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Growth and Flowering Performance of Marigold (*Tagetes erecta* L.) under Different Nitrogen Fertilization Regimes

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ABSTRACT

A pot study was conducted in the winter season 2022-2023 at the Nursery of the Department of Horticulture, Sindh Agriculture University, Tandojam, to evaluate the response of two varieties of marigold namely Deep Orange and Marvel Yellow to different nitrogen application rates. The experiment was laid out in a Completely Randomized Design (CRD) with factorial arrangement of treatments and replicated three times with five levels of nitrogen (0, 30, 60, 90, and 120 kg ha^{-1}) and two varieties of marigold. The following data were obtained: plant height, number of branches per plant, days to flowering, individual flower weight, total flower weight per plant, flower diameter and flowering duration. The results revealed that nitrogen application had a significant effect on all the growth and flowering traits of marigold. The vegetative growth, flower development and yield of both varieties were generally enhanced with increasing nitrogen levels, with varying magnitude of response. Marvel yellow consistently outperformed Deep Orange at all nitrogen rates, especially at the highest rate (120 kg ha^{-1}) where it exhibited the tallest plants (20.03 cm), the most branches (34.33), the heaviest single flower (9.27 g) and the greatest flower yield per plant (22.64 g). The most flower diameter (40 mm), the first flowering initiation (16 days) and the most flowering period (39.66 days) were also achieved under the highest nitrogen treatment. Nitrogen fertilization stimulated growth of both cultivars but differences in growth were less marked at low nitrogen rates. The results show that the use of 120 kg ha^{-1} nitrogen application can significantly increase the growth, flowering ability and flower yield of marigold especially for cultivar Marvel Yellow. The results obtained would be helpful for choosing appropriate cultivars and proper nitrogen management to improve marigold production under similar agro-climatic conditions.

Introduction

Marigold (*Tagetes spp*.) is a popular ornamental flowering plant and member of the Asteraceae family. The various species can be distinguished by their flowering time, with the earliest being *T. erecta L.* and the latest being *T. patula* L., which are commonly referred to as African marigold and French marigold, respectively. They are cherished throughout the world for their ornamental beauty and for other extensive applications in the floriculture, cosmetic and industrial industries. Growers also favor the ease with which marigold is grown, as it is relatively resistant to most soil and climatic conditions, in comparison with many other ornamental flower crops. The larger adaption potential in Marigold would make it suitable for obtaining larger flower size and flower production (Pandey et al., 2021). Marigold is a fast-growing annual ornamental plant that will grow to about 1.5 m (5 feet) tall in a good growing environment. It is widely cultivated as an ornamental species, and is known for its great colour variation in flowers. Nevertheless, majority of people enjoy and cultivate the yellow and orange varieties. Besides extensively grown varieties white, red and variegated coloured cultivars are also nurtured on small scale (FAN, 2018). Growth and flowering of Marigold is also favorable and can be successfully grown throughout the year if environmental conditions are favorable, and it thrives best under sunny conditions (Sheoran et al., 2022). In addition to their ornamental use, marigold has been known for centuries because of its medicinal uses. Various components of the plant have been traditionally used for anti-muscle pain, anti-itch, anti-ear ailment, anti-eye ailments, anti-piles and anti-blood purifier properties (Poudel et al., 2017).

Maintenance of marigold productivity and flower quality is highly dependent upon good crop management practices, especially balanced fertilization. Improper nutrient availability adversely affects vegetative growth, resulting in poor shoot development and leaf growth and ultimately leading to poor flower quality and shorter flowering period (Ahmad et al., 2015). Of these critical nutrients, nitrogen and phosphorus are regarded as the most important for plant growth, flowering and seed production in ornamental crops. Nitrogen is an important component in the development of vigor and flower production of plants and is, therefore, an important element to manage efficiently to make marigold cultivation profitable. Nutrient management is particularly critical when nutrient deficiency is present (Darras et al., 2020), to ensure high quality and production in flowers. Nitrogen helps in the production of chlorophyll, photosynthesis and vegetative growth, which all improve flowering and increased flower production. It is important to manage its use, however, as excessive nitrogen can stimulate luxuriant vegetative growth, cause dark green leaves and delay flowering which ultimately may impact crop quality and productivity (Li et al., 2023). Use of nitrogen at the correct rate and growth stage, therefore, is critical for obtaining balanced plant growth and optimum flower production. Fertilizers are expensive inputs and in container gardening, technical expertise, such as how much fertilizer to apply, can be a critical factor to maximizing yield. In commercial floriculture, the use of container culture (made from Styrofoam pots) has grown in popularity due to the decreased risk of soil borne pests and diseases and the lower requirements for space, labour and production costs. In growing systems such as these, proper use of fertilizer is even more critical, as the growth process is entirely reliant on the fertilizer applied by the grower. As a result, it is vital to know the optimum fertilizer requirement in order to secure high quality flowers and to ensure the most acceptable production. To satisfy the ever increasing demand of commercial floriculture, especially in tropical and subtropical countries where marigold is widely cultivated, it is necessary to improve the number of flowers produced by the plant (Teja et al., 2017).

Nitrogen is an essential plant nutrient which plays a significant role in plant growth, development and productivity. The adequate supply of nitrogen leads to healthy vegetative growth and better crop performance and yield. Correct nitrogen application at the correct stage of growth and development will result in good vegetative growth, increased plant vigour and normal flowering initiation. However, deficiency in N severely inhibits plant growth, biomass production, and the number of flowers produced (Shrestha et al., 2018). Thus, close control of nitrogen is required to maintain proper plant growth and obtain maximum flowering results. Too much nitrogen, however, can negatively affect the plant growth life cycle by causing unnecessary vegetative growth and slowing and delaying the flowering process (Shah et al., 2018). It has been reported that higher level of nitrogen application leads to better flowering which in turn improves flower production, provided it is applied at an optimal rate (Singh et al., 2017). The decrease in the marigold plant vigour with the advancement of the season may likely be associated with nitrogen deficiency. But when nutrients are poorly managed, it can have a negative impact on the growth and yield of flowering annual plants, creating nutrient deficiencies within the plant. Optimal nutrient application should be based on the nutrient needs of the crop during various growth stages instead of applying nutrients uniformly throughout the growing season (Gao et al., 2021). Also, there is inter-specific and even intra-specific difference in nutrient requirements. Thus, if the wrong nutrient source or fertilizer rates are used, the crop can develop nutritional disorders which will prevent normal growth and reduce flower production. Nutrient deficiency or excess can lead to abnormal plant growth and is known as a nutritional disorder (Abbas et al., 2021). Optimizing flower yield per unit area relies not only on fertilizer application rates but also on the selection of high-yielding varieties (Mehta et al., 1995; Sharma, 2024; Mehta et al., 1995; Sharma, 2024). This study assessed the effects of nitrogen (N) application rates on two marigold varieties, 'Deep Orange' and

'Marvel Yellow'. We tested their growth behaviour, flowering response, and productionto categorize the best variety and N dosage for optimum flowering.

Materials and Methods

Study Area

The experiment was conducted at the Nursery of Department of Horticulture, Sindh Agriculture University, Tandojam during winter season of 2022-2023. The experiment was performed to investigate the effect of various levels of nitrogenous fertilizer on vegetative growth, flowering pattern and performance of the marigold varieties.

Experimental Design and Treatment Details

Two factors viz nitrogen application rate and marigold varieties were used in the experiment in a completely randomized design (CRD) with factorial arrangement. There were three replicates for each treatment. A total of 30 experimental units with ten plants per replication in pots containing a sandy silt soil mixture were used. Two cultivars of marigold were used for study: Deep Orange (V_1) and Marvel Yellow (V_2) which were commercially available. Five nitrogen treatments were applied to study the effect of nitrogen on growth and flowering of the plants. These consisted of a control without nitrogen (N_1 = 0 kg ha^{-1}; 0 g urea pot^{-1}) and four nitrogen levels consisting of N_2 = 30 kg ha^{-1} (0.16 g urea pot^{-1}), N_3 = 60 kg ha^{-1} (0.32 g urea pot^{-1}), N_4 = 90 kg ha^{-1} (0.48 g urea pot^{-1}), and N_5 = 120 kg ha^{-1} (0.64 g urea pot^{-1}). The information for all the treatments is summarized in Table 1.

Table 1. Treatment details

Treatments (Nitrogen levels)	Deep Orange (V_1)	Marvel Yellow (V_2)	Application
N_1	Control	Control	No Application
N_2	30 kg ha^{-1} (0.16 g urea pot^{-1})	30 kg ha^{-1} (0.16 g urea pot^{-1})	Soil Application
N_3	60 kg ha^{-1} (0.32 g urea pot^{-1})	60 kg ha^{-1} (0.32 g urea pot^{-1})	Soil Application
N_4	90 kg ha^{-1} (0.48 g urea pot^{-1})	90 kg ha^{-1} (0.48 g urea pot^{-1})	Soil Application
N_5	120 kg ha^{-1} (0.64 g urea pot^{-1})	120 kg ha^{-1} (0.64 g urea pot^{-1})	Soil Application

Even and uniform seedling marigolds were potted in a well-prepared potting mix. The nitrogen supply was in the form of urea, depending on the treatment level required. Standard practices of irrigation, weeding and general crop management were applied to all pots throughout the experiment, thus providing uniform growing conditions.

Assessment of Growth and Flowering Characteristics

The growth and flowering characteristics of the plants were assessed. Growth and flowering data were taken when the plants were in flowering phase. Plant height (cm) was determined from soil surface to the tip of the main stem with a measuring tape and the average value of plant height was calculated. Ten plants were chosen at random in each treatment and the number of branches per plant was counted and the average number of branches per plant was calculated. The number of days from transplanting to flowering of the first flower was determined on ten plants per treatment selected at random and the average days to flowering calculated. The flowers were picked off the plant immediately after opening and single flower weight (g) was determined by weighing each flower on a digital balance before calculating the mean. Total flower weight per plant (g) was determined by measuring the weight of all the flowers that have been harvested from the each plant during the flowering period. The diameter of each flower (cm) was taken with a vernier caliper at the widest point of the flower and the average was determined. The time from flowering until senescence was recorded and the number of days each flower spent in a fully open and attractive state (blooming period) was calculated.

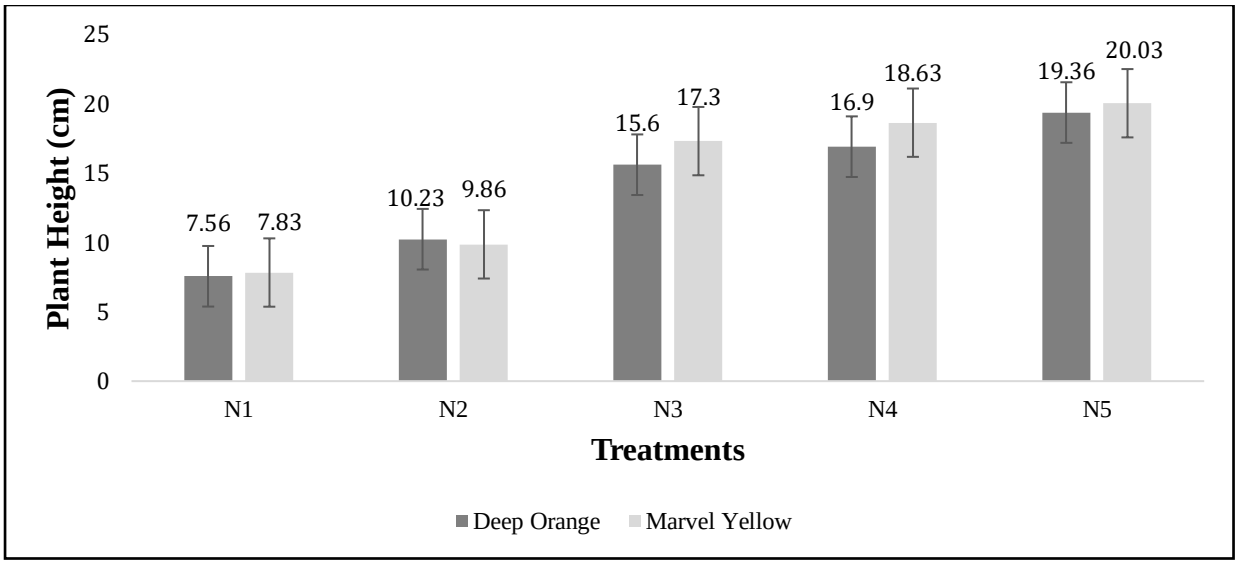
Statistical Analysis: All the data collected were analyzed statistically (Statistix 8.1, Analytical Software, 2006). The Least Significant Difference (LSD) test at 5% probability level was used to compare treatment means to establish significant difference between the treatments.

Results

The growth parameters measured for each variety of Marigold demonstrated marked differences among the treatments.

Plant Height (cm)

Nitrogen application significantly affected the plant height in both cultivar of marigold. As the nitrogen level increased, the plant height increased correspondingly, with the tallest plant height obtained under the highest dose of nitrogen (N_5). Deep Orange and Marvel Yellow planted at N_5, attained average heights of 19.36 cm and 20.03 cm, respectively. N_4 was followed by N_5, in which the heights of the plants were 16.90 and 18.63cm, respectively, for the Deep Orange and Marvel Yellow varieties. Intermediate values were observed for the N_3 (15.60 cm and 17.30 cm) and N_2 (10.23 cm and 9.86 cm) treatments, while the control (N_1) had the shortest plants (7.56 cm in Deep Orange and 7.83 cm in Marvel Yellow) (Figure 1). In all the nitrogen treatments, Marvel Yellow gave a higher plant height than Deep Orange. A significant interaction of nitrogen level and variety was also recorded with the tallest plants recorded in Marvel Yellow (20.03 cm) and the shortest plants recorded in Deep Orange (N_1: no nitrogen, 7.56 cm).

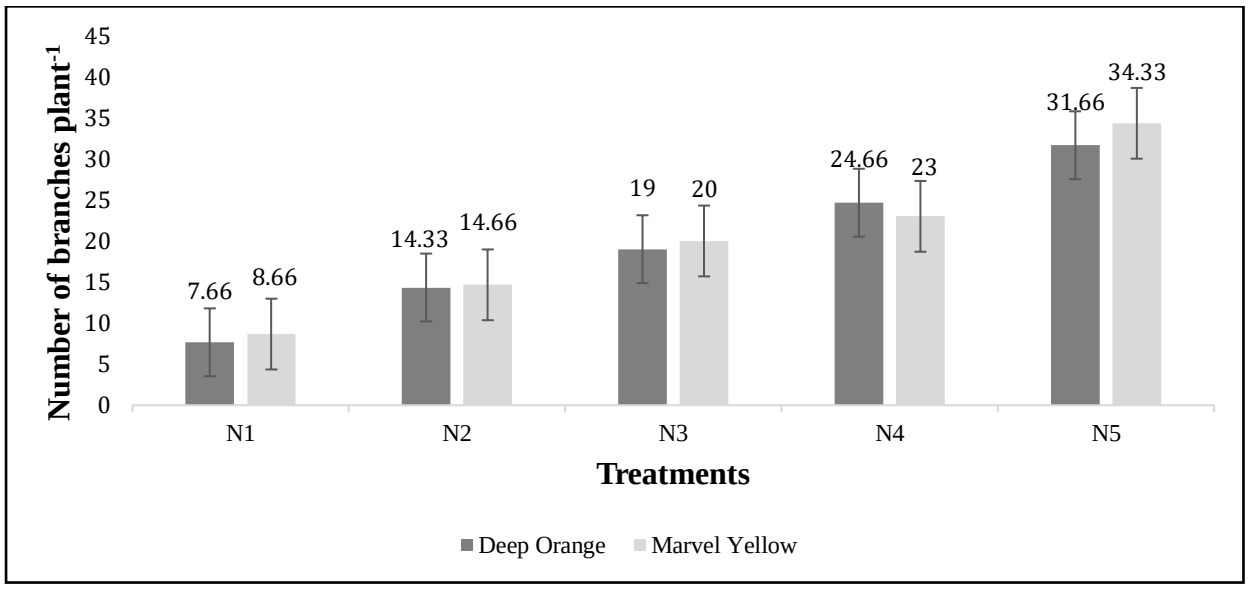


Treatments		Varieties	T x V
SE±	1.2089	0.5406	0.8548
LSD 0.05	2.5398	1.1358	1.7959
P value	0.0000	0.1562	0.6863

Figure 1. The Plant height of different marigold varieties grown at various nitrogen levels.

No. of Branches

The number of branches per plant was significantly influenced by nitrogen application and marigold varieties. In both varieties (Deep Orange and Marvel Yellow) the number of branches increased with increasing nitrogen levels. The highest number of branches was recorded under the N5 treatment, where Marvel Yellow produced 34.33 branches per plant and Deep Orange produced 31.66. Plants treated with N4 developed 23.00 and 24.66 branches, respectively, followed by N3 with 20.00 and 19.00 branches, and N2 with 14.66 and 14.33 branches for Marvel Yellow and Deep Orange, respectively. The control treatment (N1) produced the fewest branches, with 8.66 in Marvel Yellow and 7.66 in Deep Orange (Figure 2). Overall, when compared to the various nitrogen treatments, Marvel Yellow yielded slightly more branches than Deep Orange. A significant interaction between the nitrogen levels and varieties was noted with the N_5 × Marvel Yellow treatment having the most branches and the N_1 × Deep Orange treatment having the least number of branches.

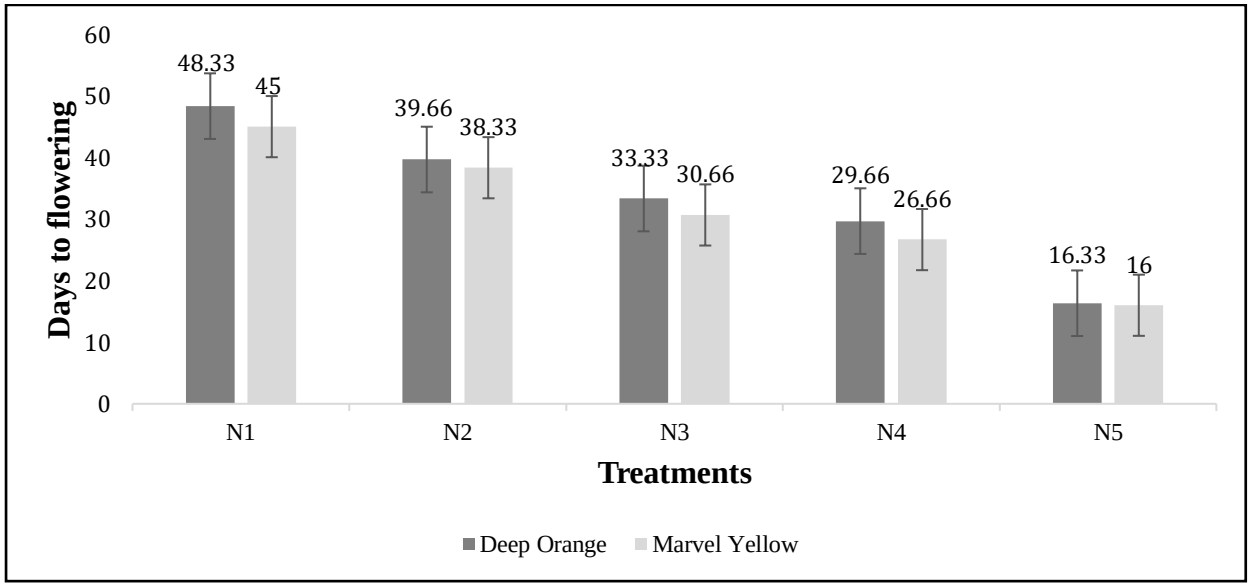


	Treatments	Varieties	T x V
SE±	1.6607	0.7427	1.1743
LSD 0.05	3.4891	1.5604	2.4671
P value	0.0000	0.0000	0.5561

Figure 2. The no. of branches per plant in marigold varieties under various nitrogen levels.

Days to Flowering

Both marigold varieties showed that nitrogen application had a significant effect on days to flowering. Deep Orange and Marvel Yellow flowered after 16.33 and 16.00 days respectively. The earliest flowering occurred in plants nourished with the highest N fertilization level (N_5). With the reduction in nitrogen, the number of days to flower was increased, and the N_1 (control) treatment had the latest flowering with 48.33 days (Deep Orange) and 45.00 days (Marvel Yellow) (Figure 3). In all nitrogen treatments, Marvel Yellow flowered slightly earlier than Deep Orange. A significant interaction with variety and nitrogen level was also detected, with the N_5 × Marvel Yellow treatment having the earliest flowering and the N_1 × Deep Orange the latest.

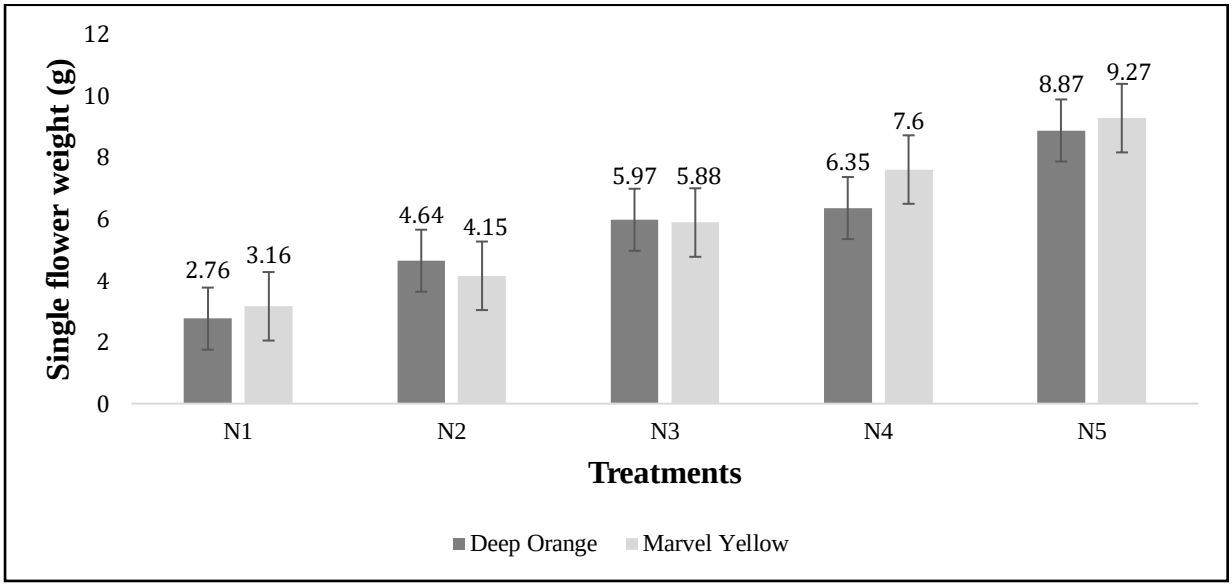


	Treatments	=Varieties	T x V
SE±	2.2895	1.0239	1.6189
LSD 0.05	4.8101	2.1512	3.4013
P value	0.0001	0.8960	0.7726

Figure 3. Days to flowering of marigold varieties on various nitrogen treatments.

Single Flower Weight (g)

The single flower weight of marigold was significantly influenced by both nitrogen application and varieties. In both Deep Orange and Marvel Yellow, flower weight increased steadily with increasing nitrogen levels. The highest single flower weight was obtained with the treatment N5 where the flower weights were 9.27 g for Marvel Yellow and 8.87 g for Deep Orange. Relatively heavier flowers were also obtained in plants supplied nitrogen with N_4 with flower weight of 7.60 g for Marvel Yellow and 6.35 g for Deep Orange. Intermediate weights were seen for N3 (5.88 g and 5.97 g for Marvel Yellow and Deep Orange, respectively) and lower weights were seen for N2 (4.15 g and 4.64 g for Marvel Yellow and Deep Orange, respectively).The lightest flowers were seen in the control treatment (N1) with 3.16 g in Marvel Yellow and 2.76 g in Deep Orange (Figure 4). With the various N treatments, Marvel Yellow flowered slightly heavier than Deep Orange. The interaction between nitrogen level and variety was also significant, with the single flower weight of the N_5 × Marvel Yellow having the highest weight, and the N_1 × Deep Orange the lowest.



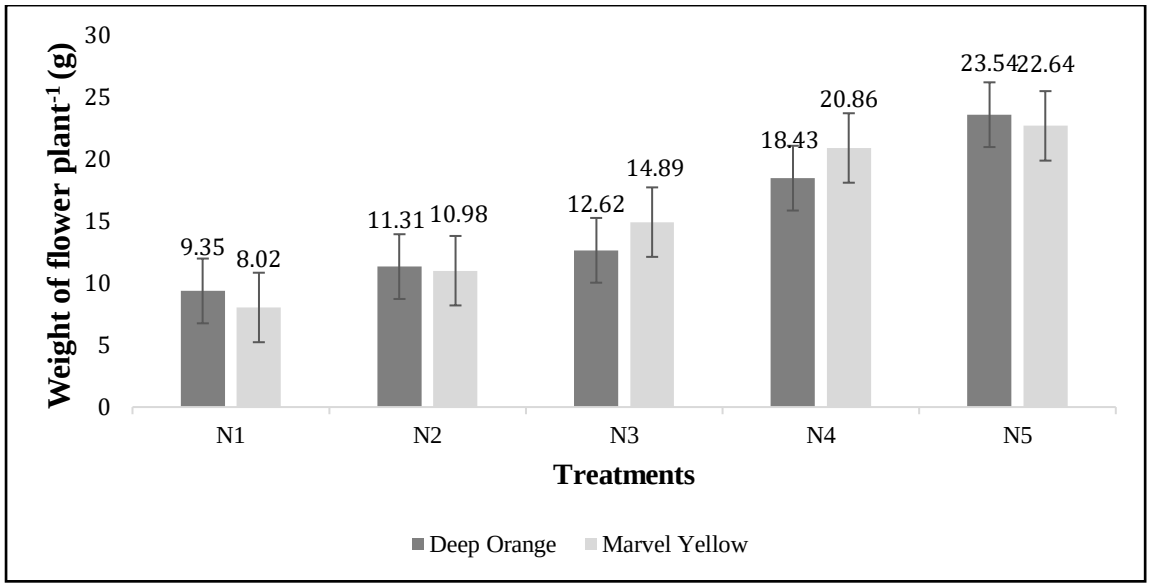
Treatments	Varieties	T x V
SE±	0.7355	0.3289	0.5200
LSD 0.05	1.5451	0.6910	1.0926
P value	0.0000	0.3842	0.5531

Figure 4. Effect of Single flower weight of marigold varieties on various nitrogen levels.

Weight of Flowers per Plant (g)

The weight of flowers/plant varied among the marigold varieties, Deep Orange and Marvel Yellow, at different application rates of nitrogen. In both varieties flower weight increased with the increase of nitrogen level and the maximum weight in each variety was obtained at N5, Deep Orange with 23.54 g per plant and Marvel Yellow with 22.64 g per plant. Similarly, N4 treatment produced relatively large flower weight of 18.43 g in Deep Orange and 20.86 g in Marvel Yellow compared to other

treatments. The lowest flower weight per plant was recorded in the control treatment (N_1), Deep Orange and Marvel Yellow with flower weight 9.35 g and 8.02 g respectively (Figure 5). In general, rates of application above the 100 kg ha^{-1} level of nitrogen caused Marvel Yellow to flower more heavily than Marvel Orange, and rates of application below this level of nitrogen caused a lesser difference between the varieties. The interaction of nitrogen levels and variety exhibited significant difference.

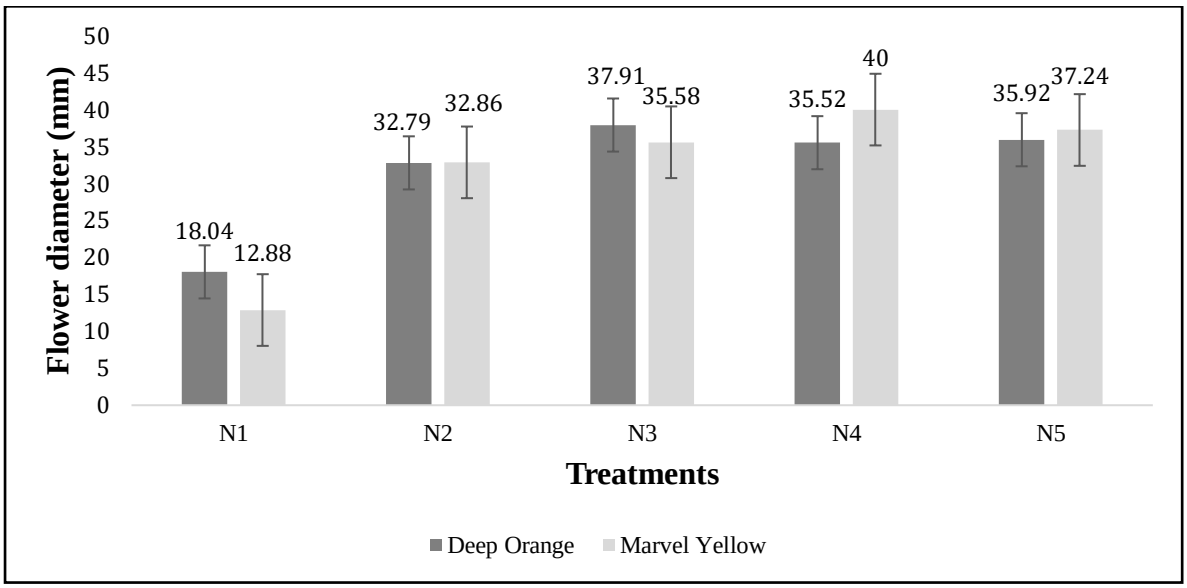


Treatments		Varieties	T x V
SE±	1.6211	0.7250	1.1463
LSD 0.05	3.4058	1.5231	2.4083
P value	0.0000	0.5623	0.3351

Figure 5. Weight of flowers per plant of marigold varieties under different nitrogen levels.

Flower Diameter (mm)

Nitrogen application and marigold varieties significantly influenced the diameter of flowers (mm). Under N3, the flower diameter was 37.91 mm in Deep Orange and 35.58 mm in Marvel Yellow, which is an obvious improvement from N2. Generally, an increase in N resulted in an increase in flower size in both cultivars with the highest flower diameter recorded at N5, 40.00 mm in Marvel Yellow and 35.92 mm in Deep Orange, respectively, which is an improvement over N2. The smallest diameter of flowers was observed in the control treatment (N_1) which had mean flower diameter of 18.04 mm in Deep Orange and 12.88 mm in Marvel Yellow (Figure 6). Under the control treatment, the diameter of the flowers of Deep Orange was generally larger than that of Marvel Yellow, whereas under the higher nitrogen treatments, the diameter of the flowers on Marvel Yellow was generally larger than that of Deep Orange. The effect of nitrogen level × variety was significant; the N_5 × Marvel Yellow treatment had the largest diameter of flowers, while the N_1 × Marvel Yellow treatment had the smallest.

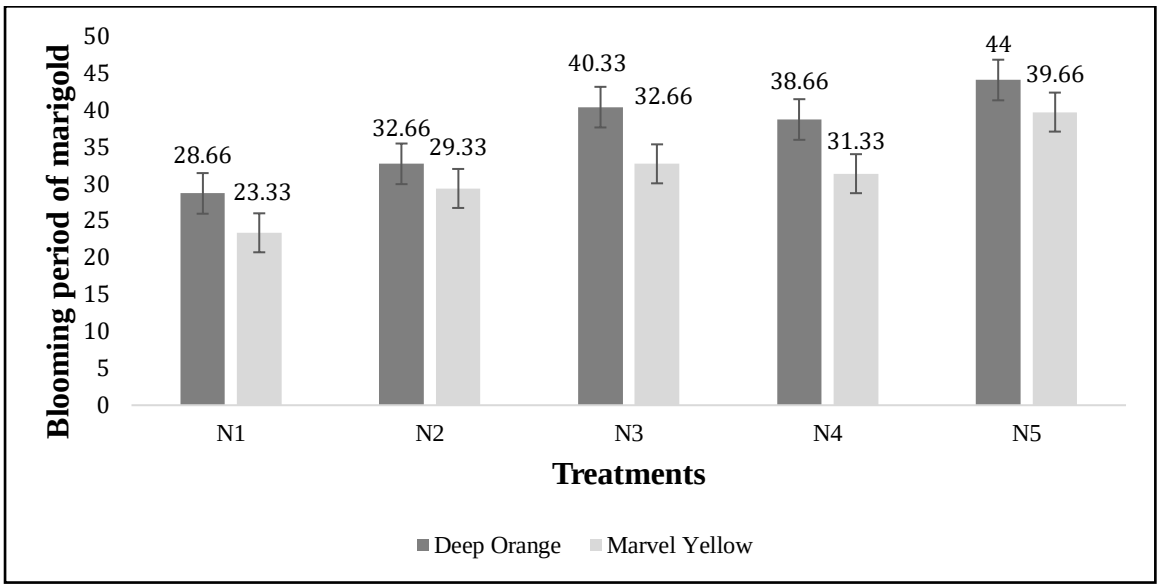


Treatments		Varieties	T x V
SE±	5.4551	2.4396	3.8573
LSD 0.05	11.461	5.1254	8.1040
P value	0.0001	0.8960	0.7726

Figure 6. Flower diameter (mm) of marigold varieties under different nitrogen levels.

Blooming Period

The flowering period of marigold was highly affected due to both nitrogen application and varieties. The plants supplied with the highest nitrogen level (N5) exhibited maximum blooming period, with averages of 44 days for Deep Orange and 39.66 days for Marvel Yellow. Flowering duration was also longer at intermediate nitrogen applications (N3 and N4) than at the lower nitrogen applications, with Deep Orange flowering period was 40.33 and 38.66 days, and Marvel Yellow flowering 32.66 and 31.33 days, respectively. The flowering period was highest with an average of 32.66 days for Deep Orange and 29.33 days for Marvel Yellow under N_2. The control treatment (N_1) had the lowest numbers of flowering days with averages of 28.66 days for Deep Orange and 23.33 days for Marvel Yellow (Figure 7). Overall, Deep Orange had the longer flowering period than Marvel Yellow, regardless of the nitrogen level. A significant interaction was also noted between nitrogen level and variety with the N_5 × Deep Orange treatment exhibited the longest flowering period and the N_1 × Marvel Yellow treatment revealing the shortest.



	Treatments	Varieties	T x V
SE±	2.1528	0.9628	1.5223
LSD 0.05	4.5229	2.0227	3.1982
P value	0.0000	0.0000	0.5561

Figure 7. Blooming period of marigold varieties under different nitrogen levels.

Discussion

Balanced management of fertilizers is important to improve crop growth, maximize productivity and ensure sustainable farming practices (Fatima et al., 2024). The effects of varying rates of nitrogen application on two varieties of marigold were determined in the current experiment. The results showed that the growth and flowering response of marigold was significantly influenced by the rate of nitrogen and different marigold varieties, thus demonstrating that providing adequate nitrogen supply is important for improving plant growth and production of flowers. Nitrogen levels and varieties of marigold demonstrated marked effect on plant height.N5 (120 kg ha^{-1}) had the tallest plants (up to 20.03 cm) under the variety “Marvel Yellow” and the shortest plants (7.56 cm) under the control (N1) variety “Deep Orange”. As the nitrogen level increases, the plant's height also increases, which is the basic mechanism by which nitrogen promotes vegetative growth by increasing the synthesis of chlorophyll, formation of proteins, and elongation of cells (Walia& Kumar, 2021). The results of the present study agree with previous findings reported for ornamental crops. Higher nitrogen rate has been shown to likewise result in a rise in plant height in China aster (Chaitra & Patil, 2006) and marigold (Arab et al., 2015). Similarly, Ahmed et al. (2017) and Teja et al. (2017) reported that as the nitrogen level increased, the height of the plants also increased significantly, due to the increased availability of nutrients and uptake by the plants and increased photosynthetic activity. The efficiency of nitrogen use was higher in the Marvel Yellow variety over all the nitrogen treatments which indicates a greater genetic ability of the variety to utilize the nitrogen efficiently. Likewise, a positive effect of N on vegetative growth was found as the number of branches per plant rose as N levels increased, with N_5 × Marvel Yellow having the most branches (34.33) followed by N_5 × Deep Orange (31.66).Plants grown without nitrogen application produced the fewest branches, with 7.66 branches per plant in Deep Orange and 8.66 in Marvel Yellow. The increase in branching observed with higher nitrogen levels may be attributed to enhanced vegetative growth, which promotes the development of lateral buds and results in a more compact and bushy plants. These findings are in agreement with Shafiullah et al. (2018), who reported that the number of branches produced was greatly improved in ornamental crops in response to high levels of nitrogen application. Similar results were also reported by Shinda et al. (2020), who observed a positive effect of nitrogen nutrition on the branching potential of marigold. While differences between the varieties were small and consistent, “Marvel Yellow” produced more branches than “Deep Orange”. This may be due to its improved efficiency of nitrogen uptake and utilization resulting in greater branch production in Marvel yellow. As the level of nitrogen increased, the number of days to flowering decreased, suggesting earlier flowering in plants treated with nitrogen. N5 × “Marvel Yellow” had the earliest flowering (16.00 days) while the latest flowering was recorded in N1 × “Deep Orange” (48.33 days).The earlier flowering observed under higher nitrogen levels may be attributed

to enhanced vegetative growth, improved protein synthesis, and better hormonal regulation, which accelerate the transition from vegetative to reproductive growth (Zhang et al., 2023). These findings are consistent with those of Subedi et al. (2020), who observed that up to 150 kg ha^{-1} of nitrogen application was found to significantly increase the rate of flower initiation and shorten the flowering time in marigold. With regards to varieties earlier flowering was noted in Marvel Yellow across all nitrogen rates. The early flowering of "Marvel Yellow" across all treatments is due to its faster growth rate and may be more nitrogen responsive than "Deep Orange."The influences of nitrogen nutrition on flower weight and size were significant. The flower weight was observed to increase with the application of Nitrogen. "Marvel Yellow" × N5 recorded the highest weight of flowers (9.27 g) and N1 × "Deep Orange" the lowest weight of flowers (2.76 g). Since flower weight was found to increase with nitrogen application, the increased amount of carbohydrate accumulation and improvement in physiological processes could be responsible for the flower growth and development (Teja et al., 2017). The same trend was observed by Moosavi et al. (2014) for marigold, where flower biomass was significantly increased with nitrogen fertilization. The individual flower weight was slightly greater for Marvel Yellow than for Deep Orange, perhaps related to its higher ability to make use of the available nitrogen, leading to better flower development at higher N levels. A similar trend was observed for total flower weight per plant, where increasing nitrogen application significantly improved flower yield. The highest flower weight per plant was recorded in the N5 × Deep Orange treatment (23.54 g), whereas the lowest was observed in the N1 × Marvel Yellow treatment (8.02 g), indicates, both nitrogen level and varietal characteristics influenced overall flower production. This higher production of flowers in the higher doses of nitrogen might be attributed to better vegetative growth, increased number of branches and increased flower size, all of which are contributing factors for overall production. The present findings are in agreement with those of Subedi et al. (2020) and Moosavi et al. (2014), who reported that nitrogen application significantly increased flower production in marigold, with optimum performance observed at rates up to 150 kg ha^{-1}. In the present study, however, Marvel Yellow exhibited its highest flower weight under the highest nitrogen treatment, indicating that the variety responded favorably to increased nitrogen availability under the prevailing experimental conditions. While "Deep Orange" flower weight was highest at the highest N rate, indicating that the varietal responses to N availability are different. Nitrogen levels and varieties were also significant for flower diameter (mm). The largest flowers diameter was recorded for N4 × "Marvel Yellow" with mean of 40 mm and the smallest was N1 × "Marvel Yellow" with mean of 12.88 mm. The application of nitrogen generally improved flower diameter in both marigold cultivars. This improvement can be attributed to the improved nutrient uptake, cell growth and enhanced photosynthetic activity, which in turn ensures more carbohydrates for flower development (Arun et al. 2022; Vinutha, 2017). Nitrogen application resulted in a positive response for both cultivars, but the responses were slightly different. When applying Nitrogen at moderate levels, flower size produced by Marvel Yellow was generally larger than Deep Orange which was the largest diameter flower produced at N_5 (highest application rate). This difference may be due to natural genetic variation in both varieties in their nitrogen use efficiency and in their nutritive allocation for flowering. This also demonstrates the fact that there is a difference in the nutrient utilization and growth response among varieties. The use of nitrogen application greatly prolonged the blooming period of marigold. Deep Orange had the longest flowering duration with 44 days under N5 while "Marvel Yellow" with N1 was the shortest with 23.33 days. The long flowering period was probably due to increased nitrogen levels which kept plant vigor and reduced senescence. Nitrogen is used in the continuous production of amino acids and photosynthates needed for the maintenance of flowers. There was a relatively longer blooming period in Deep Orange than in Marvel Yellow in all the treatments, indicating that Deep Orange has a greater persistence in the flower display. The results of the present study have been in agreement with the results of Teja et al. (2017) who found that with the increase in the nitrogen application, the flowering period was extended in ornamental plants. The overall conclusion is that, under similar agro-climatic conditions, application of nitrogen at 120 kg ha^{-1} along with use of a responsive cultivar like Marvel Yellow could help increase the yield potential of marigold, improve vegetative growth and increase flowering performance.

Conclusion

It is concluded that, overall, the different nitrogen levels significantly affected the growth, flowering, and yield parameters of the marigold varieties. The highest level of N supplied (120 kg ha^{-1}) resulted in the most vigorous plant growth and highest flower production when combined with the Marvel Yellow variety. The study results highlight the importance of selecting an appropriate cultivar and nitrogen fertilization dose to obtain the maximum floral yield of marigold. Furthermore, the results from this experiment offer sound advice to marigold growers on selecting a cultivar and an appropriate rate of nitrogen fertilization for producing better vegetative growth and flower production.

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Author Contribution

All authors made equal contributions to the design, conduct, and writing of this manuscript.

Conflict of Interest

The authors declare that there are no conflicts of interest related to this study.

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