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Standardization of Spacing and NPK Levels for Growth, Yield and Quality of Gaillardia (*Gaillardia pulchella* Foug.) under Eastern Dry Zone Condition

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ABSTRACT

A field experiment was conducted during 2015-16 to standardize spacing and NPK level requirement of gaillardia comprising twelve treatment combinations. Number of branches per plant (76.13), plant spread (99.19 cm^2), leaf area (65.91 cm^2) flower head diameter (6.79 cm), petiole length (45.12 cm), corolla length (2.81 cm), 100 flowers weight (395 g), flower yield per plant (408.52 g) and shelf life of flowers (27.16 hours) were found to be statistically higher in 60 × 60 cm spacing. However, higher plant height (96.80 cm at harvest), flower yield per hectare (11.35 t) and minimum days to flowering were found in 45 × 30 cm spacing. Among varied levels of NPK F_4 (125% RDF - 225:120:90 NPK kg/ha) was recorded higher plant height (98.80 cm), plant spread (98.71 cm^2), number of branches per plant (74.18), leaf area (64.92 cm^2), flower head diameter (6.76 cm), petiole length (45.12 cm), corolla length (2.83 cm), 100 flowers weight (334.66 g), flower yield per plant (362.93 g), flower yield per hectare (15.20 t) and shelf life of flowers (27.10 h). However, significantly minimum days to flowering was in F_1 (75% RDF - 112.5:60:45 NPK kg/ha). Interaction of different levels of spacing and varied levels of NPK on flower head diameter, corolla length, yield per plant and shelf life of flowers was found to be significant.

Keywords Gaillardia, Spacing, NPK levels, Growth and Yield.

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INTRODUCTION

Gaillardia (*Gaillardia pulchella* Foug.) a member of the family Asteraceae, is native of Central and Western United States. Gaillardia is a flowering annual cultivated for its attractive flowers for varied uses like loose flowers, cut flowers, making garlands, veni, floral decorations, weddings, religious, ceremonial, social occasions and landscape garden. It is popularly known as blanket flower. It is becoming an important alternative commercial crop to chrysanthemum due to year around cultivation and similarity.

Successful production of gaillardia depends upon many factors like soil fertility, irrigation, plant density, plant protection measures, but manurial schedule and spacing plays a major role in crop production and productivity. This crop is not popular in Eastern dry zone of Karnataka and is slowly picking up due to ease of production, growing demand and price. Spacing plays an important role on growth and flowering of the plant by creating congenial environmental conditions. Proper spacing helps in availability of nutrients, aeration and light intensity by which crop can express properly in terms of quantity and enhanced quality. Among essential nutrients, nitrogen, phosphorus and potassium are the most important and are required in sufficient quantities for plant growth and flowering. Keeping all these points in view, the present investigation on "Standardization of spacing and NPK levels for growth, yield and quality of gaillardia under Eastern dry zone condition" was carried out.

MATERIALS AND METHODS

The field experiment was conducted out in the Department of Floriculture and Landscape Architecture, College of Horticulture, UHS campus, GKVK, Bengaluru during 2015-16. Three different spacings,viz., S_1 (45 × 30 cm), S_2 (60 × 45 cm) and S_3 (60 × 60 cm) and four levels of nutrients, viz., F_1 (75% recommended dose of fertilizers (RDF) - 112.5:60:45 NPK kg/ha), F_2 (100% RDF- 50:80:60 NPK kg/ha), F_3 (125% RDF- 187.5:100:75 NPK kg/ha) and F_4 (125% RDF - 225:120:90 NPK kg/ha) were planned and laid out in Factorial Randomized Complete Block Design (FRCBD) and replicated three times. Land was brought to a fine tilth by repeated ploughing and harrowing. After land preparation, layout was done as per treatments and forty days old healthy and uniformly grown seedlings were used for transplanting. Transplanting was done according to combination of the different spacing and NPK levels. Transplanting was done during evening hours and light irrigation was given immediately after transplanting. All other recommended agronomic package and practices were followed to grow a successful crop. From each treatment five plants were selected at random for recording growth parameters (plant height, plant spread, number of branches and leaf area), flowering parameters (days taken first bud appearance, first blooming and 50% flowering) quality parameters (flower head diameter, petiole length and corolla length), yield parameters (flower yield/plant, flower yield/ha, 100 flower weight) and shelf life of flowers.

RESULTS AND DISCUSSION

Effect of spacing on growth

Spacing had significant effect on growth of gaillardia is evident fromthe results. Plant height increased with decrease in spacing. Maximum plant height (96.80 cm) was recorded with spacing, S_1 (45 × 30 cm) which was on par (93.12 cm) with S_2 (60 × 45 cm) and it was recorded minimum (90.39 cm) in S_3 (60 × 60 cm). Increase in plant height at closer spacing might be due to heavy competition between plants for light resulted in elongation of main stem and also might be due to fact that the plants tends to grow vertically when they are crowded owing to shadowing effect of the plants one another (Chaudhary *et al.* 2008). Whereas, maximum plant spread (99.19 cm^2), number of branches (76.13) and leaf area (65.91 cm^2) was recorded in wider spacing of S_3 (60 × 60 cm) which were at par (96.79, 76.13 and 63.32 cm^2, respectively) with S_2 (60 × 45 cm) and it was minimum (87.55 cm^2, 58.21 and 56.41 cm^2, respectively) in closer spacing S_1 (45 × 30 cm) as indicated in Table 1. This might be due to high competition for space, nutrients, light intensity and water in closer spacing leading to poor growth of the plant (Pandey and Rao 2014).

Effect of nutrient levels on growth

The nutrient levels showed significant variations for all growth parameters studied during crop growth. Among different levels NPK, F_4 (125% RDF - 225:120:90 NPK kg/ha) was recorded higher plant height (98.80 cm at harvest), plant spread (98.71 cm^2), number of branches (74.18), leaf area (64.92 cm^2) and was on par with F_3 (Table 1) and it was recorded minimum (83.46 cm, 89.52 cm^2, 62.87 and 58.00 cm^2, respectively) in F_1 (75% RDF - 112.5:60:45 NPK kg/ha). This might be attributed to the availability of three major nutrients that may lead to an enhanced growth as a result of increased cell division,

Table 1. Effect of spacing and varied levels of NPK on vegetative parameters in gaillardia. NS= Non-significant, F= NPK levels, S=Spacing, S × F= Spacing × NPK levels, DAT= Days after transplanting. S_1= 45 × 30 cm, S_2= 60 × 45 cm, S_3= 60 × 60 cm. F_1= 112.5:60:45 kg NPK/ha, F_2= 150:80:60 kg NPK/ha, F_3= 187.5:100:75 kg NPK/ha, F_4= 225:120:90 kg NPK/ha.

	Plant height (cm)					Plant spread (cm^2)				
Treatments	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean
S_1	85.17	96.68	102.04	103.33	96.80	82.71	85.47	89.89	92.13	87.55
S_2	83.88	93.73	96.83	98.03	93.12	90.21	96.65	98.79	101.52	96.79
S_3	81.33	91.13	94.04	95.05	90.39	95.63	98.62	100.02	102.48	99.19
Mean	83.46	93.84	97.63	98.80		89.52	93.57	96.23	98.71	

Source	SEm±	CD at 5%	SEm±	CD at 5%
S	1.40	4.11	1.08	3.19
F	1.62	4.75	1.25	3.69
S × F	2.92	NS	2.17	NS

Table 1. Continued.

	Number of branches per plant					Lea area (cm^2)				
Treatments	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean
S_1	50.40	55.80	61.70	64.94	58.21	53.67	55.34	57.65	59.00	56.41
S_2	67.73	72.90	75.68	77.23	73.39	57.75	63.33	65.43	66.75	63.32
S_3	70.47	75.34	78.05	80.38	76.13	62.58	65.01	67.05	69.00	65.91
Mean	62.87	68.01	71.81	74.18		58.00	61.22	63.37	64.92	

Source	SEm±	CD at 5%	SEm ±	CD at 5%
S_1	1.03	3.03	0.91	2.67
S_2	1.19	3.50	1.05	3.09
S × F	2.06	NS	1.82	NS

cell enlargement and maximum conversion of photosynthates (Dorajeerao *et al*. 2012a, Dorajeerao *et al.* 2012b, Karetha *et al.* 2011, Sharma *et al.* 2009).

Interaction between spacing and nutrient levels

Interactions of spacing and varied levels of nutrients had no significant effect on plant height, plant spread, number of branches and leaf area. These results are in confirmation in marigold (Sharma *et al.* 2009).

Effect of spacing on flowering, quality and yield

Number of days taken to first bud appearance, days to first blooming and days to 50 % flowering were also significantly varied among different spacing levels. Days taken to first bud appearance, days to first blooming and days to 50 % flowering was delayed significantly by increasing spacing levels from 45 × 30 cm to 60 × 60 cm. Plants spaced widely, remained in vegetative phase for long time on account of lesser competition from adjacent plants for space and light, thus it might have delayed flowering. Similar results with delayed flowering parameters were in annual chrysanthemum (Dorajeerao *et al.* 2012b). Increasing levels of spacing significantly increased the flower diameter, disc diameter, petiole length and corolla length. Spacing plays a major role in production of quality flowers by providing good aeration as well as light during flowering period. Spacing of 60 × 60 cm influenced the flower diameter (6.79 cm), petiole length (45.12 cm) which was on par (43.38 cm) with S_2 (60 × 45 cm) and corolla length (2.81 cm), whereas it was found minimum (6.15 cm, 39.74 cm and 2.40 cm, respectively) in S_1 (45 × 30 cm) (Tables 2 and 3). Similar results were obtained by in annual chrysanthemum (Dorajeerao *et al*. 2012a).

Flower production in gaillardia was significantly influenced by the increasing spacing levels. 100

Table 2. Effect of spacing and NPK levels on flowering parameters of gaillardia. NS= Non-significant, F= NPK levels, S=Spacing, S ×F= Spacing × NPK levels, DAT= Days after transplanting. S_1= 45 × 30 cm, S_2= 60 × 45 cm, S_3= 60 × 60 cm. F_1= 112.5:60:45 kg NPK/ha, F_2= 150:80:60 kg NPK/ha, F_3= 187.5:100:75 kg NPK/ha, F_4= 225:120:90 kg NPK/ha.

	Days to first bud appearance					Days to first blooming					Days to 50 % flowering				
Treatment	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean
S_1	29.33	31.00	35.33	35.67	32.83	39.67	40.67	45.33	45.67	42.83	49.67	51.00	55.33	55.67	52.92
S_2	36.33	37.33	42.00	43.67	39.83	46.33	48.00	52.00	53.67	50.00	56.67	57.67	62.00	63.67	60.00
S_3	44.00	45.00	48.67	49.67	46.83	54.00	55.00	59.00	60.00	57.00	64.00	65.67	68.87	71.00	67.33
Mean	36.56	37.77	42.00	43.00		46.67	47.88	52.11	53.11		56.78	58.11	62.00	63.44	

Source	SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%
S	1.52	4.47	1.50	4.41	1.50	4.39
F	1.76	5.17	1.73	5.09	1.73	5.08
S × F	3.05	NS	3.00	NS	3.00	NS

flowers weight and flower yield per plant recorded maximum (395 g and 408.52 g, respectively) in S_3 (60 × 60 cm) and it was minimum (249.00 g and 216.48 g, respectively) in S_1 (45 × 30 cm). Maximum yield per plant at wider spacing might be due to fact that, in wider spacing the number of branches per plant was more which in turn lead to more number of flowers per plant and flower yield per plant. Flower yield per hectare was increased with decreasing levels of spacing. It was recorded maximum (16.03 t) in S_1 (45 × 30 cm) which was followed by S_2 - 60 × 45 cm (12.01 t/ha) and minimum (11.35 t) in S_3 (60 × 60 cm). This might be due to the more plant population per unit area in closer spacing as compared to wider spacing. Similar was (Dorajeerao *et al.* 2012b) in annual chrysanthemum. In present study, spacing of 60 × 60 cm resulted in maximum shelf life (27.16 hours) of the flowers and it was found minimum (21.15 hours) in S_1 (45 × 30 cm), this might be due to spacing played major role in production of quality flowers by providing good aeration as well as light during flowering period. Similar findingwas in annual chrysanthemum (Dorajeerao *et al*. 2012b).

Effect of NPK levels on flowering, quality and yield

In the present study increasing levels of NPK 225:120:90 kg per hectare significantly delayed the first bud appearance, days to first blooming and days to 50 % flowering. Minimum days to flowering was statistically found in F_1 (75% RDF - 112.5:60:45 NPK kg/ha). This might be due to the fact that, ample NPK promotes excessive vegetative growth and

Table 3. Effect of spacing and NPK levels on different flower parameters of gaillardia. NS= Non-significant, F= NPK levels, S=Spacing, S ×F= Spacing × NPK levels. S_1= 45 × 30 cm, S_2= 60 × 45 cm, S_3= 60 × 60 cm. F_1= 112.5:60:45 kg NPK/ha, F_2= 150:80:60 kg NPK/ha, F_3= 187.5:100:75 kg NPK/ha, F_4= 225:120:90 kg NPK/ha.

	Flower head diameter (cm)					Petiole length (cm)					Corolla length (cm)				
Treatments	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean
S_1	5.97	6.12	6.17	6.33	6.15	36.43	39.33	41.03	42.17	39.74	2.19	2.39	2.48	2.55	2.40
S_2	6.15	6.48	6.67	6.81	6.53	40.00	42.67	44.67	46.20	43.38	2.33	2.77	2.90	2.92	2.73
S_3	6.26	6.72	7.04	7.13	6.79	42.13	44.67	46.67	47.00	45.12	2.47	2.80	2.93	3.02	2.81
Mean	6.13	6.43	6.62	6.76		39.52	42.22	44.12	45.12		2.33	2.65	2.77	2.83	

Source	SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%
S	0.04	0.12	0.71	2.10	0.02	0.06
F	0.05	0.14	0.82	2.42	0.02	0.07
S × F	0.08	0.23	1.43	NS	0.04	0.12

Table 4. Effect of spacing and NPK levels on 100 flowers weight (g), flower yield per plant (g),yield per hectare (t) and shelf life of flowers (hours) in gaillardia. NS= Non-significant, F= NPK levels, S=Spacing, S × F= Spacing × NPK levels. S_1= 45 × 30 cm, S_2= 60 × 45 cm, S_3= 60 × 60 cm. F_1= 112.5:60:45 kg NPK/ha, F_2= 150:80:60 kg NPK/ha, F_3= 187.5:100:75 kg NPK/ha, F_4= 225:120:90 kg NPK/ha.

	100 flowers weight (g)					Yield per plant (g)				
Treatments	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean
S_1	224.00	236.00	263.00	273.00	249.00	176.40	199.88	234.45	255.19	216.48
S_2	280.00	290.00	316.00	336.00	336.00	270.90	296.88	331.34	367.41	316.63
S_3	343.00	356.00	380.00	395.00	395.00	353.56	384.97	429.35	466.20	408.52
Mean	282.33	294.00	319.66	334.66		266.95	293.91	331.71	362.93	
Source		SEm±		CD at 5%			SEm±		CD at 5%	
S		2.40		7.06			2.34		6.86	
F		2.78		8.16			2.70		7.92	
S × F		4.81		NS			4.68		13.72	

Table 4. Continued.

	Yield per hectare (t)					Shelf life of flowers (hours)				
Treatments	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean
S_1	13.06	14.80	17.36	18.90	16.03	18.98	20.30	22.33	23.00	21.15
S_2	10.03	11.99	12.27	13.75	12.01	20.81	24.72	27.82	28.15	25.37
S_3	9.82	10.69	11.92	12.95	11.35	23.50	26.50	28.50	30.15	27.16
Mean	10.97	12.49	13.85	15.20		21.10	23.84	26.22	27.10	
Source		SEm±		CD at 5%			SEm±		CD at 5%	
S		0.29		0.85			0.19		0.56	
F		0.33		0.98			0.22		0.65	
S × F		0.58		NS			0.38		1.13	

delays flowering, while deficient nutrition causes thrifty growth and leads to early flowering. Delay in flowering due to higher levels of NPK was reported previously in annual chrysanthemum (Dorajeerao *et al.* 2012a). NPK at the higher level of 225:120:90 kg per hectare increased the flower head diameter (6.76 cm), petiole length (45.12 cm), corolla length (2.83 cm), 100 flowers weight (334.66 g), flower yield per plant (362.93 g), flower yield per hectare (15.20 t) and shelf life of flowers (27.10 h). Whereas, minimum flower head diameter (6.13 cm), petiole length (39.52 cm), corolla length (2.33 cm), 100 flowers weight (282.33 g), flower yield per plant (266.95g), flower yield per hectare (10.97 t) and shelf life of flowers (21.10 h) was found in F_1 (75% RDF - 112.5:60:45 NPK kg/ha) as presented in Table 4. The growth of sink tissue and organs (in present case, the flower) depends on the supply of photosythates from source leaves. Application of NPK might have accelerated photosynthesis by increasing the source size (number of branches and leaf area), thereby providing the developing flowers with more photosythates, which might have resulted in increased cell division and cell expansion of flower tissues. Similar results were reported in gaillardia (Karetha *et al.* 2011).

Interaction between spacing and nutrient levels

Interaction effect due to spacing and NPK levels did not cause significant variation with respect to days to first bud appearance, days to first blooming, days to 50 % flowering, flower petiole length, 100 flowers weight and flower yield per hectare. Interaction effect of spacing and NPK levels had significant influence on flower head diameter, corolla length, yield per plant and shelf life of flowers it was maximum (7.13 cm, 3.02 cm, 466.20 g/plant and 30.15 h, respectively) in the treatment combination of S_3F_4 (60 × 60 cm, 225:120:90 kg NPK/ha) and it was minimum (5.97 cm, 2.19 cm, 176.40 g/plant and 18.98 hours, respectively) in S_1F_1 (45 × 30 cm,112.5:60:45 NPK/ha) treatment combination.

CONCLUSION

From study it can be concluded that the combination of closer spacing 45 × 30 cm and higher dosage of nitrogen, phosphorus and potassium at 225:120:90 kg NPK/ha was beneficial to get maximum flower yield per hectare. Whereas, wider spacing 60 × 60 cm with 225:120:90 kg NPK/ha best to get good vegetative growth, superior quality of flowers.

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