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EFFECT OF PLANTING GEOMETRY AND WEEDICIDES ON GROWTH AND YEILD OF GAILLARDIA (*Gaillardia pulchella* L.)

T. Jessy[1]*, A.V.D. Dorajeee Rao[1], Ch. Sai Ratna Sharavani[1] and K. Uma Krishna[2]

[1]Department of Floriculture and Landscaping, Dr. YSRHU-COH, Venkataramannagudem, West Godavari, Andhra Pradesh, India 534101

[2]Department of Agricultural Statistics, Dr. YSRHU-COH, Venkataramannagudem, West Godavari, Andhra Pradesh, India 534101

*Corresponding author E-mail: jessyturaka@gmail.com

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ABSTRACT

A field experiment was conducted during 2025-2026 at Dr. Y.S.R. Horticultural University, Venkataramannagudem, to study the effect of planting geometry and weed management practices on the growth and yield of gaillardia (*Gaillardia pulchella* L.). The experiment was laid out in a Factorial Randomized Block Design with three planting geometries and four weed management treatments, replicated thrice. Among planting geometries, 30 cm × 30 cm spacing recorded the maximum plant height (67.51 cm) and earliest flower bud initiation (25.18 days) whereas 45 cm × 30 cm spacing recorded the highest leaf area (29.28 cm^2), primary branches (10.52) and flowers per plant (85.05). Manual weeding consistently improved vegetative growth and flowering compared with the other weed management treatments. The combination of 30 cm × 30 cm spacing and manual weeding recorded the maximum plant height (69.59 cm) and earliest flower bud initiation (24.20 days), while 45 cm × 30 cm spacing with manual weeding produced the highest leaf area (31.68 cm^2), primary branches (11.54) and flowers per plant (92.63). However, the maximum number of flowers per plot (5,111.63) was obtained with 20 cm × 30 cm spacing combined with manual weeding. The results indicated that wider spacing favoured individual plant growth and flowering whereas closer spacing increased total flower production per plot. Thus, appropriate planting geometry combined with manual weeding can improve the growth and flower yield of gaillardia.

***Key words*:** *Gaillardia pulchella*, planting geometry, weed management, vegetative growth, flower yield.

Introduction

Floriculture has emerged as an important sector of horticulture, contributing significantly to employment, income generation and commercial flower production in India. Major loose-flower crops include rose, jasmine, marigold, chrysanthemum, aster and gaillardia, cultivated across various flower-producing states.

Gaillardia (*Gaillardia pulchella* L.), belonging to the family Asteraceae, is an attractive ornamental crop valued for its bright red, orange and yellow flowers. It is drought-tolerant, adaptable and suitable for cultivation under full sunlight and well-drained soil conditions (Srivastava and Kandpal, 2006). The crop is commercially cultivated for loose flowers, landscape gardening, flower beds, borders and floral decorations due to its prolonged flowering and prolific bloom production (Johnkilmer, 1989). Its single, semi-double and double flower forms further enhance its ornamental and commercial value (Chaudhary *et al.*, 2008). The area under flower cultivation in India was estimated to increase from 3.97 lakh ha in 2024-25 to 4.00 lakh ha in 2025–26 with production projected at 45.84 lakh tonnes (NHB, 2025–26).

Successful gaillardia production depends on appropriate agronomic practices, particularly optimum

planting geometry and effective weed management. Planting geometry influences plant population, resource utilization, light interception, nutrient availability and canopy aeration. Suitable spacing promotes balanced plant growth and may improve flower yield and quality whereas improper spacing increases competition among plants (Divyashree *et al*., 2021).

Weeds compete with gaillardia for moisture, nutrients, sunlight and growing space, thereby adversely affecting crop growth and productivity. Manual weeding and herbicide application are important weed-control methods with herbicides potentially reducing labour requirements and improving operational efficiency. However, weed-control practices must effectively suppress weeds without causing phytotoxicity to the crop. Integrating suitable planting geometry with effective weed management may improve vegetative growth, flowering, flower yield and quality.

Material and Methods

A field experiment was conducted during 2025–2026 at the PG Research Block, Department of Floriculture and Landscaping, Dr. Y.S.R. Horticultural University, College of Horticulture, Venkataramannagudem. The experiment was laid out in a Factorial Randomized Block Design (FRBD) with two factors namely planting geometry at three levels and weed control practices at four levels, making twelve treatment combinations, which were replicated thrice, thus making thirty six plots. Each plot measured 2 m × 2 m. Planting geometry comprised three spacing treatments P_1: 20 cm × 30 cm, P_2: 30 cm × 30 cm and P_3: 45 cm × 30 cm. Weed management treatments included W_1: butachlor @ 1 kg a.i ha^{-1}, W_2: pendimethalin @ 1 kg a.i ha^{-1}), W_3: manual weeding and W_4: no weeding.

Description of treatments:

P_1W_1: (20 cm × 30 cm) + (Butachlor @ 1 kg a.i ha^{-1})
P_1W_2: (20 cm×30 cm) + (Pendimethalin @ 1kg a.i ha^{-1})
P_1W_3: (20 cm × 30 cm) + (Manual Weeding)
P_1W_4: (20 cm × 30 cm) + (No Weeding)
P_2W_1: (30 cm × 30 cm) + (Butachlor @ 1kg a.i ha^{-1})
P_2W_2: (30 cm×30 cm)+(Pendimethalin @ 1kg a.i ha^{-1})
P_2W_3: (30 cm × 30 cm) + (Manual Weeding)
P_2W_4: (30 cm × 30 cm) + (No Weeding)
P_3W_1: (45 cm × 30 cm) + (Butachlor @ 1kg a.i ha^{-1})
P_3W_2: (45 cm × 30 cm)+(Pendimethalin @ 1kg a.i ha^{-1})
P_3W_3: (45 cm × 30 cm) + (Manual Weeding)
P_3W_4: (45 cm × 30 cm) + (No Weeding)

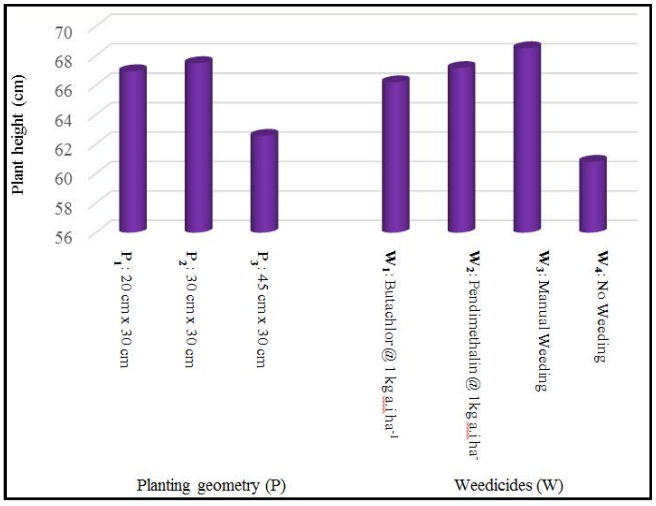


Fig. 1: Plant height (cm) as influenced by planting geometry and weedicides at 90 DAT.

Observations were recorded on five randomly selected and tagged plants in each plot at 30, 60 and 90 DAT for the growth and flower yield parameters *viz.*, plant height (cm), leaf area (cm^2), number of primary branches and days for first flower bud initiation, number of flowers per plant and number of flowers per plot were recorded at flowering. The data was analysed as per ANOVA outlined by Panse and Sukhatme (1985).

The height was measured in the five-tagged plants in each treatment from base of plant at ground level to the tip of the fully opened leaves of main stem with the help of a scale. The averages were computed and expressed in centimetre. Leaf area was measured with the help of LI 3100 leaf area meter by taking average of five leaves on tagged plants. The number of branches arising from main stem of the five tagged plants was counted. The average was computed and expressed as number of branches per plant. Number of days taken from transplanting to the visibility of first flower bud was counted to record this observation. The total number of

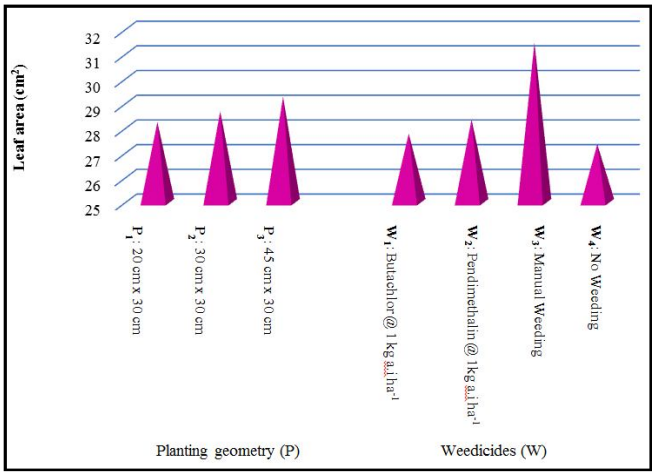


Fig. 2: Leaf area (cm^2) as influenced by planting geometry and weedicides at 90 DAT.

Table 1: Plant height (cm) as influenced by planting geometry, weedicides and their interaction at different growth stages.

Plant height (cm)															
Planting geometry (P)	**30 DAT**					**60 DAT**					**90 DAT**				
	Weedicides (W)														
	W_1	W_2	W_3	W_4	**Mean**	W_1	W_2	W_3	W_4	**Mean**	W_1	W_2	W_3	W_4	**Mean**
P_1: 20 cm × 30 cm	27.91	28.96	31.48	24.15	**28.13**	46.12	47.65	50.35	43.57	**46.92**	67.33	68.83	69.01	62.65	**66.95**
P_2: 30 cm × 30 cm	29.23	29.35	32.38	24.37	**28.83**	48.52	50.03	52.05	44.24	**48.71**	68.25	69.09	69.59	63.08	**67.51**
P_3: 45 cm × 30 cm	29.13	29.73	30.22	22.31	**27.85**	45.87	46.68	50.67	41.87	**46.27**	63.03	63.59	66.96	56.69	**62.57**
Mean	**28.76**	**29.35**	**31.36**	**23.61**	***28.27***	**46.84**	**48.12**	**51.02**	**43.22**	***47.30***	**66.20**	**67.17**	**68.52**	**60.81**	***65.68***
Factor	**SEm±**		**CD @ 5%**			**SEm±**		**CD @ 5%**			**SEm±**		**CD @ 5%**		
P	0.09		0.28			0.18		0.52			0.29		0.86		
W	0.11		0.32			0.21		0.60			0.34		1.00		
P × W	0.19		0.55			0.36		1.04			0.59		1.73		

W_1: Butachlor @ 1 kg a.i ha^{-1}; **W_2**: Pendimethalin @ 1kg a.i ha^{-1}; **W_3**: Manual Weeding; **W_4**: No Weeding

flowers harvested from tagged plants in each plot at each harvest was recorded and average number of flowers per plant was worked out. The number of flowers harvested from the plants in each plot at each harvest was recorded. The number of flowers per plot was calculated by multiplying the average number of flowers per plant by the total number of plants in each plot.

Results and Discussions

Vegetative parameters

Plant height (cm):

The highest mean plant height was recorded in P_2: 30 cm × 30 cm (67.51 cm) on par with P_1: 20 cm × 30 cm (66.95 cm), while P_3: 45 cm × 30 cm recorded the lowest height (62.57 cm). Manual weeding (W_3) produced the tallest plants (68.52 cm) whereas, no weeding (W_4) resulted in the shortest plants with a plant height of 60.81 cm. At 90 DAT, the treatment combination 30 cm × 30 cm + manual weeding (P_2W_3) recorded the maximum plant height (69.59 cm) while (45 cm × 30 cm) + no weeding (P_3W_4) recorded the lowest plant height (56.69 cm). The relevant data can be found in Table 1.

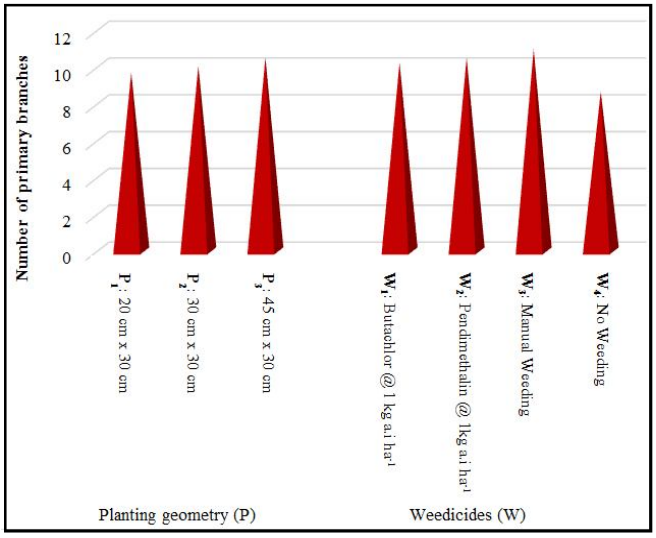


Fig. 3: Number of primary branches as influenced by planting geometry and weedicides at 90 DAT.

Comparable results were documented by Divyashree *et al.*, (2021) and Jankiram *et al.*, (2014). The superior plant height under P_2 (30 cm × 30 cm) may be attributed to a favourable balance between plant population and availability of light, water and nutrients. The marked improvement in plant height under manual weeding can be attributed to reduced competition from weeds for moisture, nutrients, space and light.

Leaf area (cm^2):

The wider spacing P_3: 45 cm × 30 cm favored leaf development which recorded the highest leaf area (29.28 cm^2). Conversely, P_1: 20 cm × 30 cm recorded the lowest value (28.25 cm^2). With respect to weed management

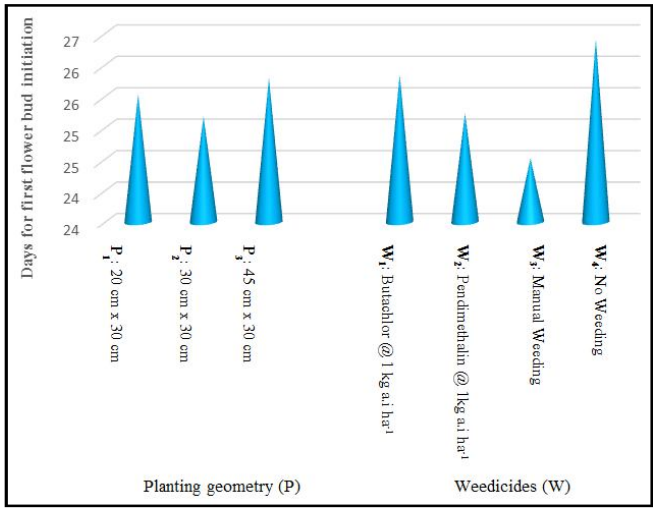


Fig. 4: Days for first flower bud initiation.

Table 2: Leaf area (cm^2) as influenced by planting geometry, weedicides and their interaction at different growth stages.

Leaf area (cm^2)															
Planting geometry (P)	**30 DAT**					**60 DAT**					**90 DAT**				
	Weedicides (W)														
	W_1	W_2	W_3	W_4	**Mean**	W_1	W_2	W_3	W_4	**Mean**	W_1	W_2	W_3	W_4	**Mean**
P_1: 20 cm × 30 cm	9.24	9.35	9.81	8.77	**9.29**	15.43	16.09	17.27	15.92	**16.18**	27.47	27.75	31.23	26.53	**28.25**
P_2: 30 cm × 30 cm	9.36	9.60	10.42	8.87	**9.56**	16.76	17.23	17.52	15.69	**16.80**	27.53	28.42	31.50	27.29	**28.69**
P_3: 45 cm × 30 cm	9.42	9.93	10.90	9.25	**9.88**	17.07	17.41	17.83	16.21	**17.13**	28.33	28.88	31.68	28.23	**29.28**
Mean	**9.34**	**9.63**	**10.38**	**8.96**	***9.58***	**16.42**	**16.91**	**17.54**	**15.94**	***16.70***	**27.78**	**28.35**	**31.47**	**27.35**	***28.74***
Factor	**SEm±**		**CD @ 5%**			**SEm±**		**CD @ 5%**			**SEm±**		**CD @ 5%**		
P	0.04		0.13			0.07		0.21			0.08		0.24		
W	0.05		0.15			0.08		0.24			0.10		0.28		
P × W	0.09		0.25			0.14		0.42			0.17		0.49		
W_1: Butachlor @ 1 kg a.i ha^{-1}; **W_2**: Pendimethalin @ 1kg a.i ha^{-1}; **W_3**: Manual Weeding; **W_4**: No Weeding															

treatments manual weeding (W_3) recorded the maximum leaf area (31.47 cm^2) whereas, no weeding (W_4) resulted in the minimum leaf area of 27.35 cm^2. The treatment combination (45 cm × 30 cm) + manual weeding (P_3W_3) recorded the highest leaf area at 90 DAT (31.68 cm^2) while (20 cm × 30 cm) + no weeding (P_1W_4) recorded minimum leaf area (26.53 cm^2). The corresponding data are presented in Table 2.

The increase in leaf area under wider spacing might be due to improved availability of space, light and other resources allowing better leaf expansion. Better weed control would further favour leaf development by reducing competition. The present response is similar with that reported by Banu *et al.*, (2022)

Number of Primary branches:

Planting geometry of 45 cm × 30 cm (P_3) recorded the highest number of primary branches (10.52) is significantly superior to P_1: 20 cm × 30 cm which recorded the lowest (9.70). Under weed management treatments manual weeding (W_3) recorded the highest (10.97) whereas, no weeding (W_4) resulted in the lowest with 8.66. The treatment combination (45 cm × 30 cm) + manual weeding (P_3W_3) recorded the highest at 90 DAT (11.54) while (20 cm × 30 cm) + no weeding (P_1W_4) recorded the lowest number of primary branches (8.40) at 90DAT. The detailed data can be found in Table 3.

The greater number of primary branches under wider spacing may be attributed to the increased availability of

Table 3: Number of primary branches as influenced by planting geometry, weedicides and their interaction at different growth stages.

Number of primary branches															
Planting geometry (P)	**30 DAT**					**60 DAT**					**90 DAT**				
	Weedicides (W)														
	W_1	W_2	W_3	W_4	**Mean**	W_1	W_2	W_3	W_4	**Mean**	W_1	W_2	W_3	W_4	**Mean**
P_1: 20 cm × 30 cm	4.510 (2.124)	4.573 (2.139)	4.630 (2.152)	3.593 (1.896)	**4.327 (2.077)**	8.167 (2.858)	8.600 (2.933)	8.967 (2.994)	7.667 (2.769)	**8.350 (2.888)**	9.833 (3.136)	10.167 (3.189)	10.400 (3.225)	8.400 (2.898)	**9.700 (3.112)**
P_2: 30 cm × 30 cm	4.537 (2.130)	4.607 (2.146)	4.853 (2.203)	3.620 (1.903)	**4.404 (2.095)**	8.747 (2.957)	8.873 (2.979)	9.467 (3.077)	8.137 (2.852)	**8.806 (2.966)**	10.367 (3.220)	10.433 (3.230)	10.967 (3.311)	8.433 (2.904)	**10.050 (3.166)**
P_3: 45 cm × 30 cm	4.607 (2.146)	4.677 (2.163)	5.103 (2.259)	3.657 (1.912)	**4.511 (2.120)**	8.867 (2.978)	8.967 (2.994)	9.810 (3.132)	8.210 (2.865)	**8.963 (2.992)**	10.500 (3.240)	10.900 (3.301)	11.537 (3.397)	9.140 (3.023)	**10.519 (3.240)**
Mean	**4.551 (2.133)**	**4.619 (2.149)**	**4.862 (2.205)**	**3.623 (1.903)**	***4.414 (2.098)***	**8.593 (2.931)**	**8.813 (2.969)**	**9.414 (3.068)**	**8.004 (2.829)**	***8.706 (2.949)***	**10.233 (3.199)**	**10.500 (3.240)**	**10.968 (3.311)**	**8.658 (2.942)**	***10.090 (3.173)***
Factor	**SEm±**		**CD @ 5%**			**SEm±**		**CD @ 5%**			**SEm±**		**CD @ 5%**		
P	0.003		0.009			0.005		0.013			0.008		0.023		
W	0.003		0.010			0.005		0.016			0.009		0.027		
P × W	0.006		0.017			0.009		0.027			0.016		0.046		
W_1: Butachlor @ 1 kg a.i ha^{-1}; **W_2**: Pendimethalin @ 1kg a.i ha^{-1}; **W_3**: Manual Weeding; **W_4**: No Weeding The parentheses values are square root transformed values.															

Table 4: Days for first flower bud initiation.

Planting geometry (P)	Days for first flower bud initiation				
	Weedicides (W)				
	W_1	W_2	W_3	W_4	Mean
P_1: 20 cm × 30 cm	25.83	25.21	24.52	26.54	**25.53**
P_2: 30 cm × 30 cm	25.54	25.08	24.20	25.91	**25.18**
P_3: 45 cm × 30 cm	26.14	25.41	24.82	26.78	**25.79**
Mean	**25.84**	**25.23**	**24.51**	**26.41**	***25.50***
Factor	SEm±		CD @ 5%		
P	0.03		0.09		
W	0.03		0.10		
P × W	0.06		0.18		

W_1: Butachlor @ 1 kg a.i ha^{-1}; **W_2**: Pendimethalin @ 1kg a.i ha^{-1}; **W_3**: Manual Weeding; **W_4**: No Weeding

space and assimilates for lateral growth. Better weed control would favour branch initiation by reducing competition. It agrees with the response reported by Dali *et al*., (2023).

Yield parameters

Days for first flower bud initiation:

Among the three levels of planting geometry, 30 cm × 30 cm (P_2) recorded the minimal days (25.18 days) and P_3: 45 cm × 30 cm recorded the maximum number of days for first flower bud initiation (25.79 days). Under weed management treatments manual weeding (W_3) recorded the minimum number of days for first flower bud initiation (24.51 days) whereas, no weeding (W_4) resulted in the more days for first flower bud initiation (26.41 days). The treatment combination (30 cm × 30 cm) + manual weeding (P_2W_3) recorded the minimal number days for first flower bud initiation (24.20 days) while (45 cm × 30 cm) + no weeding (P_3W_4) recorded the greater number of days for first flower bud initiation (26.78 days). The relevant data can be found in Table 4.

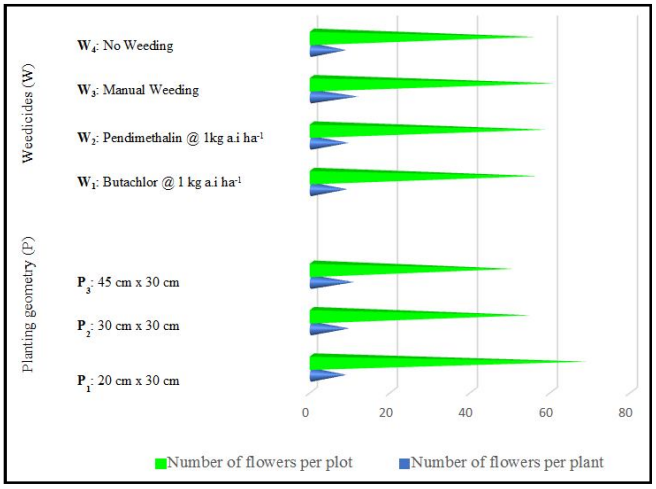


Fig. 5: Number of flowers per plant and Number of flowers per plot as influenced by planting geometry and weedicides.

Earlier bud initiation under P_2: 30 cm × 30 cm and manual weeding might be due to more favourable vegetative growth and reduced competition from weeds allowing plants to attain the physiological condition required for reproductive transition earlier where similar results were recorded by Subramanyam (1991).

Number of flowers per plant:

Under the three planting geometry levels, planting geometry of 45 cm × 30 cm (P_3) recorded a greater number of flowers (85.05) and P_1: 20 cm × 30 cm recorded minimum of (79.19). Among weed management treatments manual weeding (W_3) recorded maximum

Table 5: Number of flowers per plant and number of flowers per plot as influenced by planting geometry, weedicides and their interaction.

Planting geometry (P)	Number of flowers per plant					Number of flowers per plot				
	Weedicides (W)									
	W_1	W_2	W_3	W_4	Mean	W_1	W_2	W_3	W_4	Mean
P_1: 20 cm × 30 cm	75.20 (8.67)	82.37 (8.84)	85.17 (9.23)	74.03 (8.26)	**79.19 (8.75)**	4378.53 (66.17)	4942.60 (70.30)	5111.63 (72.23)	4413.00 (66.43)	**4711.44 (68.78)**
P_2: 30 cm × 30 cm	79.77 (8.93)	84.40 (9.19)	90.10 (10.90)	76.73 (8.76)	**82.75 (9.44)**	2875.77 (53.63)	3039.80 (55.13)	3244.27 (56.96)	2763.13 (52.57)	**2980.74 (54.57)**
P_3: 45 cm × 30 cm	82.90 (9.07)	85.27 (9.66)	92.63 (14.73)	79.40 (8.91)	**85.05 (10.59)**	2489.33 (49.89)	2558.70 (50.58)	2778.40 (52.71)	2383.33 (48.82)	**2552.44 (50.50)**
Mean	**79.29 (8.89)**	**84.01 (9.23)**	**89.30 (11.62)**	**76.72 (8.64)**	***82.33 (9.60)***	**3247.88 (56.56)**	**3513.70 (58.67)**	**3711.43 (60.63)**	**3186.49 (55.94)**	***3414.88 (57.95)***
Factor	SEm±		CD @ 5%			SEm±		CD @ 5%		
P	0.06		0.18			0.10		0.31		
W	0.07		0.20			0.12		0.36		
P × W	0.12		0.35			0.21		0.62		

W_1: Butachlor @ 1 kg a.i ha^{-1}; **W_2**: Pendimethalin @ 1kg a.i ha^{-1}; **W_3**: Manual Weeding; **W_4**: No Weeding
The parentheses values are square root transformed values.

number of flowers per plant (89.30) whereas, no weeding (W_4) resulted in the minimum of (76.72). The treatment combination (45 cm × 30 cm) + manual weeding (P_3W_3) recorded maximum number of flowers per plant (92.63) while (20 cm × 30 cm) + no weeding (P_1W_4) recorded minimum of (74.03). The corresponding data found in Table 5.

Divyashree *et al*., (2021) similarly reported higher flower yield per plant under wider spacing in gaillardia. The higher number of flowers per plant under wider spacing might be due to greater canopy development, more branching and better resource availability per plant. The advantage of manual weeding can be attributed to reduced competition, allowing greater assimilate availability for reproductive growth.

Number of flowers per plot:

In respect of planting geometry levels 20 cm × 30 cm (P_1) recorded the maximum number of flowers (4711.4) and P_3: 45 cm × 30 cm recorded the lowest of (2552.44). Among weed management treatments, manual weeding (W_3) recorded maximum number of flowers per plot (3711.43) whereas, no weeding (W_4) resulted in a minimum of (3186.49). The treatment combination (20 cm × 30 cm) + manual weeding (P_1W_3) exhibited maximum number of flowers per plot (5111.63) whereas, (45 cm × 30 cm) + no weeding (P_3W_4) showed the minimum of (2383.33). The relevant data is summarized in Table 5.

The higher number of flowers per plot under closer spacing could be attributed to the greater plant population per unit area, which compensated for any reduction in flower production at the individual plant level. Similar observations were reported by Dorajeerao and Mokashi (2012) in chrysanthemum.

Conclusion

Planting geometry and weed management practices influenced the growth, flowering and yield of gaillardia. Wider spacing of P_3: 45 cm × 30 cm with manual weeding (W_3) promoted greater leaf area and primary branching while the highest plant height was recorded under P_2: 30 cm × 30 cm with manual weeding. The earliest flower bud initiation was observed in 30 cm × 30 cm + manual weeding (P_2W_3). The maximum number of flowers per plant was recorded in 45 cm × 30 cm + manual weeding (P_3W_3) whereas the maximum number of flowers per plot was obtained in 20 cm × 30 cm + manual weeding (P_1W_3). Thus, 45 cm × 30 cm + manual weeding (P_3W_3) favoured individual plant growth and flowering while 20 cm × 30 cm + manual weeding (P_1W_3) was superior for total flower production per plot.

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