mulch), T_6 (pendimethalin 1500 g + straw mulch) and T_{14} (mulching of straw *fb* HW). Similarly, the tallest spike with longest rachis was observed in T_{16} and it was followed by T_{13}, whereas the maximum floret diameter as well as number of florets per spike were also recorded in $T_{16,}$ but it was closely followed by T_{13}, T_{15} and T_6. Further, the maximum number of marketable spikes (17.67 each) were produced by T_{16}, T_{13} and $T_{6,}$ but T_{14}, T_{12} (pendimethalin 1000 g *fb* HW + pendimethalin 1000 g), T_5, T_4 and T_{10} (pendimethalin 1000 g *fb* carfentrazone 30 g) were also observed at par with these treatments (T_{16}, T_{13} & T_6). While the minimum number of marketable spikes (3.67 each) were produced by T_{17} (weedy check) and T_2 (oxyflurofen 500 g *fb* metsulfuron-methyl 5 g). However, overall superior quality of flowers (table 4) was obtained with plants grown in T_{16} followed by T_{13}, T_{15} and T_{14}. Besides this, the treatments T_{13}, T_{14}, T_{12} and T_6 generally resulted in almost similar enhancement in both quantitative and qualitative floral parameters during the present investigation.

Table 3: Effect of weed management practices on different vegetative characteristics in Gladiolus cv. 'Nova Lux'

Treatments		Plant height excluding spike (cm)	Plant height including spike (cm)	Number of leaves/ sprout	Average leaf area/sprout (cm^2)
Oxyfluorfen 500g *fb* carfentrazone 30g	T1	45.33	80.27	7.07	432.06
Oxyfluorfen 500g *fb* metsulfuron-methyl 5g	T2	37.47	49.67	7.00	400.70
Oxyfluorfen 500g *fb* HW+oxyfluorfen 500g	T3	46.67	82.93	7.27	438.18
Pendimethalin 1000g+straw mulch	T4	49.47	90.27	7.00	493.77
Pendimethalin 1250g+straw mulch	T5	50.27	95.87	7.47	505.07
Pendimethalin 1500g+straw mulch	T6	50.53	96.60	7.60	505.31
Butachlor 1000g *fb* carfentrazone 30g	T7	44.47	77.00	7.27	417.43
Butachlor 1000g *fb* metsulfuron-methyl 5g	T8	41.40	54.47	7.40	409.91
Butachlor 100g *fb* HW+butachlor 1000g	T9	42.27	67.27	7.33	416.75
Pendimethalin 1000g *fb* carfentrazone 30g	T10	47.07	83.67	7.33	446.73
Pendimethalin 1000g *fb* metsulfuron-methyl 5g	T11	44.80	77.33	7.27	428.19
Pendimethalin 1000g *fb* HW+ pendimethalin 1000g	T12	47.40	83.93	7.20	457.49
Mulching of black poly-ethylene sheet (100 µ)	T13	52.60	102.87	7.87	547.74
Mulching of straw (10 t) *fb* HW (75 DOP)	T14	47.93	88.87	7.47	463.93
Hand weeding/hoeing at 25, 50 & 75 DOP	T15	52.20	98.80	7.40	541.03
Weed free (HW as and when required)	T16	53.27	106.27	7.47	576.01
Weedy check (control)	T17	40.87	54.00	7.33	408.57
CD @ 5%		2.42	3.94	NS	28.81

Table 4: Effect of weed management practices on different floral characteristics in Gladiolus cv. 'Nova Lux'

Treatments		Days taken for spike emergence	Days taken for colour breaking in basal floret	Days to opening basal floret	Duration of flowering	Spike length (cm)	Rachis length (cm)	Number of florets/ spike	Number of spikes/ plant	Diameter of floret (cm)	Number of marketable spikes
Oxyfluorfen 500g *fb* carfentrazone 30g	T1	74.53	82.60	85.00	20.67	60.20	40.40	14.67	1.4	8.98	12.00
Oxyfluorfen 500 g *fb* metsulfuron-methyl 5g	T2	76.20	84.27	86.80	13.73	38.27	21.40	10.13	1.4	8.16	3.67
Oxyfluorfen 500g *fb* HW+oxyfluorfen 500g	T3	74.47	82.60	84.87	21.47	62.60	40.93	14.93	1.6	9.01	13.67
Pendimethalin 1000g+straw mulch	T4	70.60	78.13	80.87	25.13	63.47	44.00	16.40	1.8	9.37	16.67
Pendimethalin 1250g+straw mulch	T5	69.80	77.40	80.13	25.13	64.20	44.93	17.00	1.8	9.38	17.33
Pendimethalin 1500g+straw mulch	T6	69.00	77.20	79.73	25.40	64.07	46.13	17.13	1.8	9.43	17.67
Butachlor 1000g *fb* carfentrazone 30g	T7	75.47	83.27	86.00	15.73	44.27	25.20	10.80	1.4	8.32	10.33
Butachlor1000g *fb* metsulfuron-methyl 5g	T8	76.07	83.73	86.67	14.27	43.27	24.73	10.60	1.4	8.24	9.00
Butachlor 100g *fb* HW+butachlor 1000g	T9	75.67	83.67	85.80	16.67	52.53	31.53	11.00	1.4	8.41	12.67
Pendimethalin 1000g *fb* carfentrazone 30g	T10	73.53	81.93	84.00	22.07	62.67	41.27	15.73	1.6	9.05	15.33
Pendimethalin 1000g *fb* metsulfuron-methyl 5g	T11	74.53	82.40	85.27	20.27	55.00	34.67	11.53	1.4	8.51	13.33
Pendimethalin 1000g *fb* HW+ pendimethalin 1000g	T12	73.47	81.40	83.80	22.50	62.93	43.27	15.87	1.8	9.27	17.33
Mulching of black poly-ethylene sheet (100 µ)	T13	65.67	73.67	76.20	25.47	74.00	53.67	17.67	1.8	9.53	17.67
Mulching of straw (10 t) *fb* HW (75 DOP)	T14	70.93	78.87	81.53	24.87	63.33	43.80	15.93	1.8	9.28	17.33
Hand weeding/hoeing at 25, 50 &75 DOP	T15	67.13	75.07	77.40	25.47	68.87	47.80	17.53	1.8	9.46	17.00
Weed free (HW as and when required)	T16	65.33	72.73	75.07	25.53	79.47	59.47	17.80	1.8	9.56	17.67
Weedy check (control)	T17	76.67	84.53	86.93	13.13	40.33	19.13	10.27	1.4	8.08	3.67
CD @ 5%		2.57	2.79	2.44	1.78	2.57	4.18	0.74	NS	0.10	2.50

There are few reports in gladiolus as well as other bulbous crops covering the effect of mulches on floral characteristics. However, Sindhu et al. (2013) recorded the best performances of gladiolus under polyethylene mulch *viz.* days taken to flowering and spike emergence, diameter of floret, duration of flowering and length of spike. Similar enhancement in floral parameters with the application of polyethylene mulch in gladiolus field were also reported by Kumari et al. (2013) and Messar et al. (2016). On the other hand, in contrast to previous findings, Soba et al. (2018) observed more improvement in growth parameters with herbicidal application of oxyfluorfen as compared to mulch material in onion crop. The above findings are also in agreement with the results obtained by Rathod and Venugopal (2017) who recorded the least number of days taken for first flowering and maximum spike length under weed free (check) followed by pre-emergence application of pendimethalin @ 1.0 kg/ha in tuberose. The present findings also got support from other findings of Rao et al. (2014) and Ali et al. (2015) who reported the significant improvement in both quantitative and qualitative floral parameters with the application of pendimethalin in gladiolus field.

Effect on daughter corm and cormel characteristics

All the corm and cormel parameters were significantly influenced by the different treatments, except numbers of corms/plant which was observed non-significant. However, the number of corms per plant varied from 1.73 to 2.07 with respect to herbicidal treatments and 2.07 to 2.13 with respect to mulching treatments either alone or in combination with herbicides (table 5). Among mulched plots, either mulching alone (T_{14} & T_{13}) or in combinations with herbicidal applications (T_6, T_5 & T_4), plants grown in T_{14} (straw mulching *fb* HW) produced noticeable heavier (weight: 52.27 g) and bigger (diameter: 6.12 cm) daughter corms which were closely followed by plants grown in T_{13} (polyethylene mulching) & T_6 (pendimethalin 1500 g + straw mulch), whereas T_{12} (pendimethalin 1000 g *fb* HW + pendimethalin 1000 g) and T_{16} (weed free) were also observed at par with T_{14} in these parameters. In addition to above parameters, the maximum number of cormels (19.07) and their weight (5.22 g) per plant were produced by T_{14} (straw mulching *fb* HW) but T_{12}, T_{13} and T_{16} were observed at par with T_{14}. While the comparatively less size of corm, weight of corm, number of cormels/plant and weight of cormels/plant was produced by T_{17} (weedy check), T_2 (oxyflurofen 500 g *fb* metsulfuron-methyl 5 g), T_8 and T_1. Among various treatments, the maximum number of marketable corms (20.67) were produced by T_{16} (weed free) and T_6, T_{14}, T_{13}, T_5 & T_4 were observed at par with T_{16} (table 5). These results are might be due to that the mulch provides better soil environmental conditions for corm and cormel growth by storing moisture for long time and maintaining soil micro flora and fauna. Sindhu et al. (2013) also reported that mulches provide favourable environment for better root growth by increasing soil temperature and conserving soil moisture regimes. The present findings also got support from other findings of Kumari et al. (2013), who reported that plants with mulched treatments showed significantly more number of corms, weight of corms, number of cormels and their weight as compared to non-mulched treatments in gladiolus field. Similar enhancement in bulb parameters with the application of mulch materials in tuberose field were also reported by Amin et al. (2015).

Table 5: Effect of weed management practices on daughter corm and cormel characteristics in Gladiolus cv. 'Nova Lux'

Treatments		Number of corms/ plant	Diameter of corm (cm)	Weight of corm (g)	Number of cormels/ plant	Weight of cormel/plant (g)	Number of marketable daughter corms
Oxyfluorfen 500g *fb* carfentrazone 30g	T1	1.87	3.95	35.70	8.87	2.24	13.00
Oxyfluorfen 500g *fb* metsulfuron-methyl 5g	T2	1.73	3.48	28.02	5.60	1.28	8.67
Oxyfluorfen 500g *fb* HW+oxyfluorfen 500g	T3	1.87	5.28	40.84	13.87	3.64	18.00
Pendimethalin 1000g+straw mulch	T4	2.07	5.52	46.97	16.20	4.37	20.00
Pendimethalin 1250g+straw mulch	T5	2.07	5.88	49.26	16.33	4.44	20.00
Pendimethalin 1500g+straw mulch	T6	2.13	5.97	50.06	17.20	4.60	20.33
Butachlor 1000g *fb* carfentrazone 30g	T7	1.87	5.40	40.85	14.80	3.84	18.00
Butachlor1000g *fb* metsulfuron-methyl 5g	T8	1.73	3.68	33.99	7.20	1.97	13.67
Butachlor 100g *fb* HW+butachlor 1000g	T9	1.80	5.41	43.90	15.67	4.26	12.67
Pendimethalin 1000g *fb* carfentrazone 30g	T10	2.07	5.50	44.41	15.87	4.32	17.33
Pendimethalin 1000g *fb* metsulfuron-methyl 5g	T11	1.73	4.12	38.02	10.00	2.74	17.00
Pendimethalin 1000g *fb* HW+ pendimethalin 1000g	T12	1.87	6.06	51.86	18.67	5.06	16.00
Mulching of black poly-ethylene sheet (100 µ)	T13	2.13	6.04	50.74	18.60	4.98	20.00
Mulching of straw (10 t) *fb* HW (75 DOP)	T14	2.07	6.12	52.27	19.07	5.22	20.00
Hand weeding/hoeing at 25, 50 & 75 DOP	T15	1.93	5.90	49.53	16.47	4.46	18.00
Weed free (HW as and when required)	T16	2.13	5.99	50.10	18.07	4.72	20.67
Weedy check (control)	T17	1.73	3.36	27.57	10.60	2.84	6.67
CD @ 5%		NS	0.27	2.25	1.16	0.46	2.14

CONCLUSION

It has been concluded from the present investigation that among the application of herbicides or mulch materials either alone or in combinations, T_{13} (black polyethylene mulch) was observed very effective in controlling weeds followed by T_{12} (pendimethalin 1000 g *fb* HW + pendimethalin 1000 g/ha), T_{14} (mulching of straw *fb* HW at 75 DOP) and T_6 (pendimethalin 1500 g + straw mulch). *Polypogon monspeliensis*, *Phalaris minor*, *Cyperus rotundus* and *Cynodon dactylon* among the monocots and *Chenopodium murale*, *Convolvulus arvensis*, *Fumaria parviflora* and *Coronopus didymus* in dicots were found dominant weeds controlled in the experimental gladiolus field. In crop parameters, however T_{16} (weed free) was observed superior in vegetative and floral characteristics but T_{13} was also observed at par with T_{16}. Regarding corm and cormel production, T_{14} was observed superior and it was followed by T_{15} (three HW/hoeing) and T_{13}. Amongst the herbicidal treatments, T_{12} was observed comparatively more efficient in controlling weeds and resulted in better vegetative and reproductive parameters. Interestingly, the herbicidal applications of oxyflurofen and metsulfuron-methyl (T_2 &T_8) caused phytotoxicity to the crop plants and the symptoms of phytotoxocity were observed at all the dates of observation. Among various weed management practices tested in this investigation, overall the application of mulch materials (either alone or in combinations) was observed next to the weed free treatment with

the aspect of visually control of weeds as well as production of flowers and corms in gladiolus.

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