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EFFECT OF INTEGRATED NITROGEN MANAGEMENT THROUGH RDN AND NANO UREA FOLIAR SPRAY ON YIELD AND ECONOMICS OF GAILLARDIA (*Gaillardia pulchella*) cv. LOCAL

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ABSTRACT

A field experiment was conducted during Summer, 2024 at the Horticulture Polytechnic, ASPEE College of Horticulture, Navsari Agricultural University, Navsari, Gujarat, India. This study investigated the effect of integrated nitrogen management through RDN and Nano Urea foliar spray on yield and economics of gaillardia (*Gaillardia pulchella*) cv. Local. The experiment was laid out in Randomized Block Design (RBD) with seven treatments replicated thrice. The treatments were T_1:100% RDN, T_2: 50% RDN + Nano Urea @ 2 ml/lit, T_3: 75% RDN + Nano Urea @ 2 ml/lit, T_4: 50% RDN + Nano Urea @ 3 ml/lit, T_5: 75% RDN + Nano Urea @ 3 ml/lit, T_6: 50% RDN + Nano Urea @ 4 ml/lit, T_7: 75% RDN + Nano Urea @ 4 ml/lit. Among the treatments, combination of 50% RDN + Nano Urea @ 2 ml/lit water recorded minimum days to first bud appearance (37.56 days). The same treatment also produced maximum flower diameter (65.18 mm), flowering duration (57.92 days), flower longevity (12.27 days), shelf life (9.08 hours), number of flowers per plant (74.14), average weight flowers (2.19 g), total flower weight per plant (162.36 g), flower yield per plot (2597.86 g) and flower yield per hectare (18034.72 kg), net return (` 4,53,800) and BCR (2.56).

Key words : Gaillardia, Nano Urea, RDN, Foliar spray.

Introduction

Floriculture is the flourishing discipline of cultivating and marketing of flowers and ornamental plants, emerged as a promising industry in India. Flowers are an integral part of human life due to their diversity in beauty, colour, form, texture and fragrance. Without flowers, the world would not have been so beautiful, as charming and as cherishing today. They have a high aesthetic value in our daily lives because they represent purity, beauty, tranquillity, love and passion. Nowadays, Floriculture is fast growing and highly competitive industry with the continuous growing of new varieties and introduction of new flower crops. Our country currently occupies about 285 thousand ha area for floriculture with loose flower production around 22.84 Lakh MT and cut flower production around 9.47 Lakh MT during 2024-25. Total floriculture export for India during 2024-25 was 717.82 crore and major importing countries are USA, Netherlands, UAE, UK and Germany. Currently, India has more than 300 export-oriented units (EOUs) working in floriculture. (Anonymous, 2025a).

Gaillardia (*Gaillardia pulchella*) flower commonly referred to as 'Fire Wheel' or 'Blanket Flower. It is an important flower crop of the *Asteraceae* family and is indigenous to the Central and Western United States. The 18th century French botanist Mr. Gaillard de Marentoneau, suggested the generic name gaillardia. Morinaaga *et al*. (1929) reported that *Gaillardia pulchella* is diploid (2n=36). Numerous factors, including like, soil fertility, irrigation availability, plant density and plant protection

measures, are necessary for the successful commercial production of the gaillardia flower. Proper fertilization, particularly nitrogen is one of the decisive factors influencing the growth and flowering of annual plants. Nitrogen deficiency reduces stem elongation, leaf area, photosynthesis rate, dry matter accumulation and leaf chlorophyll content (Bar-Tar *et al*., 2001 and Zhao *et al*., 2003). While, excessive application of N usually increases input cost, pest incidence can diminish crop and poor quality flowers.

Interest in nanotechnology has grown as a result of the increasing difficulties facing in Indian agriculture, with the aim of boosting crop yield and improving resource use efficiency. Utilizing nanomaterials of smaller than 100 nm size, nanotechnology has become a cutting edge science to develop concentrated plant nutrients sources with increased absorption rates, improved utilization efficacy and reduced losses (Kumar *et al*., 2021). Nano fertilizers have large surface areas and particle sizes that are smaller than the pore size of stomata's, which allows for easily penetration into plant tissues from the applied surface and improved nutrient absorption and use efficiency. Plant cell walls have pores that range in diameter from 5 to 50 nm. As a result, only aggregates of nanoparticles with a diameter smaller than the plant cell wall pore diameter could easily penetrate and reach the plasma membrane. Nanoparticles with a size less than 5 nm go through the cuticular pathway, whereas those with larger sizes travel through the stomatal pathway before reaching the conducting system and they aid in the rapid and simple absorption of nutrients by leaves (Dimkpa *et al*., 2015 and Qureshi *et al*., 2018). Nano Urea is more efficacious in terms of nutrient absorption owing to lesser losses which contains 4 % total nitrogen (w/v). The size of nano-nitrogen particles ranges from 20 - 50 nm. The water contains an even distribution of these particles. It contains 40,000 mg/L of nitrogen in a 500 ml bottle, which is same amount of nitrogen nutrient as one bag (45 kg) of conventional urea. It enters through stomata and other openings on plant leaves during critical growth stages and is absorbed by the plant cells. It is dispersed from the source to sink inside the plant wherever it is needed due to phloem transport. For the plant to grow and develop properly, Unutilized nitrogen is stored in the vacuole and released gradually for proper growth and development of the plant (Kantwa and Yadav, 2022).

Materials and Methods

The present study was conducted at Horticulture Polytechnic, ASPEE College of Horticulture, Navsari Agricultural University, Navsari, Gujarat, India (20º 55' North latitude and 72º 54' East longitude, at an elevation of approximately 11.93 meters above mean sea level) from February 2024 to May 2024. The soil had a flat topography, a medium to poor ability for drainage and a dark greyish brown Montmorillonite-type clay minerals make up the majority of more than 50 % clay concentration. The availability of "N" in the soil was generally medium fertility level was medium in available 'P_2O_5' as well as 'K_2O' with pH of 7.4-7.8 and E.C. of 0.32- 0.40 dSm^{-1}. After one month, healthy seed was planted on the raised bed to main field at a spacing of 30 × 30 cm. Seven treatments were replicated three times in the Randomized Block Design that was used. Among the treatments were included T_1: 100% RDN (No Nano Urea spray), T_2: 50% RDN + Nano Urea @ 2ml/lit (2 spray), T_3: 75% RDN + Nano Urea @ 2ml/lit (2 spray), T_4: 50% RDN + Nano Urea @ 3ml/lit (2 spray), T_5: 75% RDN + Nano Urea @ 3ml/lit (2 spray), T_6: 50% RDN + Nano Urea @ 4ml/lit (2 spray) and T_7: 75% RDN + Nano Urea @ 4ml/lit (2 spray). The recommended dose of NPK fertilizers @100:50:100 kg ha^{-1}. Nitrogen was applied in two split doses with Nano Urea spray. whereas phosphorus and potash full dose were applied as basal dose, respectively. Nano Urea quantity should be dissolved in water Nano Urea was applied as foliar spray to the plants at 25 and 55 day after transplanting. Data on various variables were statistically analysed by analysis of variance (Panse and Sukhatme, 1967).

Methodology

Flowering and quality attributes

Days taken to first flower bud initiation : Number of days required for first flower bud initiation was counted from transplanting up to the stage till first flower bud on a plant became visible for the tagged plants. The average was calculated from five tagged plants data in the net plot.

Flower diameter (cm) : Fully opened flowers were selected from the five tagged plants of net plot and diameter was measured with the help of digital Vernier calliper at full bloom stage.

Flower duration (days) : It was measured during the flowering phase. Number of days were counted from first flower opening to last picking of flowers from net plot and is expressed in days after average was calculated.

Flower longevity (days) : The duration between the flower opening to fading was counted.

Shelf life (hours) : Five fully opened flowers were harvested from each net plot and kept at ambient condition in paper plates to measure duration between harvesting to shrinkage of flowers and were expressed in hours after

calculating average.

Yield attributes

Number of flowers per plant : It was taken during flowering phase. Total number of flowers produced by each plant during the period of experiment was counted and average of five tagged plant was calculated.

Average weight of flower (g) : Flowers were collected from tagged plants and weight of flower was calculated with the help of an electrical weight balance. Average was calculated from following formula:

$$\text{Average weight of flower} = \frac{\text{Total weight of flower}}{\text{No. of flower}}$$

Total weight of flowers per plant (g) : Flowers were collected from tagged individual plants and weight of flower was calculated with the help of an electrical weight balance.

Flower yield per plot (g) and per ha (kg) : According to treatments, all the plucked flowers from the net plot were weighted separately as per individual treatment at each harvest and summed up. Flower yield per ha was converted based on net plot area at the end of experiment.

Economics : The economics of the experiment was worked out by considering the prevailing market prices for the different inputs and products. The total cost of production was worked out by considering the prices of planting materials, FYM, fertilizers, plant growth regulators, labours employed and other miscellaneous inputs. The gross income in terms of rupees per hectare was worked out based on the main yield for each treatment considering the prevailing market price. Net income was obtained by reducing cost of cultivation from gross income per hectare. The benefit cost ratio (BCR) was also worked out by using following formula:

$$\text{BCR} = \frac{\text{Net income (Rs./ha)}}{\text{Total cost of cultivation (Rs./ha)}}$$

Results and Discussion

Flowering and quality attributes

Days taken to first flower bud initiation : The minimum days for the first flower bud appearance (37.56 days) was recorded in treatment T_2 - 50% RDN + Nano Urea @ 2 ml/lit which was statistically at par with T_4 - 50% RDN + Nano Urea @ 3 ml/lit (38.74 days), T_6 – 50% RDN + Nano Urea @ 4 ml/lit (41.03 days) and T_3 – 75 % RDN + Nano Urea @ 2 ml/lit (41.87 days). Whereas, the maximum days were noted in T_1 - control (45.28 days) treatment. Due to its gradual and efficient release of nitrogen, Nano Urea promotes vegetative growth before reproductive development. Nitrogen is essential in cell division, leaf expansion and improving plant vigor, that causes the plant to upregulate resources for producing leaves and branches over "switching on" flowering.

Flower diameter (cm) : The examination of data on the maximum diameter of the flower (65.18 mm) was recorded in treatment T_2 - 50% RDN + Nano Urea @ 2 ml/lit, which was statistically at par with T_4 - 50% RDN + Nano Urea @ 3 ml/lit (63.58 mm), T_6 – 50% RDN + Nano Urea @ 4 ml/lit (61.55 mm) and T_3 – 75% RDN + Nano Urea @ 2 ml/lit (60.37 mm). Whereas, minimum flower diameter was noted in T_1 - Control (52.66 mm) treatment. Nano Urea supports important physiological processes such as cell division, chlorophyll production and protein synthesis by increasing nitrogen availability that ultimately improves flower diameter.

Flower duration (days) : Resulted data showed that the maximum flowering duration (57.92 days) was recorded in treatment T_2 - 50% RDN + Nano Urea @ 2 ml/lit, which was statistically at par with T_4 - 50% RDN + Nano Urea @ 3 ml/lit (53.84 days), T_6 – 50% RDN + Nano Urea @ 4 ml/lit (51.73 days) and T_3 – 75% RDN + Nano Urea @ 2 ml/lit (51.71 days). Moreover, the minimum flowering duration was found in T_1 - Control (42.31 days) treatment. Nano Urea enhances flowering duration, because of its steady and efficient nitrogen supply, which increases the metabolic activity and overall strength of the plant. Nitrogen is a critical component of energy production as well as protein synthesis and enzymatic activities, which support blossom growth and development.

Flower longevity (days) : The evaluated data recorded maximum flower longevity (12.27 days) in treatment T_2 - 50% RDN + Nano Urea @ 2 ml/lit, which was statistically at par with T_4 - 50% RDN + Nano Urea @ 2 ml/lit (12.07 days) and T_6 - 50% RDN + Nano Urea @ 4 ml/lit (11.07 days). While, the minimum flower longevity (7.67 days) was observed in the treatment T_1 (Control). By consistent and effective supply of nitrogen, which is essential for preserving cellular processes and postponing senescence.

Shelf life (hours) : The data revealed that the higher shelf life (9.08 hours) was recorded in treatment T_2 - 50% RDN + Nano Urea @ 2 ml/lit, which was statistically at par with T_4 - 50% RDN + Nano Urea @ 3 ml/lit (8.52 hours), T_6 - 50% RDN + Nano Urea @ 4 ml/lit (8.45 hours) and T_3 - 75% RDN + Nano Urea @ 2 ml/lit (8.34

Table 1 : Effect of integrated nitrogen management through RDN and Nano Urea foliar spray on Flowering and quality attributes of gaillardia cv. Local.

Treatments	Days to first bud appearance	Flower diameter (mm)	Flowering duration (days)	Longevity of flower (days)	Shelf life (hours)
T_1:100% RDN	45.28	52.66	42.31	7.67	6.76
T_2: 50% RDN + Nano Urea @ 2 ml/lit	37.56	65.18	57.92	12.27	9.08
T_3: 75% RDN + Nano Urea @ 2 ml/lit	41.87	60.37	51.71	10.47	8.34
T_4: 50% RDN + Nano Urea @ 3 ml/lit	38.74	63.58	53.84	12.07	8.52
T_5: 75% RDN + Nano Urea @ 3 ml/lit	42.70	59.17	47.82	10.40	7.58
T_6: 50% RDN + Nano Urea @ 4 ml/lit	41.03	61.55	51.73	11.07	8.45
T_7: 75% RDN + Nano Urea @ 4 ml/lit	43.54	59.09	46.35	9.13	7.09
SEm (±)	1.47	1.65	2.61	0.51	0.34
CD at 5%	4.53	5.10	8.04	1.56	1.03
CV (%)	6.13	4.76	9.00	8.43	7.29

hours). While, the minimum shelf life (6.76 hours) was recorded with T_1 (Control) treatment. Steady supply of nitrogen through Nano Urea improves the physiological and biochemical stability of harvested flowers, ultimately lengthen shelf life of flowers.

Yield attributes

Number of flowers per plant : The perusal of the data related to number of flowers per plant (74.14) was recorded maximum in treatment T_2 - 50% RDN + Nano Urea @ 2 ml/lit, which was statistically at par with treatment T_4 - 50% RDN + Nano Urea @ 3 ml/lit (70.25). Moreover, the minimum number of flowers per plant (60.26) was recorded with T_1 (Control) treatment. By enhancing nitrogen availability, which is crucial for robust vegetative and reproductive growth, Nano Urea boosts more number of flowers per plant.

Average and Total weight of flower (g) : The perusal of the data showed that the maximum average weight of flower (2.19 g) was recorded in treatment T_2 - 50% RDN + Nano Urea @ 2 ml/lit, which was statistically at par with treatment T_4 - 50% RDN + Nano Urea @ 3 ml/lit (2.09 g). While, minimum weight of flowers (1.58 g) was recorded with T_1 (Control) treatment.

The data on total weight of flower (162.36 g) was recorded maximum in treatment T_2 - 50% RDN + Nano Urea @ 2 ml/lit, which was statistically at par with treatment T_4 - 50% RDN + Nano Urea @ 3 ml/lit (146.82 g). While, the minimum weight of flowers (95.2 g) was recorded with T_1 (Control) treatment. Nanoparticles of Nano Urea improve dispersion and absorption of nutrients. Nitrogen improves the flow of nitrogen within the plant, which encourages more and bigger blooms by increasing photosynthetic rate, protein synthesis and energy production.

Flower yield per plot (g) and per ha (kg) : Significantly highest flower yield per plot (2597.86 g) was recorded in treatment T_2 - 50% RDN + Nano Urea @ 2 ml/lit, which was statistically at par with treatment T_4 - 50% RDN + Nano Urea @ 3 ml/lit (2349.16 g). While, the minimum flower yield per plot (1523.37 g) was recorded with T_1 (Control) treatment. Moreover, the maximum flower production per hectare (18034.72 kg) was also recorded in treatment T_2 - 50% RDN + Nano Urea @ 2 ml/lit, which was statistically at par with treatment T_4 - 50% RDN + Nano Urea @ 3 ml/lit (16312.50 kg). While, the minimum weight of flowers (10576.38 g) was recorded with T_1 (Control) treatment. Nano Urea efficiently supplies nitrogen, which is essential for plant growth and reproductive development, that increases flower production. More flowers with larger size and weight result from increased in photosynthetic rate, protein synthesis and energy generation due to improved absorption and usage of nitrogen.

Economics : From the above study, it is apparent (Table 3) that the highest net returns (` 4,53,800) was recorded under the treatment $T_2$: 50% RDN + Nano Urea @ 2 ml/lit and minimum return of (` 1,92,645) was obtained under treatment T_1 - Control.

For BCR, treatment T_2: 50% RDN + Nano Urea @ 2 ml/lit gave the highest BCR (2.56) and it was followed by treatment T_4: 50% RDN + Nano Urea @ 3 ml/lit *i.e.*, 2.22 BCR. The result indicates that the treatment T_2: 50% RDN + Nano Urea @ 2 ml/lit economically most beneficial for flower production of gaillardia cv. Local.

Table 2 : Effect of integrated nitrogen management through RDN and Nano Urea foliar spray on yield attributes in gaillardia.

Treatments	Number of flowers per plant	Average weight of flower per plant (g)	Total weight of flowers per plant (g)	Flower yield	
				Per plot (g)	Per hectare (kg)
T_1:100% RDN	60.26	1.58	95.21	1523.37	10576.38
T_2: 50% RDN + Nano Urea @ 2 ml/lit	74.14	2.19	162.36	2597.86	18034.72
T_3: 75% RDN + Nano Urea @ 2 ml/lit	64.20	1.86	119.41	1910.59	13270.83
T_4: 50% RDN + Nano Urea @ 3 ml/lit	70.25	2.09	146.82	2349.16	16312.50
T_5: 75% RDN + Nano Urea @ 3 ml/lit	62.69	1.78	111.58	1785.41	12402.78
T_6: 50% RDN + Nano Urea @ 4 ml/lit	65.37	1.96	128.12	2050.00	14236.11
T_7: 75% RDN + Nano Urea @ 4 ml/lit	62.20	1.69	105.11	1681.88	11680.55
SEm(±)	2.68	0.06	4.77	108.38	752.62
CD at 5 %	8.24	0.17	14.69	333.90	2318.70
CV (%)	7.07	10.13	12.87	8.57	8.57

Table 3 : Effect of integrated nitrogen management through RDN and Nano Urea foliar spray on economics of flower production per hectare in gaillardia (Rs./ha) cv. Local.

Treatments	Yield of flowers per ha (kg)	Gross income (Rs.)	Fixed cost (Rs.)	Variable cost (Rs.)	Total cost (Rs./ha)	Net realization (Rs./ha)	BCR
T_1	10576.38	370173.00	1,76,676	852.00	1,77,528.00	1,92,645	1.09
T_2	18034.72	631215.00	1,76,676	739.00	1,77,415.00	4,53,800	2.56
T_3	13270.83	464479.00	1,76,676	952.00	1,77,628.00	2,86,851	1.61
T_4	16312.50	570938.00	1,76,676	890.00	1,77,566.00	3,93,372	2.22
T_5	12402.78	434097.00	1,76,676	1102.00	1,77,778.00	2,56,319	1.44
T_6	14236.11	498264.00	1,76,676	1051.00	1,77,727.00	3,20,537	1.80
T_7	11680.55	408819.00	1,76,676	1264.00	1,77,940.00	2,30,879	1.30

Conclusion

Based on the results of the present study, it can be concluded that soil application of 50% RDN combined with foliar application of Nano Urea @ 2 ml/lit water at 25 and 55 days after transplanting significantly improved flower quality, flower yield and economic returns in gaillardia cv. Local.

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