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Effect of nitrogen doses on growth and yield of marigold (*Tagetes erecta* L.) in subtropical climate of Nepal

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ABSTRACT

Marigold (*Tagetes erecta* L.) is a potential commercial flower with an increasing demand in Nepal every year. A field experiment was carried out to study the effect of different doses of nitrogen on growth and flower yield of marigold under container gardening at Bharatpur-11, Bhojad, Chitwan, Nepal during autumn 2018. Five treatments including different doses of nitrogen, i.e. (T1-Control (0:90:75) kg NPK ha^{-1}; T2-(45:90:75) kg NPK ha^{-1}; T3-(90:90:75) kg NPK ha^{-1}; T4-(135:90:75) kg NPK ha^{-1}; and T5-(180:90:75) kg NPK ha^{-1}) were evaluated in Randomized Block Design with four replications. Results showed that plant height, plant spread, and number of branches were statistically significant. Marigold plant applied with 180 kg ha^{-1} nitrogen gave the maximum height (49.47 cm), spread (36.40 cm), and number of branches (24.75 plant^{-1}) in 45 DAT (days after transplanting) while the control plot showed the least. Similarly, nitrogen @ 180 kg ha^{-1} was found to be effective for early flowering initiation (32.50 DAT) and days (41.25 DAT) compared to control (39 and 48.75 DAT, respectively) and also resulted in maximum number of flower (34.73 plant^{-1}), flower diameter (7.03 cm) and yield (22.29 t ha^{-1}) compared to other treatments. Thus, the overall results suggest that the application of 180 kg N ha^{-1} in marigold produced the highest flower production.

Keywords: Flower, growth, nitrogen, *Tagetes erecta* L., yield

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1 Introduction

Floriculture is one of the leading sectors of the Nepalese economy, and contributes 0.05% of the total national Gross Domestic Product with the 24% annual growth rate of flowers production (FAN, 2016). The imports of flowers and garlands worth more than 100 million, particularly during the festive season in Nepal (MoF, 2016). Marigold (*Tagetes erecta* L.) is a potential commercial flower with growing demand in the context of Nepal due to its cultural and religious importance. Flower growers are attracted towards its cultivation because of its habit of free flowering, earliness, broad range of attractive color, form, size, quality and more importantly, the high demand of cut-flower (Datta and Singh, 2008). Despite the growing demand, the supply of marigold as a garland and cut-flower is very low in Nepal. A large number of farmers are not attracted to floriculture yet, and those engaged in this sub-sector typically follow the conventional way of farming (FAN, 2016). The annual productivity of marigold in Nepal is very low compared to global yield with wide yield gap due to various biotic and abiotic factors (MoF, 2017).

The management of fertilizers, particularly nitrogen, is one of the major yield limiting factors. Sustainable flower production with high value ornamental production and low production cost demands optimal fertilizer management (Zhang et al., 2012). Nitrogen applied as fertilizer is considered as the key source for meeting the nitrogen requirements of plant growth (Konnerup and Brix, 2010). Nitrogen increases vegetative growth and accelerates the flower opening cycle during the flowering season (Fan et al., 2005). On the other side, excessive and improper use of nitrogen fertilization has a detrimental effect. High nitrogen application results in dark green leaves and delay flowering (Singh and Sehrawat, 2002). Proper nitrogen application, at the correct rates and time, contributes to the optimal growth and, higher flower and seed yield of ornamentals (Kashif, 2001). Recently, container gardening using Styrofoam is increasingly popular in commercial floriculture due to low risk of soil-borne disease pests, weeds and less space, time and money required. Since fertilizers are costly inputs, technical know-how, including an appropriate dose of fertilizer, is often crucial for maximum return in container gardening. In this sense, an instant effort is needed to increase flower yield aiming to support tropical and subtropical commercial flower growers.

The objective of this study was to assess the different doses of nitrogen on growth and yield of marigold under container gardening in subtropical climate of Nepal.

2 Materials and Methods

2.1 Experimental site

The experiment was conducted at Bharatpur-11, Bhojad, Chitwan, terai belt of Nepal and characterized by tropical and subtropical climate. The latitude, longitude and altitude of the experimental site are 27°54′ N, 84°48′ E, and 244 m above sea level (masl), respectively.

2.2 Experimental design and treatments

The marigold variety used for the investigation was American marigold cultivar Bali Orange. The experiment was carried out in Styrofoam containers (wastage fish tray used in fish packaging) with dimension of 65 ×45 ×33 cm^3 (length × width × height) in the field. The design of the experiment was randomized complete block (RCB) with five different treatments and four replications. The detail of treatments was given in Table 1. Two Styrofoam containers represented a single plot, consisted of 4 rows of 2 plants per row having a gross area of 0.75 m^2 with a row spacing of 0.45 m and a plant spacing of 0.30 m. A total of 6 holes were made at the bottom of the containers with the help of an iron rod for drainage and the drainage layer was formed by adding small pebbles to the bottom of the holes before the soil was added. The Styrofoam containers were filled with black soil, from fertile crop land up to the level 25 cm from the base and then one month old seedlings were transplanted on it.

Table 1. Treatment details used in the experiment

Treatments	Fertilizer doses (kg ha^{-1})		
	N	P	K
T1 (control)	0	90	75
T2	45	90	75
T3	90	90	75
T4	135	90	75
T5	180	90	75

2.3 Cultural practices

Well decomposed farm yard manure @ 15 t ha^{-1} in combination with half dose of nitrogen as mentioned in different treatment level and full dose of phosphorous (90 kg ha^{-1}) and potash (75 kg ha^{-1}) were applied as basal at the time of media preparation. Nitrogen was applied in different doses except in control that constituted the different treatments.

2.4 Data collection and analysis

Five plants from each experimental plot were randomly selected for data collection. Data on growth and yield attributing components like plant height (cm), plant spread (cm), number of branches, days to first flower initiation, days to 50% flowering, flower diameter (cm), flower number per plant and yield (t ha^{-1}) were recorded. Microsoft excel was used for tabulation of data and for simple calculation. Data were analyzed statistically by performing analysis of variance (Steel and Torrie, 1980) by using GenStat software (15th edition) and the means were separated by using Least Significance Difference (LSD) test at 5% level of significance Gomez and Gomez (1984); Shrestha (2019).

3 Results and Discussion

3.1 Growth parameters

The growth parameters like plant height, spread and branches of marigold varied significantly among the different doses of nitrogen at 45 days after planting (Table 2). The higher plant height (49.47 cm), spread (36.40 cm) and branches (24.75) of marigold were recorded in the plot with 180 kg ha^{-1} followed by the height of 45.97 cm, spread of 33.60 cm and 21.80 branches in the plot with 135 kg N ha^{-1} at 45 days after transplanting. The lower plant height (40.87 cm),

Table 2. Effect of different doses of nitrogen on growth parameters of marigold at 45 days after transplanting at Bharatpur, Chitwan during autumn 2018

Treatments	Plant height (cm)	Plant spread (cm)	Branches
Control	40.87d	28.00c	17.97d
45 kg N ha^{-1}	43.05c	31.25b	19.92c
90 kg N ha^{-1}	45.07b	31.45b	21.07bc
135 kg N ha^{-1}	45.97b	33.60b	21.80b
180 kg N ha^{-1}	49.47a	36.40a	24.75a
Mean	44.89	32.14	21.1
SEM (±)	0.637	0.745	0.58
LSD0.05	1.96**	2.30**	1.77**
CV (%)	2.8	4.6	5.5

Values are means of four replications. The means followed by the same letter on the same column are not significantly different by LSD (P<0.01), SEM- standard error mean; **: significant at 0.01 level

Table 3. Effect of different doses of nitrogen on yield and yield attributing components of marigold at Bharatpur, Chitwan during autumn 2018

Treatments	DFI	DFI_{50}	Flower diameter (cm)	Flowers plant^{-1}	Yield (t ha^{-1})
Control	39.00a	48.75a	5.44b	28.30d	9.90e
45 kg N ha^{-1}	38.25ab	47.50a	6.65a	29.55cd	13.19d
90 kg N ha^{-1}	37.25b	47.00a	6.70a	30.90c	14.68c
135 kg N ha^{-1}	33.50c	42.50b	6.68a	33.02b	18.33b
180 kg N ha^{-1}	32.50c	41.25b	7.03a	34.73a	22.29a
Mean	36.1	45.4	6.5	31.3	15.7
SEM (±)	0.35	0.6	0.13	0.504	0.111
LSD0.05	1.10**	1.86**	0.39**	1.55**	0.34**
CV (%)	2	2.7	3.9	3.2	1.4

DFI =days to flower initiation, DFI_{50} = days to 50% flowering; Values are means of four replications. The means followed by the same letter on the same column are not significantly different by LSD (P<0.01), SEM-standard error mean; **: significant at 0.01 level

spread (28 cm) and branches (17.97) were recorded in control plot with no nitrogen (Table 2). Data revealed that increased nitrogen level expressed significant effect over the rest of the treatments by increasing plant height, spread and branches of marigold, which is similar with the findings of (Arora and Khanna, 1986). Malik (1994) reported that fundamentally nitrogen is part of chlorophyll and proteins that enhance plant vegetative growth. The increase in plant height, spread and branches is due to greater uptake of nutrient by plant system through soil application (Teja et al., 2017). Hence, it has positive effect in promoting the growth of plant by involving cell division, cell elongation, and protein synthesis. This will ultimately enhance the vegetative growth. Similar kind of observation with increased plant height by external application of higher dose of fertilizer was noticed in China aster (Singh, 2000) and marigold (Acharya and Dashora, 2004). The result regarding the spread of marigold is in conformity with the earlier findings of Kumar et al. (2003) in China aster and Chadha et al. (1999) in marigold. The number of branches were increased with increasing doze of nitrogen and the finding is in line with Shafiullahh et al. (2018) and Singh and Kumar (2009).

3.2 Yield and its attributing parameters

The various yield and yield attributing parameters like days to first flower initiation, days to 50% flowering, flower diameter (cm), flower per plant and yield (t ha^{-1}) of marigold varied significantly among the different doses of nitrogen (Table 3). The yield of marigold was significantly affected by doses of nitrogen in this study. This results are similar to the results reported by Subedi et al. (2020) who found that the nitrogen dose up to 150 kg ha^{-1} significantly affected the yield of flower in marigold. The first flower ini-

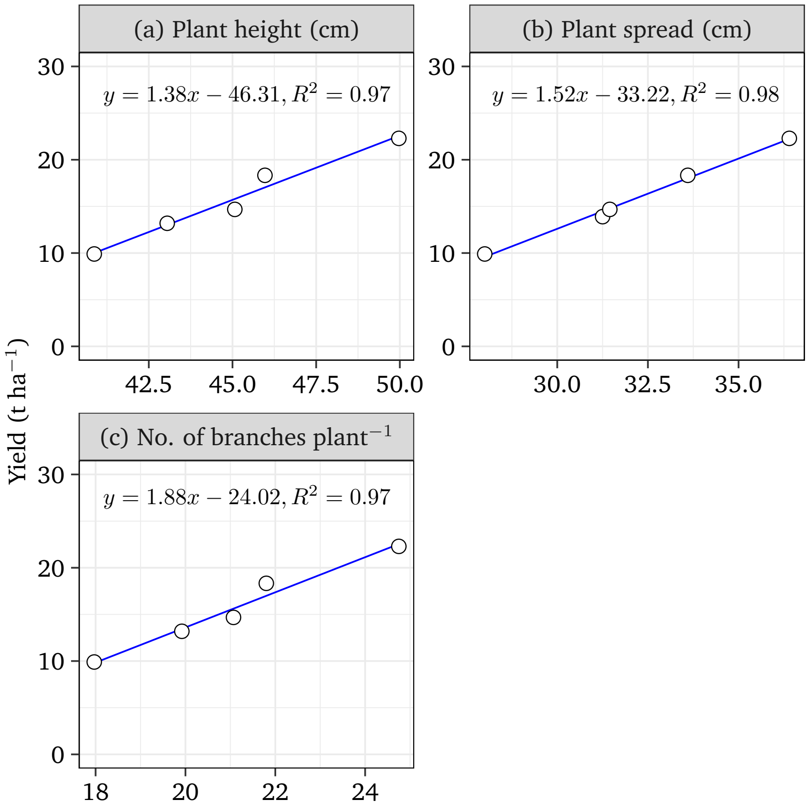

Figure 1. Relationship between growth parameters to yield of marigold at Bharatpur, Chitwan during autumn 2018

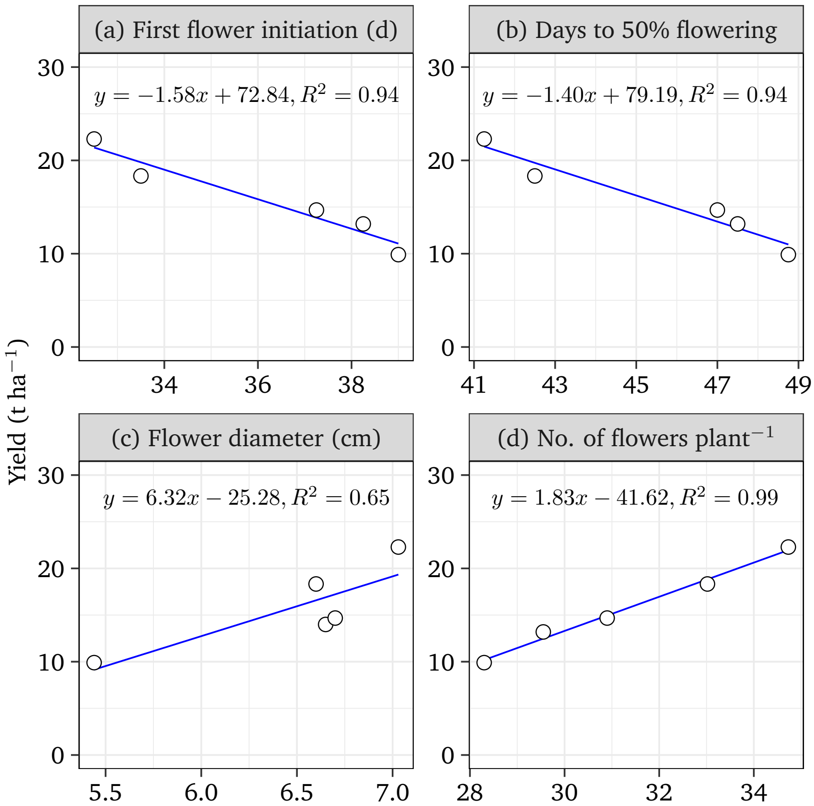

Figure 2. Relationship between yield attributing parameters to yield of marigold at Bharatpur, Chitwan during autumn 2018

tiation (32.50 d) and days to 50% flowering (41.25 d) were recorded early in the plot with 180 kg N ha^{-1} which was statistically at par with the plot of 135 kg N ha^{-1}. The delayed flower initiation (39 d) with late days to 50% flowering (48.75 d) was recorded in control plot which was statistically at par with rest of the treatments (Table 3). The higher flower diameter of 7.03 cm was recorded in the plot with 180 kg N ha^{-1} which was statistically at par with other doses of nitrogen. The lower diameter (5.44 cm) was recorded in control plot (Table 3). The higher no of flower per plant (34.73) and yield (22.29 t ha^{-1}) were recorded in the plot with 180 kg N ha^{-1} followed by the flower per plant 33.02 and yield of 18.33 t ha^{-1} in the plot with 135 kg N ha^{-1}. The lower no of flower per plant (28.30) with lower yield (9.90 t ha^{-1}) were recorded in control plot with no nitrogen (Table 3).

The earliest flower bud initiation observed with the application of nitrogen @ 180 kg ha^{-1} might be due to quick vegetative growth and thereafter, enhancing reproductive development of flower under optimum nitrogen treatment. Higher content of nitrogen might have also accelerated protein synthesis which promotes earlier floral primordial development (Vijay Kumar and Shanmungavelu, 1978). The increased flower number per plant in treatment 180 kg N ha^{-1} was probably due to the increased number of branches per plant. The increase in number of flower per plant with the application of nitrogen significantly increased the growth parameters, that might have synthesized more plant metabolite which ultimately led to increase in flower production (Chan et al., 1958). The increased flower yield in plant with the application of higher dose of nitrogen might be due to the positive impact of nitrogen fertilizer on vegetative growth, and concentration of photosynthesizing pigment. Additionally, this is due to the increased carbohydrate reserve for the development of floral primordial apart from the structural development of plant (Teja et al., 2017). The present results are in conformation with earlier findings of (Pop and Pirsan, 2019; Agarwal et al., 2002; Sharma et al., 2006; Singh and Saha, 2009) in marigold.

3.3 Growth parameters *vs.* yield

A linear significant positive correlation between yield and plant height ($r = 0.98$), plant spread ($r = 0.99$) and no of branches ($r = 0.98$) was observed representing the best fit having $R^2 = 0.97$ (Fig. 1). Obviously the yield increased with the increase in growth parameters like plant height, spread and no of branches. The predicted linear regression line was also displayed upward slope i.e. $y = 1.38x - 46.31$, with regression coefficient $R^2 = 0.97$ for plant height, $y = 1.52x$˘33.22, with $R^2 = 0.98$ for plant spread and $y = 1.88x$˘24.02, with $R^2 = 0.97$ for no of branches where 'y' denoted predicted yield of marigold and 'x' stood for growth parameters like plant height, spread and no of branches respectively (Fig. 1)

3.4 Yield attributing parameters *vs.* yield

Flower yield was correlated with various traits (Fig. 1 and Fig. 2). Flower yield is a complex trait, the expression of which depends on the action and multiple interactions of various components. A linear significant negative correlation between yield and higher days to flower initiation and higher days to 50% flowering ($r = -0.97$) was observed representing the best fit having $R^2 = 0.97$ (Fig. 2). Obviously the yield was decreased with the increase in flower initiation days and days to 50% flowering. The yield is increased with the earlier flowering days in marigold. The predicted linear regression line was also displayed downward slope i.e. $y = -1.58x + 72.84$, with $R^2 = 0.94$ for days to first flower initiation, $y = -1.40x + 79.19$, with $R^2 = 0.94$ for days to 50% flowering where 'y' denoted predicted yield of marigold and 'x' stood for yield parameters like days to first flower initiation and days to 50% flowering respectively (Fig. 2). Similarly, a linear significant positive correlation between yield and flower diameter ($r = 0.80$) and flower per plant ($r = 0.99$) was observed representing the best fit having $R^2 = 0.98$ (Fig. 2). Obviously the yield increased with the increase in yield parameters like flower diameter and flower number per plant. The predicted linear regression line was also displayed upward slope i.e. $y = 6.32x - 25.28$, with $R^2 = 0.65$ for flower diameter and $y = 1.83x - 41.62$, with $R^2 = 0.99$ for flower per plant where 'y' denoted predicted yield of marigold and 'x' stood for yield parameters like flower diameter and flower per plant respectively (Fig. 2). The associations of yield attributing characters with flower yield per plant are in desirable direction and selection of these traits may ultimately improve the yield. Similar results were quoted by Mathad et al. (2005), Singh and Saha (2009), Karuppaiah and Kumar (2010) and Kavitha and Anburani (2010) in African marigold.

4 Conclusions

Marigold plants were affected greatly by different doses of nitrogen. The nitrogen @180 kg ha^{-1} showed noteworthy performance on plant growth, flowering, and yield parameters of marigold under container gardening in Chitwan. The height, spread, number of branches and yield (t ha^{-1}) in marigold has been increased by 18%, 22%, 29% and 55% respectively with the highest dose of nitrogen (180 kg ha^{-1}). It is therefore advisable to use 180 kg N ha^{-1} along with the recommended doses of phosphorus and potassium for higher yield when growing marigold in the Styrofoam container.

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Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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