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Influence of weed management on vegetative growth, flower and bulb parameters of tuberose

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Abstract
A field experiment was conducted at the AICRP on Floriculture Unit, Horticulture Farm, Department of Horticulture, Rajasthan College of Agriculture, Udaipur. The experiment consisted with fourteen treatments comprising of hand weeding, herbicides and weedy check replicated thrice in randomized block design. Among the various weed management practices tested, out of them pre-emergence application of pendimethalin @ 0.75 kg a.i./ha + 1 hand weeding (HW) at 40 days after planting (DAP) reported lowest weeds counts at 50 DAP (13.1 m^{-2}), fresh weight (20.83 g) and dry weight of weeds (3.28 g) with maximum weed control efficiency (93.10 %) as compare to weedy check. However, 3 HW at 30, 60 and 90 DAP had superior effect on the plant height (89.36 cm), leaves/plant (51.76), spike length (78.52 cm), spike emergence (110.68 days), first flowering (116.44 days), floret/spike (47.97), spike/plant (4.81), flower weight/plant (138.47 g), flower diameter (4.49 cm), flower duration (26.17 days), spike durability in field (20.60 days), bulbs/plant (16.43), bulb diameter (3.85 cm), fresh weight of bulb (28.49 g), bulblets ha^{-1} (33.39) and fresh weight of bulblet (3.37 g) followed by pendimethalin @ 0.75 kg a.i./ha + 1 HW.

Keywords: Tuberose, Hand weeding, Herbicide, Weedy check, Pre-emergence, Spike

Introduction
Tuberose (*Polianthes tuberosa* L.) commonly known as 'Rajanigandha' belongs to family Amaryllidaceae and native to Mexico from where it spread to different parts of the world. It is believed that tuberose was brought to India via Europe in 16th century. It is commercially propagated by bulbs and generally, bulbs diameter ranges between 1.5 to 2.5 cm are suitable for planting. Tuberose is cultivated on large scale in France, South Africa, North Carolina, USA, tropical and subtropical areas in India. In India, the commercial cultivation of tuberose is done mainly in Mysore, Devanhalli taluk (Karnataka), East Godavari, Guntur, Chitoor (Andhra Pradesh), Coimbatore and Madurai (Tamil Nadu), Pune, Thane, Sangli (Maharashtra), Ranaghat, Krishna Nagar (West Bengal) as reported by Chadha and Bhattacharjee (1995) [3]. This is fact that in tuberose cultivation one of the main constrain is weed. Weeds cause irreparable damage to crops by competing for water, nutrients, light, space and also acting as alternate hosts to a number of pathogens and insect pests. Manual weeding is time consuming and costly hence, chemical weed control is one of the alternative methods to control weeds. Therefore, suitable strategy for weed control is the prime need to reduce weed competition and to improve the quality of cut spike and flower production. In the last four decades, considerable developments had taken place in chemical weed control, which can increase crop returns by reducing the production cost. Hence, combination of cultural and herbicide in various ornamental plants are effective techniques as compared to others methods of weed control. Consequently, these are moderately cheapest, appropriate and effective for removing of weeds. There is possibility to be application of herbicide with hand weeding which can be more effective and economically to reducing weed opposition at right time to obtain highest flower production in tuberose.

Materials and Methods
The experiment was carried out during April 2015 to study the weed management practices in tuberose cv. Prajwal. Fourteen treatments including namely, Pre emergence (PE) application of Pendimethalin @ 0.75 kg/ha, Pendimethalin @ 1.0 kg/ha, Pendimethalin @ 0.75 kg/ha + 1 hand weeding (HW) at 40 DAP, Oxyfluorfen @ 0.50 kg/ha, Oxyfluorfen @ 0.75 kg/ha, Oxyfluorfen @ 0.50 kg/ha + 1 HW at 40 DAP, Atrazine @ 1.0 kg/ha, Atrazine @ 1.5 kg/ha, Atrazine @ 1.0 kg/ha + 1 HW 40 DAP, Butachlor @ 1.0 kg/ha, Butachlor @ 1.5 kg/ha, Butachlor @ 1.0 kg/ha + 1 HW at 40 DAP, 3 HW at 30, 60 and 90 days interval and Weedy check (control) in Randomized Block Design, with 3 replications, at AICRP on Floriculture

Project, Horticulture Farm, RCA Campus, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan, situated at 24º35' N latitude, 73º42' E longitude and at 579.5 m above MSL altitude. Mean maximum (39.1 °C) and minimum (23.4 °C) temperature, and relative humidity of maximum (89.36 %) and minimum (41.23 %), were recorded during the experiment. Bulb of tuberose cv. 'Prajwal' were collected from AICRP on Floriculture Project Centre, MPUAT, Udaipur. All pre-emergent herbicide, which was sprayed once at 4 days before transplanting and second year before sprouting of bulb at the time of dormancy period. The required quantity of herbicides was dissolved in water and applied by foot sprayer. Herbicide, treatments were compared with hand weeding where the weeds were removed manually. Healthy and uniform sized bulb of 1.5-2.5 cm diameter were planted in the third week of April at a spacing of 30 cm x 30 cm at 5-6 cm depth. Thirty bulb of each treatment per replication were planted in each plot. The soil was clay loam in texture, with pH 7.34 and EC 0.54 dSm^{-1} under irrigated condition. Well-decomposed 2.5 kg/m^2 farm yard manure was incorporated into all the plots two weeks prior to planting. A basal fertilizer dose comprising 250 kg N_2, 200 kg P_2O_5 and 200 kg K_2O ha^{-1} was applied at planting and the remaining half dose of N 125 kg was applied 45 days after planting (Meena, 2016) [9]. Uniform cultural practices were followed throughout the experiment. The bulbs were lifted from the field when the foliage turned yellow Shade drying of bulbs was followed by cleaning, counting and weighing of bulbs for recording of desired observations. Further, bulbs were stored after treatment with fungicide for succeeding crop. Data on weed population, vegetative growth, flowering, bulb and bulblet production were recorded in five randomly selected plants, and pooled values of two year were analyzed statistically. The weed population was recorded at 50 day after planting with 50 cm x 50 cm quadrat, thrown randomly in the plots from two spots. All the weeds in 50 cm x 50 cm quadrat were cut from soil surfaces is above ground and put into paper bags in every plot. The fresh weight of weeds was recorded with the help of electronic weighing machine. The weed samples were sundried for 1-2 days until they lost maximum moisture. Then samples were kept in oven for 48 h at 50 °C and final dry weight was recorded. Weed control efficiency (WCE) was calculated with following formula.

$$\text{Weed control efficiency (\%)} = \frac{\text{DWC–DWT}}{\text{DWC}} \text{ X } 100$$

Where, DWC is dry weight of weeds in weedy check i.e. control and DWT is weed dry weight of treatments

Results and Discussion

Weeds population parameters

In the present investigation the pre emergence application of Pendimethelin @ 0.75 kg/ha + 1 HW (40 days) at 50 DAP showed significantly lowest weed population (13.14), fresh weight (20.83 g) and dry weight of weeds (3.28 g) with highest weed control efficiency (93.10 % m^{-2}), whereas, the weedy check i.e. control plots produced highest weeds density (85.15 m^{-2}), fresh weight (121.56 g/m^2) and dry weight (47.51 g/m^2) with lowest weed control efficiency (0.00 % m^{-2}), respectively. At 50 DAP, the herbicide treatments in combination with one hand weeding at 40 days i.e. pendimethelin @ 0.75 kg/ha (PE) + 1 HW was superior and recorded better weed suppression compared to other treatments. This might be due to the effect of pre emergence herbicides coupled with hand weeding which clearly shows that herbicides alone treatments can check the weeds to some extents, but when coupled with hand weeding, shows remarkable results. Similar finding were reported by Desai (2011) [4] in gladiolus, Bala (2017) [1] or Kumar *et al.* (2017) [7] in chrysanthemum and Jeevan *et al.* (2016) [6] in tuberose cv. Hyderabad Single. Weed control efficiency followed similar trends like then weed dry matter. Higher weed control efficiency under these treatments can be accounted to lower dry weight of weeds in these treatments. Whereas, the lowest weed control efficiency was observed in weedy check (control) due to poor or no control of weeds. All other treatments recorded comparatively higher weed control efficiency due to lower dry weight of weeds as compared to unweeded control. The similar result suggested by Kumar *et al*. (2012) [8] in gladiolus, Jeevan *et al.* (2016) [6] in tuberose and Rathod and Venugopal (2017) [10] in tuberose cv. Prajwal.

Vegetative growth parameters

The highest plant height (89.36 cm) leaves/plant, (51.76) and spike length (78.52) were recorded in treatment 3 HW at 30, 60 and 90 days interval, followed by pre emergence application of Pendimethelin 0.75 kg/ha + 1 HW at 40 days, whereas, lowest data for vegetative growth was noted in weedy check (71.59 cm), (33.33 cm) and (58.41), respectively. The favorable effect of hand weeding and Pendimethelin + 1 HW on plant height, spike length and leaves/plant might be due to better availability of nutrients; moisture, sunlight and space for crop growth and development by reducing the crop weed competition during the plant growth period. This is conformity for vegetative growth parameters were observed by Desai (2011) [4] in gladiolus, Sharma *et al*. (2014) [11] in chrysanthemum, Jeevan *et al*. (2016) [6] in tuberose and Bala (2017) [1] in chrysanthemum with hand weeding followed by Pendimethelin + 1 HW.

Floral parameters

The significantly earliest spike emergence (110.68 days), first flowering (116.44 days) with highest number of florets/spike (47.97), spike/plant (4.81), flower weight/plant (138.47 g), flower diameter (4.49 cm), flowering duration (26.17 days) and durability of the spike in field (20.60 days) were observed in 3 HW at 30, 60 and 90 days interval, it is at par with pendimethelin @ 0.75 kg/ha + 1 HW at 40 days. Whereas, late spike emerge and flowering with lowest trend noted in weedy check (118.88 days, 124.97 days, 38.24, 3.47, 79.77 g, 3.66 cm, 18.56 days and 12.60 days), respectively. This was due to the crop plants in these treatments experienced good vegetative growth right from the early stages of growth period to the end of cropping period because of less competition of weeds for nutrients, water, space, sunlight and nutrients, which might have resulted in higher photosynthetic activity improved the number of florets per spike and other floral parameters. This is in conformity with the findings of Desai (2011) [4] in gladiolus, Sharma *et al*. (2014) [11] and Bala (2017) [1] in chrysanthemum, Jeevan *et al.* (2016) [6] and Rathod and Venugopal (2017) [10] in tuberose.

Bulb parameters

The result revealed that a highly significant difference in bulb parameters were observed among the different weed management practices during investigation. The maximum number of bulbs/plant (16.43), diameter of bulb (3.85 cm),

fresh weight of bulb (28.49 g), number of bulblets/plant (33.39) and fresh weight of bulblet (3.37 g) were recorded in 3 HW at 30, 60 and 90 days interval followed by T_3-pendimethelin @ 0.75 kg/ha + 1 HW at 40 days**,** whereas, it was minimum noted in weedy check (9.42, 2.10 cm, 15.02 g, 25.26 and 1.93 g), respectively. This might be due to the fact that the crop plants in these treatments recorded good vegetative growth during starting period to the end of cropping period because of less competition of weeds for nutrients, water, space, sunlight and nutrients which might have resulted in higher photosynthetic activity, more accumulation of food reserves in the cells resulting in enlargement of cells and which increases the number of bulb, diameter, fresh weight of bulb and bulblets. Similar result were recorded by Bhat *et al.* (2013) [2] reported that weed free and pendimethalin @ 1.0 kg/ha in gladiolus and Jain *et al.* (2015) [5] noted highest average weight of bulb/plant, bulblet/plant and diameter of bulb in tuberose cv. 'Prajwal' with the weed free treatment.

Table 1: Effect of weed management practices on weeds population parameters at 50 DAP

Treatments	Weeds counts per m^{-2}	Fresh weight of weeds m^{-2} (g)	Dry weight of weeds m^{-2} (g)	WCE (%)
Pendimethalin 0.75 kg/ha PE	21.81 (4.72)	28.62 (5.40)	10.01 (3.24)	78.93
Pendimethalin 1.0 kg/ha PE	21.20 (4.66)	27.24 (5.25)	7.33 (2.80)	84.57
Pendimethalin 0.75 kg/ha PE + 1 HW	13.14 (3.69)	20.83 (4.62)	3.28 (1.94)	93.10
Oxyfluorfen 0.50 kg/ha PE	23.48 (4.90)	31.33 (5.64)	10.86 (3.37)	77.15
Oxyfluorfen 0.75 kg/ha PE	23.19 (4.87)	30.25 (5.53)	10.49 (3.32)	77.91
Oxyfluorfen 0.50 kg/ha PE + 1 HW	14.40 (3.86)	21.04 (4.64)	6.01 (2.55)	87.36
Atrazine 1.0 kg/ha PE	27.48 (5.29)	36.84 (6.11)	15.01 (3.94)	68.40
Atrazine 1.5 kg/ha PE	26.21 (5.15)	35.68 (6.01)	14.32 (3.85)	69.86
Atrazine 1.0 kg/ha PE + 1 HW	14.76 (3.91)	21.37 (4.68)	6.15 (2.58)	87.05
Butachlor 1.0 kg/ha PE	31.08 (5.62)	41.74 (6.50)	18.54 (4.36)	60.98
Butachlor 1.5 kg/ha PE	30.09 (5.53)	40.64 (6.41)	17.84 (4.28)	62.45
Butachlor 1.0 kg/ha PE + 1 HW	16.13 (4.08)	23.01 (4.85)	6.74 (2.69)	85.81
3 HW at 30, 60 and 90 days interval	16.44 (4.12)	23.16 (4.86)	7.27 (2.79)	84.69
Weedy check (control)	85.15 (9.25)	121.56 (11.05)	47.51 (6.93)	0.00
SEm ±	0.09	0.11	0.05	0.49
CD at 5 %	0.26	0.32	0.14	1.41
CV %	3.14	3.26	2.41	1.16

* The data in parenthesis represent the transformed values of square root (n+0.5)

Table 2: Effect of weed management practices on vegetative growth and floral parameters

Treatments	Plant height (cm)	Leaves plant^{-1}	Spike length (cm)	Spike emergence (days)	First flowering (days)
Pendimethalin 0.75 kg/ha PE	84.59	41.23	71.64	112.59	118.88
Pendimethalin 1.0 kg/ha PE	85.19	44.96	72.32	112.25	118.27
Pendimethalin 0.75 kg/ha PE + 1 HW	87.75	49.36	76.51	110.88	116.84
Oxyfluorfen 0.50 kg/ha PE	81.90	40.03	68.72	113.73	120.09
Oxyfluorfen 0.75 kg/ha PE	84.38	44.23	71.54	112.96	119.18
Oxyfluorfen 0.50 kg/ha PE + 1 HW	86.88	45.43	75.04	111.21	117.10
Atrazine 1.0 kg/ha PE	82.04	38.66	68.86	113.63	119.85
Atrazine 1.5 kg/ha PE	83.59	42.63	71.31	113.34	119.77
Atrazine 1.0 kg/ha PE + 1 HW	86.54	44.69	73.36	111.67	117.43
Butachlor 1.0 kg/ha PE	78.93	35.73	65.75	114.78	120.94
Butachlor 1.5 kg/ha PE	82.16	37.63	68.98	113.39	120.35
Butachlor 1.0 kg/ha PE + 1 HW	86.07	44.23	73.56	111.99	117.88
3 HW at 30, 60 and 90 days interval	89.36	51.76	78.52	110.68	116.44
Weedy check (control)	71.59	33.33	58.41	118.88	124.97
SEm ±	2.09	1.82	2.07	1.20	1.38
CD at 5 %	6.07	5.29	6.01	3.50	4.01
CV %	4.32	7.43	5.04	1.85	2.01

Table 3: Effect of weed management practices on floral parameters

Treatments	Florets spike^{-1}	Spikes plant^{-1}	Flower wt. plant^{-1} (g)	Flower diameter (cm)	Flowering duration (days)	Durability of spike (days)
Pendimethalin 0.75 kg/ha PE	43.55	4.26	111.53	3.88	21.82	15.07
Pendimethalin 1.0 kg/ha PE	43.99	4.40	116.12	4.13	22.51	15.53
Pendimethalin 0.75 kg/ha PE + 1 HW	46.95	4.79	135.08	4.50	25.48	20.27
Oxyfluorfen 0.50 kg/ha PE	41.08	4.18	102.99	3.92	19.51	13.87
Oxyfluorfen 0.75 kg/ha PE	43.49	4.38	114.26	3.95	21.89	15.20
Oxyfluorfen 0.50 kg/ha PE + 1 HW	45.27	4.56	123.86	4.22	24.80	20.13
Atrazine 1.0 kg/ha PE	42.13	4.12	104.19	3.84	21.17	14.20
Atrazine 1.5 kg/ha PE	43.35	4.26	110.65	3.99	20.53	14.67
Atrazine 1.0 kg/ha PE + 1 HW	44.61	4.45	119.12	4.13	24.51	19.47
Butachlor 1.0 kg/ha PE	40.87	4.00	98.16	3.68	19.18	13.47
Butachlor 1.5 kg/ha PE	42.94	4.04	104.01	3.72	19.46	13.80
Butachlor 1.0 kg/ha PE + 1 HW	44.37	4.41	117.40	3.98	22.82	18.60
3 HW at 30, 60 and 90 days interval	47.97	4.81	138.47	4.49	26.17	20.60
Weedy check (control)	38.24	3.47	79.77	3.66	18.56	12.60
SEm ±	1.14	0.11	4.49	0.12	0.64	0.63
CD at 5 %	3.33	0.32	13.04	0.36	1.85	1.84
CV %	4.56	4.44	6.90	5.30	5.00	6.73

Table 4: Effect of weed management practices on bulb parameters

Treatments	Bulbs plant^{-1}	Bulbs diameter (cm)	Fresh weight of bulb (g)	Bulblets plant^{-1}	Fresh weight of bulblet (g)
Pendimethalin 0.75 kg/ha PE	13.35	2.92	23.43	29.34	2.79
Pendimethalin 1.0 kg/ha PE	13.57	3.13	24.27	30.65	2.93
Pendimethalin 0.75 kg/ha PE + 1 HW	15.80	3.65	28.11	32.73	3.29
Oxyfluorfen 0.50 kg/ha PE	12.86	2.70	19.61	27.82	2.51
Oxyfluorfen 0.75 kg/ha PE	13.20	3.07	23.83	29.76	2.92
Oxyfluorfen 0.50 kg/ha PE + 1 HW	14.82	3.36	27.43	32.44	3.23
Atrazine 1.0 kg/ha PE	13.08	2.67	20.22	26.34	2.40
Atrazine 1.5 kg/ha PE	13.19	2.89	23.02	29.18	2.58
Atrazine 1.0 kg/ha PE + 1 HW	14.17	3.31	26.14	31.26	3.23
Butachlor 1.0 kg/ha PE	11.86	2.33	16.27	25.97	2.18
Butachlor 1.5 kg/ha PE	12.19	2.45	17.17	26.12	2.29
Butachlor 1.0 kg/ha PE + 1 HW	13.15	3.15	25.56	31.06	2.94
3 HW at 30, 60 and 90 days interval	16.43	3.85	28.49	33.39	3.37
Weedy check (control)	9.42	2.10	15.02	25.26	1.93
SEm $\pm$	0.60	0.08	0.79	0.91	0.09
CD at 5 %	1.74	0.24	2.30	2.65	0.25
CV %	7.78	4.91	6.01	5.37	5.36

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