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Labdhi Dedhia
M.Sc. Student, Department of Horticulture, College of Horticulture, Pune, Maharashtra, India

Subhash Bhalekar
Professor: Department of Horticulture, College of Agriculture, Pune, Maharashtra, India

Priyanka Adate
M.Sc. Student, Department of Horticulture, College of Horticulture, Pune, Maharashtra, India

Corresponding Author:
Labdhi Dedhia
M.Sc. Student, Department of Horticulture, College of Horticulture, Pune, Maharashtra, India

Effect of different nitrogen levels on growth, yield and yield attributes of gaillardia (*Gaillardia pulchella* L.) cv. MG-9-1

Labdhi Dedhia, Subhash Bhalekar and Priyanka Adate

Abstract
The present investigation was conducted on silty clay loam soil at Modibaug Garden, College of Horticulture, Pune, during the *kharif* season of 2019-2020 to study the effect of different nitrogen levels on growth, yield and yield attributes of gaillardia (*Gaillardia pulchella* L.) cv. MG- 9-1. The experiment was laid in Randomized Block Design with three replications comprising of seven treatments with different levels of nitrogen (0, 50,100,150, 200, 250 and 300 kg N/ha) and phosphorous and potash each at 80 kg /ha The treatment comprising of 200 kg nitrogen, 80 kg of each phosphorous and potassium per hectare was optimum for higher growth characters like plant height (cm), plant spread (cm), number of branches and fresh and dry weight of plant (kg), quality flower parameters like diameter of flower (cm), number of ray florets per flower and vase and storage life of flower (hrs.) and yield parameters like number of flowers per plant, weight of flowers per plant (g), yield of flowers per plant (kg) and yield of flowers per ha (q), which was found at par with 250:80:80 NPK kg/ha. Therefore, based on the present study, it is concluded that for getting good quality flower yield of gaillardia cv. MG 9-1, application of 200 kg nitrogen, 80 Kg of each phosphorous and potassium is recommended.

Keywords: Gaillardia, *Gaillardia pulchella* L., nitrogen content, yield, flower quality

Introduction

Gaillardia (*Gaillardia pulchella*) is a member of Asteraceae family with 18 gametic and 36 somatic chromosomes. It is an herbaceous annual or short-lived perennial and is native to Central and Western United States (Helen *et al*. 2007) [8]. It is popularly known as a blanket flower or fire wheel and is one of the hardiest annuals which can be grown in the garden under a wide variety of soil and climatic conditions. Gaillardia flourishes well in any garden soil and can withstand high light intensities, high temperature and drought better than most flowering plants. It is also tolerant to salinity (Tija and Rose, 1988) [25]. Besides its utility in landscape and cut flowers, gaillardia is useful in reducing erosion in coastal dune areas.

The successful commercial flower production of gaillardia depends upon many factors like soil fertility, availability of irrigation, plant density, plant protection measures followed *etc*. However, the manurial schedule plays a vital role in the production of the gaillardia crop. Proper fertilization, particularly nitrogen (N), is one of the decisive factors influencing the growth and flowering of perennial plants cultivated in containers. Nitrogen deficiency reduces stem elongation, leaf area, leaf or canopy photosynthesis, dry matter accumulation and leaf chlorophyll content (Bar-Tar *et al*., 2001: Zhao *et al.*, 2003) [4, 26], while excessive application of N usually increases input cost and can diminish plant and water quality.

In view of its importance and ease of cultivation, nutritional management of the gaillardia crop is one of the important factors that can manifest the performance of the crop. But there is a lack of information concerning its nutritional requirements. Thus it is imperative to work out a specific combination of nutrients, which might enable the gaillardia growers to harvest the maximum possible economic yields. Keeping these facts in mind, the present experiment was formulated to standardize the optimum NPK dosage for gaillardia.

Materials and Methods

The present investigation on "Effect of different nitrogen levels on growth yield and yield attributes of gaillardia. (*Gaillardia pulchella* L.) cv. MG-9-1" was carried out in Modibaug Garden of Horticulture Section, Mahatma Phule Krishi Vidyapeeth, College of Agriculture,

Shivajinagar, Pune during the *kharif* season of 2019-2020.
Pune is situated in mid-west Maharashtra at an altitude of 559 m above MSL. It is located in a tropical region at 18.32^0 N latitude and 73.51^0 E longitudes the average annual rainfall in this area is 650-750 mm and is normally distributed from June to October. The maximum temperature ranges between 34^0C to 40^0C in summer but with the onset of monsoon, it drops down to around 27 ^{0}C. The average maximum and minimum temperature recorded during the period of the experiment was 32.1^0 C and 18.5 ^{0}C, respectively. The relative humidity during the crop growth period ranged between 42 to 82 percent.
The experiment comprising seven treatments with different levels of nitrogen (0, 50, 100, 150, 200, 250 and 300 kg N/ha) and phosphorous and potash each at 80 kg /ha were tested in Randomized Block Design with three replications. The cultivar MG-9-1 was used in the experiment and plants were planted at 60 cm × 45 cm with a plot size of 2.4 m × 2.7 m. The fertilizers were supplied in the form of urea, single super phosphate and murate of potash to each of the plots.

Statistical Analysis
The data recorded on each character were analyzed by the ANOVA technique as described by Panse and Sukhatme (1967). The statistical analysis was carried out by using OP-STAT Software available from the website of CCS-HAU, Hisar.

Results and Discussion
The findings of the present study as well as relevant discussion have been presented under the following heads:

Growth Characters
The effect of different nitrogen levels showed significant treatment differences for various growth characters and is presented in Table 1.

Plant height (cm)
The plant height was recorded in centimeters at 90, 120 and 150 DAT (days after transplanting), the treatment T_7 (300 kg N/ha) recorded maximum plant height 88.80 cm and 99.56 cm respectively at 90 and 120 DAT respectively, which was found statistically at par with T_4 (82.28 cm and 96.24 cm), T_5 (83.90 cm and 98.73 cm) and T_6 (82.47cm and.74 cm). At 150 DAT the maximum plant height of 111.77 cm was recorded in treatment T_6 (250 kg N/ha), which was found at par with treatment T_4 (104.56 cm), T_5 (108.55 cm) and T_7 (109.47 cm). Thus, higher doses of nitrogen from 0 kg N/ha to 300 kg N/ha had improved cell division, which resulted in greater plant height. The core function of nitrogen is the initiation of meristematic activity of plants also, increases the passage of metabolites and photosynthesis in the plant, which enables the plant to have quick and better upward vegetative growth. The present findings in respect of plant height, in general, are in agreement with those earlier reported by Sowmyamala (2013) [22], Gawade (2016) [6], Pawar (2019) [20] in gaillardia, Mali (2013) [13], Joshi (2014) [7], P. Ravi Teja *et al.* (2017) [15] in chrysanthemum, Maheta (2015) [12] in china aster.

Plant spread (cm)
Plant spread in East-West and North-South directions were measured at 90 DAT. The maximum plant spread was recorded in the treatment T_6 (250 kg N/ha) in both E-W (67.38 cm) and N-S (58.71 cm) direction and the treatments T_4 (E-W 62.5 cm and N-S 54.86 cm), T_5 (E-W 65.76 cm and N-S 56 cm) and T_7 (E-W 67.07 cm and N-S 57.23 cm), was at par with it. The rise in plant spread may be attributed to the association of nitrogen in the synthesis of protoplasm and primarily in the formation of amino acids and increase in auxin activities due to nitrogen fertilization. This difference in plant spread was may be due to respective differences in treatments and similar results were obtained by Paghdar (2013) [16], Sowmyamala (2013) [22], Parihar (2014) [19], Gawade (2016) [6], Pawar (2019) [20] in gaillardia, Maheta (2015) [12] in china aster, Abhipsa (2018) [2] in marigold.

Number of branches per plant (primary and secondary)
The number of primary and secondary branches were calculated at 90 DAT, and the maximum number of primary branches (21.66) and the number of secondary branches per plant (59.66) was recorded in treatment T_5 (200 kg N/ha) and treatment T_6 (19.44 and 52.88) was statistically at par with it. Similarly, the fresh weight of the plant (3.28 kg), recorded the highest magnitude in the treatment T_6 (250 kg N/ha) which was at statistically par with T_5 (2.76 kg) and T_7 (3.71 kg). While the dry weight of the plant (1.05 kg) was recorded highest in the treatment T_6 (250 kg N/ha). Nitrogen supply to roots is found to stimulate the production and export of cytokine to the shoots (Wagner and Michael, 1971). The increased level of cytokinins in plants might have caused the lateral buds to sprout giving more lateral branches. These results are in agreement with Awchar (2010) [3], Paghdar (2013) [16], Gawade (2016) [6], Pawar (2019) [20] in gaillardia, Maharnor *et al.* (2011) [11] in marigold, Mali (2013) [13] in chrysanthemum.

Fresh and Dry weight of plants (kg)
The observation on the fresh and dry weight of plants was recorded at the time of the last harvest. The highest fresh weight of (3.28 kg) and dry weight (1.05 kg) per plant were recorded in the treatment T_6 (250 NPK kg/ha), whereas minimum fresh weight (2.43 kg) and dry weight (0.78 kg) per plant were recorded in control with (0 NPK kg/ha). The surge in vegetative growth might be due to an increase in plant height, plant spread and the number of branches per plant. Similar findings have been reported by Karetha (2011) [10], Parihar (2014) [19] in gaillardia, Mohanty, Srichandan *et al.* (2018) [14] in marigold and Dorajeerao *et al.* (2010) [5] in chrysanthemum.

Flowering Characters
There were significant differences for all the flowering-related traits under study across different treatments the data presented in Table 2.

Days to initiation of flowering (days)
The treatment T_1 (0 kg N/ha) recorded early flowering (53.39 days), which was found at par with the treatment T_2 (50 kg N/ha) which required (53.66 days) for initiation of flowering when compared with all other treatments. The maximum days for initiation of flowering (59.85 days) was noticed in the treatment T_7 (300 kg N/ha). The deviation in the average days required for initiation of flowering occurred due to the source-sink relationship determined by phytohormones in a more or less specific manner. Similar observations have been reported by Patel *et al.* (2010) [18], Paghdar (2013) [16], Sowmyamala (2013) [22], Parihar (2014) [19] in gaillardia, Maheta 2015) [12] in China aster and Shafiullah *et al*. (2013) in marigold.

Days to 50 percent flowering (days)
The number of days taken for 50% flowering ranged from 65 to 71 days. The treatment T_1 (0 kg N/ha) was recorded (65 days) for 50% flowering and which was early and was found at par with the treatments T_2 (66.33days), T_3 (67.33days) and T_4 (67.33days). The maximum days to 50 percent flowering (71.33 days) was recorded in the treatment T_7 (300 kg N/ha). Fluctuations in phytohormones are the main reason for flower formation balance. The distinction might be due to better translocation of photosynthates from source to sink. The findings obtained are in correlation with Kanesh (2005) [9], Patel (2010) [18] in gaillardia, Tembhare (2014), Maheta (2015) [12] in China aster, Abhipsa (2018) [2] in marigold and Mali (2013) [13] in chrysanthemum.

Days to first flower picking (days)
The treatment T_1 control showed early (68 days) for first flower picking. The treatment T_7 (300 kg N/ha) recorded more number (74.33 days) for first flower picking.

Mean flower diameter (cm)
The highest flower diameter of (6.91 cm), was recorded in the treatment T_5 (200 kg N/ha), which was statistically at par with the treatment T_6 (6.52 cm). The increment in nitrogen level beyond 200 kg/ha, did not fetch any significant improvement in the diameter of the flower. The minimum average flower diameter of (5.28 cm) was observed in the treatment T_1 (0 kg N/ha). The balanced application of fertilizers resulted in increased carbohydrate assimilation which underwent hydrolysis and got converted into reducing sugars which ultimately helped in increasing flower size. The present findings in respect of flower diameter are in close affirmative with Gawade (2016) [6], Salve (2017) [21], and Pawar (2019) [20] in gaillardia, Abhipsa (2018) [2] in marigold.

Mean number of ray florets per flower
The treatment T_5 (200 kg N/ha) recorded a greater (155.70) number of ray florets/ flower, which was statistically at par with the treatments *viz*., T_4 (128.40), T_6 (147.08) and T_7 (138.38) and least number of ray floret/ flower (81) were observed in the treatment T_1 (0 kg N/ha). Although, the ray florets being a genetic factor, the variation in the number of ray florets per flower may be due to the fact that, nitrogen increases the transport of metabolites and photosynthesis in the plant. The results recorded in the present investigation are in agreement with Gawade (2016) [6], Salve (2017) [21] and Pawar (2019) [20] in gaillardia.

Yield Characters
The data presented in Table 3 reveals significant differences for the yield traits under study across different treatments.

Number of flowers per plant
The treatment T_5 (200 kg N/ha) recorded more number of flower/plant (165.54) which was found to be the highest, however it was at par with the treatment T_6 (250 kg N/ha) and showed (146.71) flowers/plant. The minimum (130.32) number of flowers/plant was observed in the control treatment T_1 (0 kg N/ha). The variation in the number of flowers per plant found in different treatments might be due to the number of branches, spread of the plant, genetic factors and environmental conditions. This finding were similar with Patel (2010) [18], Paghdar (2013) [16], Sowmyamalal (2013) [22], Parihar (2014) [19], in gaillardia, Maheta (2015) [12] in china aster, Abhipsa (2018) [2] in marigold.

Weight of flowers per plant (g)
The treatment T_5 (200 kg N/ha) recorded the highest flower yield per plant (613.33 g) but was at par with the treatment T_6 (523 g). Nitrogen levels beyond 200 kg/ha did not illustrate any drastic improvement in the weight of flowers per plant. The lowest weight of flowers per plant (373.33 g) was observed in the treatment T_1 (0 kg N/ha). An increase in plant height and number of branches per plant due to optimum nitrogen application might result in the maximum weight of flowers per plant. These findings of the present study coincide with those obtained by Patel (2010) [18], in gaillardia, Mali (2013) [13], P.Ravi Teja *et al.* (2016) in chrysanthemum.

Weight of 100 flowers (g)
The average weight of 100 flowers varied from 287.08 g to 368.74 g. The highest weight of 100 flowers was (368.74 g) registered in treatment T_5 (200 kg N/ha), but it was found at par with the treatment T_3 (323.56 g), T_4 (344.34 g), T_6 (348.29g) and T_7 (323.02 g). The lowest weight of 100 flowers was (287.08 g) registered in control treatment T_1 (0 kg N/ha). This variation recorded in weight of 100 flowers recorded may be due to flower diameter, the number of ray florets, genetic factors and environmental conditions. Similar findings were also reported by Agale (2012) [1], Gawade (2016) [6], Salve (2017) [21] and Pawar (2019) [20] in gaillardia.

Yield of flowers per plot (kg)
The treatment T_5 (200 kg N/ha) recorded the significantly highest (14.69 kg) yield of flowers per plot, but it was at par with the treatment T_6 (12.55 kg). The lowest yield of flowers per plot was observed (8.99 kg) in control treatment T_1 (0 kg N/ha). The yield of flowers per plot was improved nitrogen application up to 200 kg N/ha and beyond that, the yield of flowers per plot was seen declining. These findings of the present study coincide with those obtained by Karetha (2011) [10], Patel (2010) [18] in gaillardia, Mali (2013) [13], P. Ravi Teja *et al.* (2016) in chrysanthemum.

Yield of flowers per hectare (quintals)
The treatment T_5 (200 kg N/ha) recorded a flower yield of (222.70 q/ha) which was found to be the highest yield of flowers per hectare among the treatments under study, but treatment T_6 (193.72 q) were found to be at par with T_5. The lowest yield of flowers per hectare was (138.79 q/ha) observed in treatment control T_1 (0 kg N/ha). The significant variation in the yield of flowers per hectare might be due to the number of flowers, weight of the flowers per plant, weight of the flowers per plot and genetic makeup and environmental conditions. Thus, a copious supply of nitrogen enhanced the photosynthetic activity of plants; ultimately increasing the carbohydrates assimilates which leads to acceleration in flower yield.
This finding of the present investigation in agreement with those obtained by Kanesh (2005) [9], Karetha (2011) [10], Patel (2010) [18] in gaillardia, P. Ravi Teja *et al.* (2016), in chrysanthemum and Maheta (2015) [12] in china aster.

Vase life and Shelf life (hrs.)
Different levels of nitrogen had a significant impact on the vase and shelf-life of the flowers. It is quite apparent from the data in Table 3 that higher vase life of cut flowers (111.84 hrs.) and the highest storage life of loose flowers (63.60 hrs.)

were recorded in the treatment T_5 (200 kg N/ha) The storage life of loose flowers recorded in the treatment T_5 (200 kg N/ha) was statistically at par with the treatments T_4 (55.68 hrs.), T_6 (60.48 hrs.) and T_7 (59.52 hrs.)

Nitrogen being a fundamental element of protoplasm and chlorophyll, thus its increased rates might have permitted more accumulation of carbohydrates in the flower stalks, which might have been utilized for improving vase life. These findings were closely associated with the findings of Karetha *et al.* (2011) [10], Paghdar (2013) [16], Parihar (2014) [19], Gawade (2016) [6], Salve (2017) [21] and Pawar (2019) [20] in gaillardia.

Table 1: Effect of nitrogen levels on different growth characters of gaillardia cv. MG 9-1

Treatment	Plant Height (cm)			Mean plant spread (cm)		Number of branches /plant		Mean fresh weight/ plant (kg)	Mean dry weight/ plant (kg)
	90 DAT*	120 DAT*	150 DAT*	E-W	N-S	Primary branches	Secondary branches		
T_1 - 00:80:80 NPK (Kg/ha)	72.09	86.56	96.66	52.98	43.23	10.77	28.55	2.43	0.78
T_2 - 50:80:80 NPK (Kg/ha)	81.10	90.33	98.22	53.37	44.84	13.22	30.99	2.58	0.82
T_3 - 100:80:80 NPK (Kg/ha)	79.67	93.19	101.25	55.89	48.23	16.22	35.56	2.59	0.79
T_4 - 150:80:80 NPK (Kg/ha)	82.28	96.24	104.56	62.5	54.86	17.44	37.45	2.61	0.81
T_5 - 200:80:80 NPK (Kg/ha)	83.90	98.73	108.55	65.76	56.0	21.66	59.66	2.76	0.78
T_6 -250:80:80 NPK (Kg/ha)	82.47	97.74	111.77	67.38	58.71	19.44	52.88	3.28	1.05
T_7 -300:80:80 NPK (Kg/ha)	88.80	99.56	109.47	67.07	57.23	18.33	49.66	3.17	0.89
SE(m)±	2.69	2.77	3.32	3.55	3.14	0.63	2.78	0.19	0.05
Critical Difference at 5%	8.28	8.53	10.23	10.12	10.7	1.94	8.55	0.57	0.14

Table 2: Effect of different nitrogen levels on flowering characters of gaillardia cv. MG 9-1

Treatments	Days to initiation of flowering (days)	Days to 50% flowering (days)	Days for first flower picking (days)	Mean flower diameter (cm)	Mean number of ray florets/flower
T_1 - 00:80:80 NPK (Kg/ha)	53.39	65.00	68.00	5.28	81.00
T_2 - 50:80:80 NPK (Kg/ha)	53.66	66.33	69.33	5.37	96.40
T_3 - 100:80:80 NPK (Kg/ha)	57.19	67.33	70.33	5.75	114.67
T_4 - 150:80:80 NPK (Kg/ha)	58.18	67.33	70.33	5.67	128.40
T_5 - 200:80:80 NPK (Kg/ha)	57.66	68.67	71.67	6.91	155.70
T_6 -250:80:80 NPK (Kg/ha)	58.95	68.67	71.67	6.52	147.08
T_7 -300:80:80 NPK (Kg/ha)	59.85	71.33	74.33	6.14	138.38
SE (m)±	1.2	1.13	1.13	0.21	11.83
Critical Difference at 5%	3.69	3.49	3.48	0.63	36.44

Table 3: Effect of different nitrogen levels on yield characters of gaillardia cv. MG 9-1

Treatments	Number of flowers per plant	Weight of flowers per plant (g)	Weight of 100 flowers (g)	Yield of flowers/ plot (kg)	Yield of flowers (q/ha)	Cut flowers (hrs.)	Loose flowers (hrs.)
T_1 - 00:80:80 NPK (Kg/ha)	130.32	373.39	287.08	8.99	138.79	72.48	31.68
T_2 - 50:80:80 NPK (Kg/ha)	132.31	403.33	303.20	9.65	149.00	93.6	32.88
T_3 - 100:80:80 NPK (Kg/ha)	139.64	450.00	323.56	10.82	166.98	102.48	42
T_4 - 150:80:80 NPK (Kg/ha)	143.75	506.15	344.34	12.15	187.50	104.16	55.68
T_5 - 200:80:80 NPK (Kg/ha)	165.54	613.33	368.74	14.69	226.70	111.84	63.60
T_6 -250:80:80 NPK (Kg/ha)	146.71	523	348.29	12.55	193.72	107.04	60.48
T_7 -300:80:80 NPK (Kg/ha)	138.72	450.00	323.02	10.75	165.96	109.20	59.52
SE(m)±	6.47	32.53	15.38	0.80	12.03	0.1	3.05
Critical Difference at 5%	19.44	100.24	47.38	2.46	37.90	0.3	9.39

Based on the present field experiment, it is concluded that, for obtaining good quality flower yield of gaillardia cv. MG 9-1, under silty clay loam soil, application of 200 kg nitrogen, 80 Kg of each phosphorous and potassium per hectare is optimum fertilizer dose for better growth characters like plant height (cm), plant spread (cm), number of branches and fresh and dry weight of plant (kg), quality flower parameters like diameter of flower (cm), number of ray florets per flower and vase and storage life of flower (hrs.) and yield parameters like number of flowers per plant, weight of flowers per plant (g), yield of flowers per plant (kg) and yield of flowers per ha (q).

Author contributions

SG hypothesized the experiment; LD carried out the trial and recorded observations under the guidance of SG; LD and SG performed the statistical analysis and wrote the manuscript.

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