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Effect of Nitrogen and Plant Spacing on Nutrients Uptake, Yield and Growth of Tuberose (*Polianthes tuberosa* L.)

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Abstract

Plant spacing and nitrogen are the most important factors for increasing tuberose quality and quantity. In this study, field experiment carried out as factorial Randomized Completely Block Design (RCBD) in 3 replications. Different levels of nitrogen (0, 50, 100, 150, 200, 250 kg/ha) of ammonium nitrate was used. Second factor was different plant spaces (10, 15, 20 and 25 cm). Results showed that the 25 cm plant space had a significant effect on flower stalk height, stem diameter, spike length, floret diameter, floret weight, vase life and nutrient uptake. Nitrogen levels affected on stem diameter, spike length and nitrogen uptake. The results show that using 200 kg/ha N can improves growth and yield of tuberose as flower stalk height, stem diameter and bulb weight. Data showed that the maximum quality and quantity of flower obtained in 25 cm plant spacing plus 200 kg/ha N.

Keywords: Flower quality and quantity, Nitrogen, Plant spacing, Tuberose.

INTRODUCTION

Tuberose (*Polianthes tuberosa* L.) is one of the most important cut flowers in tropical and subtropical regions of the world. It cultivated about 288 hectares and with production of about 29 million cut flowers, has the fourth rank among cultivated cut flowers in Iran. It is produced in greenhouses and open space (Statistics of Ornamental Plants, 2007).

Nutrients such as nitrogen play a major role in the growth and development of plants (Scott, 2008). This essential nutrient improves the chemical and biological properties of the soil, and therefore enhances higher yields of plants. Silberbush *et al*., (2003), Kim *et al*., (1998) and Engelbrecht (2004) have emphasized to supply nutrients to the soil during the growth of plants to increase their quality or productivity. Optimum plant density is another important factor for high plant growth and yield. In tuberose, the spacing has a great importance for manipulating flower quality and quantity characteristics. Therefore, inter and intra row spacing and balanced supply of nutrient such as nitrogen are important for obtaining higher tuberose flower quality and quantity. But, the information on the effects of integrated use of nitrogen and plant spacing on yield and quality of flower in tuberose is very limited. It has been reported that the highest plant height, panicle length and number of flowers per panicle obtained at 350 N kg/ha (Singh, 2000). In an experiment, it was evaluated the effects of nitrogen doses and plant densities on growth and yield of tuberose. Growth and yield increased with increases in nitrogen doses and plant densities. Highest flower stem height, yield, number of stems and flower clusters was related to 200 kg/ha N and three number bulbs in each hole (Patil *et al*., 1999). Yadav *et al*., (1985) investigated nitrogen and phosphorus levels on the growth and yield of tuberose. The best results obtained at of N: P_2O_5 ratio of 1: 1.5 (200: 300) and split application of nitrogen in 2 stages (half at sowing + half at 40 days after planting).

Results of experiment indicated that a higher plant height (50.94 cm) and number of leaves per plant (52.30) with application of 20 kg/ha N as compared with 5 kg/ha N (42.50 and 26.37, respectively) in tuberose (Banker and Mukhopadhyay, 1990).

Gangadharan and Gopinath (2000) revealed that application of vermicompost at 15000 kg/ha + 60% recommended dose of fertilizers (RDF) increased the plant height (116.98 cm) and corm weight (39.60 g) in compared to application of vermicompost at 5000 kg/ha + 80% recommended dose of fertilizers (RDF) (93.02 cm and 34.12 g, respectively) in gladiolus.

It is noticed that flower stalk height and leave length in tuberose increased with the application of higher dose of NPK and increased flowering period and produced largest panicle length with 200: 200: 400 kg/ha NPK (Amarjeet *et al*., 1996).

Singh and Uma (1996) evaluated the effect of nitrogen levels on the growth and yield of tuberose in field experiment. They found that the best tuberose quality and quantity yield obtained at three split applications of 250 kg/ha N fertilizers (at basal, 60 and 90 days after planting).

Padaganur *et al*., (2005) revealed that application of 50% recommended dose of fertilizers (RDF) + 3 kg/m vermicompost recorded more number of florets per spike (52.65) and spike yield (64.67 gr/plot) compared to control (41.54 and 43.67, respectively) in tuberose.

Singh (1996) recorded delayed flowering (153.23 days) with closer spacing of 20 x 10 cm compared to wider spacing of 25 × 25 cm (116.31 days) in tuberose.

Mane *et al*., (2007) observed that wider spacing of 20 × 25 cm took maximum number of days required for sprouting (11.39 days) compared to closer spacing of 20 × 15 cm (9.50 days) in tuberose cv. Single.

Karuppaiah and Krishna (2005) in French marigold observed closer spacing of 20 × 30 delayed days to 50 per cent flowering (81.26 days) compared to wider spacing of 30 × 40 cm (76.84 days).

Parkash *et al*., (2006) observed the most flower yield and tuber number with spacing of 15 x 20 cm in tuberose. Results showed that the highest flower number with best tuberose quality and quantity characteristics, produced by 200: 200: 150 kg/ha NPK. The aim of the present work is to study the effect of nitrogen doses, plant density and their interaction on growth and yield components of tuberose (*Polianthes tuberosa* L.).

MATERIALS AND METHODS

A field experiment was conducted to study the impact of nitrogen levels, plant density and their interaction on growth and yield of tuberose (*Polianthes tuberosa* L.) cv. Double, a member of the Agavaceae native to Mexico, at the Mahallat National Research Ornamental Plants Station that located at 53º 33$\bar{x}$ N latitude and 50º 30$\bar{x}$ E longitude with an altitude of 1747 m above sea level. During the cropping period (June to August 2005) the mean maximum and minimum temperature were 35.8° and 18.7°C respectively. The maximum and minimum relative humidity were 68.6% and 57.1%, respectively.

This experiment was conducted in a factorial randomized completely block design in three replications in 2 m^2 plots size. Nitrogen doses from N_1 to N_6 (0, 50, 100, 150, 200 and 250 kg/ha) were as first factor and plant densities (inter-row spacing) from D1 to D4 (10 × 10, 15 × 15, 20 × 20 and 25 × 25) cm × cm, considered as the second factor. Ammonium nitrate as a source of nitrogen fertilizer applied at three splits (at basal, 30 and 60 days after planting). The soil, classified as Xeric Torriorthents, was collected from topsoil (0~30 cm) which had a sandy loam texture (about 4.6% clay, 27.4% silt and 68% sand). In this soil, organic C, total N, available P and K contents were 0.34%, 0.03%, 11.3 and 196 mg/kg, respectively. Available Fe, Zn, Mn, Cu and B concentrations were 2.8, 0.68, 15, 1.08 and 0.52 mg/kg, respectively. Soil pH and EC were 8.18 and 0.61 dS/m.

Each plot received basal application of triple superphosphate [$Ca(H_2PO_4)_2$. x H_2O, 200 kg/ha], potassium sulfate (K_2SO_4, 360 kg/ha), Magnesium sulfate ($MgSO_4.H_2O$, 100 kg/ha), Copper sulfate ($CuSO_4.5H_2O$, 20 kg/ha), Manganese sulfate ($MnSO_4.4H_2O$, 40 kg/ha), Iron chelate (Fe EDDHA, 20 kg/ha), Zinc sulfate ($ZnSO_4.H_2O$, 360 kg/ha) and Boric acid (H_3BO_3, 360 kg/ha).

The field plots were prepared and uniform size flower bulbs planted in that. The same irrigation and other cultural operations were done in the plots.

At harvesting time in August, some quality and quantity characteristics such as flower stalk height, flowering stem diameter, spike length, floret diameter, floret weight, vase life, bulb number and weight were determined.

Data were subjected to analysis of variance (ANOVA) procedure. Least significant difference (LSD) at 5% level of significance was used to compare treatment means. All data analyses were performed using the SAS statistical analysis software (SAS Institute, 2003).

RESULTS AND DISCUSSION

Flower Stalk Height

Nitrogen rate and plant density influenced flower stalk height of tuberose significantly than control (Table 1). As nitrogen rate increased, plant stalk height increased (Table 3). Sufficient nitrogen flow into plants cause the better plant growth and stimulate the auxiliary buds resulting in more flowers stalk height. Similar results were reported by Gowda *et al*. (1991); Patil *et al*., (1999) and Singh (2000). Data in Table 1 shows that the plant spacing had significant effect on flower stalk height (Table 1). Maximum flower stalk height (29.36 cm) was recorded at plant spacing of 25 × 25 cm against the minimum (25.96 cm) at 10 × 10 cm row spacing (Table 2).The most flower stalk heights were measured at 250 kg/ha N along with 10 x 10 cm as 68.21 cm (Table 4). The increased plant height might be due to intra plant competition for light, moisture, space, nutrients and aeration. This is resulted in elongation of flower stalk height, may be due to elongation of cells and number of cells due to cell division. Similar observations are also made by Hugar (1997) in *Gaillardia*; Karavadia and Dhaduk (2002) in chrysanthemum and Mane *et al*., (2007) in tuberose.

Stem Diameter

Data in tables 1 and 3 shows that the nitrogen levels had a positive and significant effect on stem diameter of tuberose. Increasing nitrogen levels up to 250 kg/ha N significantly increased stem diameter (9.18 mm) (Table 3). The increase in growth characters and yield components with the increase in nitrogen levels might be due to the role in nitrogen in stimulating vegetative growth. Nitrogen is a constituent of the proteins, nucleic acids and nucleotides that are essential to the metabolic function of a plant. Parallel finding to our results have been obtained Cho *et al*., (2001) in pearl millet; Hussein *et al*., (1980) in sunflower and Kusuma (2001) in golden rod. Data in table 1 shows that the plant spacing had significant effect on stem diameter of tuberose. Maximum stem diameter (9.74 mm) was produced at the high spacing of 25 × 25 cm, compared to the minimum stem diameter at low spacing of 10 × 10 cm which produced 7.86 mm (Table 2). This result is supported by Mane *et al*., (2007); Allam (1996) and Mojiri (2003) in sunflower. The interaction between plant spacing and nitrogen levels significantly affected stem diameter. Maximal value was measured at 25 × 25 cm plant spacing and 250 kg/ha N (Table 4). Similar observations were reported by Al-Thabet (2006) in sunflower.

Spike Length

A perusal of table 1 indicates that different nitrogen doses significantly affected spike length. Generally, increasing doses of the nitrogen raised spike length. Nitrogen applied at 250 kg/ha resulted in maximum spike length (27.66 cm) compared to the minimum (25.56 cm) in control (Table 3). This finding is in agreement with Bijimol and Singh (2001). Spike length significantly varied among plant densities (Table 1). Maximum spike length (28.03 cm) was produced at the high spacing of 25 × 25 cm, compared to the minimum spike length at low spacing of 10 x 10 cm which produced 24.66 cm (Table 2) . This result is supported by Mane *et al*., (2007). The nitrogen rate x plant spacing interaction had not significant effect on spike length but increased while plant spacing and nitrogen dose. Maximal value was measured at 25 × 25 cm plant spacing and 150 kg/ha N (Table 4). Parallel finding to our results have been obtained Munikrishnappa *et al*., (2004) in tuberose and El-Naggar and El-Nasharty (2009) in Amaryllis.

Floret Number

Nitrogen rate had not significant effect on floret per spikes across all N rates, but increasing doses of the nitrogen raised floret per spikes (Table 1). Nitrogen applied at 200 kg/ha resulted in maximum floret number per spikes (28.5) compared to the minimum (27.05) in control (Table 3).This finding is agreed with Munikrishnappa *et al*., (2004) in their experiment that found significantly increasing of floret per spikes in tuberose by increasing of nitrogen. Floret number significantly varied among plant densities (Table 1). The widest spacing recorded highest number of floret per spikes (29.36) as compared to closest spacing (25.96) (Table 2). The production of spikes having more florets may probably be due to less competition between plants for water, mineral nutrient and light. Mukhopadhyay and Banker (1981) and Roychowdhary (1989) reported similar results.

On the effects of nitrogen doses x plant spacing interaction, maximum value (30.8) was evaluated from interactions of 150 kg/ha N and spacing of 25 × 25 cm (Table 4) but differences was not statistically significant (Table 1). Some researchers obtained similar findings as Padaganur *et al*., (2005) and Bijimol and Singh (2001).

Floret Diameter

Data in Table 1 shows that the nitrogen levels had not significant effect on floret diameter of tuberose. By increasing doses of the nitrogen, floret diameter a little increased (Table 3). Similar results were reported by Bijimol and Singh (2001) in gladiolus and Munikrishnappa *et al*., (2004) in tuberose. Plant spacing significantly affected floret diameter (Table 1). The widest spacing recorded highest floret diameter (16.09 mm) (Table 2). As discussed earlier the wider spaced plants have less competition for nutrient, water and light resulted into better quality flower production. Similar types of response also observed Al-Thabet (2006) in sunflower with wider spacing. Floret diameter has not affected significantly by both nitrogen application and plant spacing. Maximum value (18.37) was evaluated from interactions of 50 kg/ha N and spacing of 20 × 20 cm (Table 4). These results have not agreed with Bijimol and Singh (2001) in gladiolus.

Vase Life

Nitrogen rate not affected tuberose vase life (Table 1). Maximum vase life (5.3 days) was produced at the 150 kg/ha N (Table 3). High nitrogen level has inverse effect on vase life as if nitrogen at the 250 kg/ha N has minimum vase life (4.2 days) (Table 3). Similar findings to our results have been obtained by Clark and Burge (1999) in *Sandersonia* and Srinivas (1994) in China aster. Tuberose vase life significantly varied among plant densities. The widest spacing recorded highest vase life (5.9 days) as compared to closest spacing (3.9 days) (Table 2). Tuberose vase life increased with increasing plant spacing in tuberose (Mane *et al*., 2007). On the effects of nitrogen levels × plant spacing interaction, maximum values were evaluated from interactions of 0 kg/ha N and spacing 25 × 25 cm, 50 kg/ha N and spacing 25 × 25 cm, 100 kg/ha N and spacing 25 × 25 cm, 150 kg/ha N and spacing 25 × 25 cm and 200 kg/ha N plus spacing 25 × 25 cm (Table 4). These findings are in agreement with of Clark and Burge (1997) in *Sandersonia* cut flower.

Flower Quality

Nitrogen rate had no effect on flower quality in all N rates (Table 1), but increasing doses of the nitrogen raised flower quality until 150 kg/ha N. Maximum value (124.3) was evaluated from 150 kg/ha N (Table 4). Whereas increasing nitrogen supply from a low to an optimum level raises cytokinin and lowers ABA concentrations, excessive nitrogen supply also leading to a secondary salt stress causes opposite reactions (Menard *et al*., 1995). Plant spacing significantly affected flower quality (Table 1). The plant spacing of 25 × 25 cm produced maximum (141.2) and 10 × 10 cm minimum flower quality (90.3) (Table 2).The increased Flower quality by plant spacing increasing, is due to less intra plant competition for light, moisture, space, nutrients and aeration. Misra *et al*., (2000) in tuberose also observed similar types of response with wider spacing. On the effects of nitrogen levels x plant spacing interaction, maximum and minimum values were evaluated from interactions of 200 kg/ha N and spacing 25 × 25 cm and 250 kg/ha N plus spacing 10 × 10 cm, respectively (Table 4). Clark and Burge (1999) found similar results in *Sandersonia* there by confirming the present findings.

Plant Nutrients

Nitrogen

Data in Table 1 shows that the nitrogen had significant effect on nitrogen concentration of tuberose (Table 1). By increasing doses of the nitrogen, nitrogen uptake increased. Maximum value (%2.35) was evaluated from 250 kg/ha N (Table 3). The increase in plant nitrogen concentration with the increase in nitrogen levels is due to the high nitrogen availability and so better uptake of it by plants. Similar observations were reported by Sunitha (2006) in marigold and Singh *et al*., (2000) in tuberose. Plant nitrogen significantly varied among plant densities (Table 1). Maximum nitrogen concentration (%2.28) was produced at the high spacing of 25 × 25 cm (Table 2). The wider spaced plants have less competition for nutrient, water and light resulted into better nutrient uptake by plants (Mojiri, 2003). The nitrogen rate x plant spacing interaction had no significant effect on nitrogen concentration but increased while plant spacing and nitrogen dose. Maximal value (%2.38) was measured at 20 × 20 cm plant spacing and 250 kg/ha N (Table 4).

Phosphorus

Nitrogen factor had no significant effect on plant phosphorus (Table 1), Maximum phosphorus uptake (%0.32) obtained from 150 kg/ha N (Table 3). These findings are similar to the findings of Singh *et al*., (2002) on gladiolus. plant spacing significantly affected plant phosphorus concentration (Table 1). The widest spacing recorded highest plant phosphorus as %0.34 (Table 2). The higher plant spaces have less competition for nutrient, resulted into better nutrient uptake by plants (Misra *et al*., 2000). On the effects of nitrogen doses x plant spacing interaction, maximum values (%0.397) were evaluated from interactions of 150 kg/ha N and 25 × 25 cm plant spacing (Table 4).

Potassium

Data shows that nitrogen factor had no significant effect on plant potassium (Table 1). Maximum potassium uptake (%2.51) obtained from 150 kg/ha N (Table 3). This result is similar to the findings of Singh *et al*., (2002) on gladiolus. Data shows that plant spacing significantly affected plant potassium concentration (Table 1). The widest spacing recorded highest value (%2.59) of potassium concentration in plant (Table 2). The higher plant spaces have less competition for nutrient, resulted into better nutrient uptake by plants (Mojiri, 2003). On the effects of nitrogen doses x plant spacing interaction, maximum values (%2.807) were evaluated from interactions of 100 kg/ha N and 25 × 25 cm plant spacing (Table 4).

CONCLUSIONS

Different nitrogen doses and plant spacing significantly affected some quality and quantity characters in tuberose. An increase in plant spacing and nitrogen rate increased flower stalk height, spike length, floret number and diameter, bulb weight, vase life and flower quality, it can be concluded that tuberose should be sown on row spacing of 25 × 25 cm with application rate of 200 kg/ha N to obtain maximum flower quality and quantity characteristics.

Literature Cited

Allam, A.Y. and Galal, A.H. 1996. Effect of nitrogen fertilization and plant density on yield and quality of sunflower. Assiut J. Agric. Sci. 27(2) :169-177.

Al-Thabet, S.S. 2006. Effect of plant spacing and nitrogen levels on growth and yield of sunflower (*Helianthus Annus* L.). J. King Saudi Univ. Agric. Sci. 19 (1): 1-11.

Amarjeet, S., Godara, N.R., Ashok, K., Singh, A. and Kumar, A. 1996 . Effect of N.P.K on flowering and flower quality of tuberose (Polinathes tuberosa L.) cv. single. Haryana Agric. Univ. J. Res. 26(1): 43-49.

Bankar, G.J. and MukhoPadhyay, A. 1990. Effect of N.P.K on growth and flowering in tuberose cv. Double. Indian J. Hort. 47(1):120-126.

Bijimol, G. and Singh, A.K. 2001. Effect of spacing and nitrogen on flowering, flower quality and postharvest life of gladiolus. J. Appl. Hort. 3: 48-50

Cho, N.K., Kang, Y.K. and Boo, C.H. 2001. Effect of split nitrogen application on agronomic characteristics, forage yield and composition of Japanese millet. J. Animal, Sci. and Tech. 43(2):253-253.

Clark, G.E. and Burge, G.K. 1997. Effects of planting density, stem pruning treatments, and shade on secondary tuber development in *Sandersonia* aurantiaca. New Zealand J. Crop and Hort. Sci. 25: 73-78.

Clark, G.E. and Burge, G.K. 1999. Effects of nitrogen nutrition on *Sandersonia* cut flower and tuber production in a soil-less medium. New Zealand J. Crop and Hort. Sci. 27(20):145 – 152.

El-Naggar, A.H. and El-Nasharty, A.B. 2009. Effect of growing media and mineral fertilization on growth, flowering, bulbs productivity and chemical constituents of Hippeastrum vittatum, Herb. American-Eurasian J. Agric. & Environ. Sci. 6 (3): 360-371.

Engelbrecht, G.M. 2004. The effects of nitrogen, phosphorus and potassium fertilization on the growth, yield and quality of Lachenalia. Ph.D. Thesis, Agric. Sci., Univ. of the Free State, Bloemfontein.

Gangadharan, G.D. and Gopinath, G. 2000. Effect of organic and inorganic fertilizers on yield of spikes, corms, cormels and returns of gladiolus cv. White Prosperity. Karnataka J. Agric. Sci. 13(4): 937 – 941.

Gowda, J.V.N., Jacob, S. and Hudder, A.G. 1991. Effect of N., P and K on growth and flowering of tuberose (*Polinates tuberosa* L.) cv. Double. Indian Perfumer. 35(2):100-101.

Hugar, A.H. 1997. Influence of spacing, nitrogen and growth regulators on growth, flower yield and seed yield in *gaillardia* (*Gaillardia pulchella* var. Picta Fouger). Ph.D. Thesis, Univ. Agric. Sci., Dharwad, India.

Hussein, M.A., El-Hattab, A.H. and Ahmed, A.K. 1980. Effect of plant spacing and nitrogen levels on morphological characters, seed yield and quality in sunflower (*Helianthus annuus* L.). J. Agron. Crop Sci. 149: 148-156.

Karavadia, B.N. and Dhaduk, B.K. 2002. Effect of spacing and nitrogen on annual chrysanthemum

(*Chrysanthemum coronarium*) cv. Local White. J. Ornamental Hort., New Sources, 5(1): 65 – 66.
Karuppaiah, P. and Krishna, G. 2005. Response of spacing and nitrogen levels on growth flowering and yield characters of French marigold (*Targets patula* L.). J. Ornamental Hort. 8(2): 96 – 99.
Kim, H.H., Ohkawa, K. and Nitta, E. 1998. Effects of bulb weight on the growth and flowering of Leucocoryne coquimbensis. F. Phill. Acta Hort. 454: 341-346.
Kusuma, G. 2001. Effect of organic and inorganic fertilizers on growth, yield and quality of golden rod. M. Sc. (Hort.) Thesis, Univ. Agric. Sci., Bangalore, India.
Mane, P.K., Bankar, G.J. and Makne, S.S. 2007. Influence of spacing, bulb size and depth of planting on flower yield and quality of tuberose (*Polianthes tuberosa* L.) cv. Single. Indian J. Agric. Res. 41 (1): 71 – 74.
Menrad, C.B., Dansereau, G.G. and Page-degivry, M.T. 1995. Influence of nitrogen supply on ABA levels and flower senescence in Rosa hybrida cv. Royalty. Acta Hort. 424, 151–153.
Misra, H., Singh, A.K. and Singh, O.P. 2000. Effect of bulb size and spacing on growth and flowering behavior of tuberose (*Polianthes tuberosa* L.). Adv. Plant Sci. 13(2):563-566.
Mojiri, A. and Arzani, A. 2003. Effects of nitrogen rate and plant density on yield and yield components of sunflower. J. Sci. Tech. Agric. and Natural Resources. 7(2): 115-125.
Mukhopadayay, A. and Bankar, G.J. 1981. Effect of time of planting on growth, flowering and bulb production in tuberose cv. Single. Indian Agric. 25: 131-134.
Munikrishnappa, P.M., Katimani, K.N. and Ravikumar, M. 2004. Effect of vermicompost on growth and yield of tuberose (*Polianthes tuberosa* L.) under semi-arid tropics of north Karnataka. National Symposium on Recent Trends and Future Strategies in Ornamental Horticulture. Univ. Agric. Sci., Dharwad, India. pp. 61.
Padaganur, V.G., Mokashi, A.N. and Patil, V.S. 2005. Effect of growth regulators on growth and yield of tuberose cv. Single. Karnataka J. Agric. Sci. 18(2): 469 – 473.
Parkash, J., Singh, N.P. and Sankaran, M. 2006. Package of practices for tuberose cultivation in tripura. ICAR Research Complex for NEH Region, Tripura Centre. Publication No• 31
Patil, P.R., Reddy, B.S., Patil, S.R. and Kulkarni, B.S. 1999. Effect of community planting and fertilizer levels on growth and flower yield of tuberose (*Polinathes tuberosa* L.) cv. Double. South Indian Hort. 47(1-6):335-338.
Roychowdhury, N. 1989. Effect of plant spacing and growth regulators on growth and flower yield of gladiolus grown under polythen tunnel. Acta Hort. 246:259-264.
SAS Institute. 2003. SAS Stat 9.1. SAS Inst., Cary, NC, USA.
Scott, P. 2008. Mineral nutrition of plants. *In:* Physiology and Behavior of Plants. John Wiley and Sons, Ltd. Pages 75-87.
Silberbush, M., Ephrath, J.E., Alekperov, C. and Ben-Asher, J. 2003. Nitrogen and potassium fertilization interactions with carbon dioxide enrichment in Hippeastrum bulb growth. Scientia Hort. 98: 85–90.
Singh, K.P. 1996. Effect of spacing on growth and flowering in tuberose (*Polianthes tuberosa* L.) cv. Shringar. Haryana J. Hort. Sci. 53(1):76 – 79.
Singh, K.P. 2000. Response of graded levels of nitrogen in tuberose (*Polinathes tuberosa* L.) cv. Single. Adv. Plant Sci. 13(1): 283-285.
Singh, K.P. and Uma, A. 1996. Response of graded levels of nitrogen on growth and flowering in shringar tuberose (*Polinathes tuberosa* L.). Indian J. Agric. Sci. 66(11)655-657.
Singh, W., Sehrawat, S.K., Dahiya, D.S., and Singh, K. 2002. Leaf nutrient status of gladiolus (*Gladiolus grandiflorus* L.) cv. Sylvia as affected by NPK application. Haryana Journal of Hort. Sci. 31(1-2):49-51.
Srinivas, K.N. 1994. Effect of different compost on growth, yield and postharvest life of China aster (*Callistephus chinensis* L. Nees). M. Sc. (Agric.) Thesis, Univ. Agric. Sci., Bangalore, India.
Statistics of ornamental plants. 2007. The office of vegtables, ornamental and medicinal plants. Minstry of jihad e agriculture.Tehran, Iran.

Sunitha, H.M. 2006. Effect of plant population, nutrition, pinching and growth regulators on plant growth, seed yield and quality of African marigold (*Tagetes erecta* L.). M. Sc. (Hort.) Thesis, Univ. Agric. Sci., Dharwad, India.

Yadav, L.P., Bose, T.K. and Maiti, R.C. 1985. Response of tuberose (*Polinathes tuberosa* L.) to nitrogen and phosphorus fertilization. Progressive Hort. 17(2): 83-86.

Tables

Table 1. ANOVA for the flower quality and quantity characteristics and nutrient uptake of tuberose.

Source	df	Flower stalk height	Spike length	Floret number	Stem diameter	Floret diameter	Nitrogen	Phosphorus	Potassium	Vase life	postharvest quality
Replication	2	0.848 ^{ns}	4.088 ^{ns}	10.512*	1.482*	0.178 ns	0.001 ^{ns}	0.018*	0.071 ^{ns}	1.722 ^{ns}	911.264 ^{ns}
N	5	17.71*	11.555*	3.946 ^{ns}	1.599**	6.217 ns	0.256 ***	0.004 ^{ns}	0.097 ^{ns}	2.056 ^{ns}	1254.214 ^{ns}
Density	3	48.018***	48.935***	36.444***	11.076***	15.574*	0.187***	0.027***	0.446***	12.204***	8141.384***
N* Density	15	7.142 ^{ns}	5.721 ^{ns}	3.327 ^{ns}	0.504 ^{ns}	4.7276 ^{ns}	0.028 ^{ns}	0.002 ^{ns}	0.071*	0.959 ^{ns}	566.762 ^{ns}
Error	46	7.03	4.931	4.252	0.356	4.38	0.026	0.002	0.065	1.664	1043.829
CV%		4.19	8.54	7.46	6.84	13.34	7.57	16.13	10.68	26.85	28.89

ns: Non significant. *, *, ****: Significant different in 5%, 1%, 0.1% respectively

Table 2. Flower quality and quantity characteristics and nutrient uptake of tuberose as affected by plant density.

Plant density	Flower stalk height (cm)	Spike length (cm)	Floret number	Stem diameter (mm)	Floret diameter (mm)	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Vase life (days)	Postharvest quality
D1	25.96 c	24.66 b	25.96 c	7.855 c	16.02 a	2.07 b	0.26 b	2.32 b	3.889 b	90.33 b
D2	27.28 bc	24.66 b	27.28 bc	8.478 b	14.31 b	2.06 b	0.27 b	2.22 b	4.667 b	107.6 b
D3	28.04 ab	26.67 a	28.04 ab	8.812 b	16.03 a	2.08 b	0.32 a	2.38 b	4.778 b	108.3 b
D4	29.36 a	28.03 a	29.36 a	9.735 a	16.09 a	2.28 a	0.34 a	2.59 a	5.889 a	141.2 a

D1= 10 x 10 cm; D2= 15 x 15 cm; D3=20 x 20 cm; D4= 25 x 25 cm

Table 3. Flower quality and quantity characteristics and nutrient uptake of tuberose as affected by nitrogen.

N levels	Flower Stalk height (cm)	Spike length (cm)	Floret number	Stem diameter (mm)	Floret diameter (mm)	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Vase life (days)	postharvest quality
N0	62.34 ab	62.34 ab	27.05 a	8.690 ab	15.44 a	1.95 d	0.27 b	2.42 ab	4.667 a	109.7 a
N50	61.76 b	61.76 b	27.12 a	8.240 b	16.57 a	2.01 cd	0.31 a	2.25 b	4.833 a	112.2 a
N100	62.45 ab	62.45 ab	27.65 a	8.699 ab	15.07 a	2.09 cd	0.30 ab	2.38 ab	5.167 a	119.7 a
N150	63.89 ab	63.89 ab	27.48 a	8.424 b	14.76 a	2.12 bc	0.32 a	2.51 a	5.333 a	124.3 a
N200	64.32 a	64.32 a	28.50 a	9.083 a	15.65 a	2.25 ab	0.29 ab	2.32 ab	4.667 a	110.8 a
N250	64.72 a	64.72 a	28.15 a	9.183 a	15.64 a	2.35 a	0.30 ab	2.39 ab	4.167 a	94.42 a

N0= 0 kg/ha, N50= 50 kg/ha, N100= 100 kg/ha, N150= 150 kg/ha; N200=200 kg/ha; N250= 250 kg/ha

Table 4. Flower quality and quantity characteristics and nutrient uptake of tuberose as affected by combined effects of nitrogen and plant density.

Treat-mens	Flowe stalk height (cm)	Spike length (cm)	Floret number	Stem di-ameter (mm)	Floret di-ameter (mm)	Nitrogen (%)	Phospho-rus (%)	Potassium (%)	Vase life (days)	posthar-vest quality
N0 D1	62.47 cf	22.65 f	23.73 e	7.767 gi	16.39 ab	1.903 gi	0.277 f	2.540 ad	3.33 bc	76.33 cd
N0 D2	63.27 ce	25.07 cf	27.40 bd	8.773 cf	15.12 ab	2.010 ei	0.280 bf	2.330 ae	5.33 ab	128.3 ac
N0 D3	63.54 be	27.69 ac	28.33 ad	8.947 ce	16.95 ab	1.737 i	0.267 cf	2.310 ae	4.00 ac	93.00 bd
N0 D4	60.10 ef	26.85 be	28.73 ad	9.273 bd	17.31 ab	2.163 ah	0.303 af	2.510 ad	6.00 a	141.0 ab
N50 D1	64.75 ad	23.67 df	27.33 bd	7.320 i	16.87 ab	1.847 hi	0.277 bf	2.210 ce	3.33 bc	79.33 cd
N50 D2	58.87 f	23.57 df	26.53 ce	7.860 fi	14.55 bc	1.970 gi	0.270 cf	2.210 ce	4.67 ac	111.7 ad
N50 D3	61.57 df	26.50 be	26.60 ce	8.660 ch	18.37 a	2.020 di	0.350 ab	2.330 ae	5.33 ab	111.7 ad
N50D4	61.87 df	26.17 bf	28.00 ad	9.120 bd	16.48 ab	2.197 ag	0.330 ad	2.243 be	6.00 a	146.0 ab
N100D1	64.45 ae	23.21 ef	26.40 ce	7.707 hi	16.17 ab	2.063 ah	0.253 df	2.253 be	5.33 ab	123.3 ac
N100 D2	62.89 cf	24.96 cf	27.80 ad	8.333 dh	14.77 b	1.940 gi	0.260 df	2.133 de	4.67 ac	104.7 ad
N100 D3	62.07 cf	25.53 cf	28.07 ad	8.740 cg	14.10 bc	2.057 bh	0.337 ad	2.340 ae	4.67 ac	105.7 ad
N100 D4	60.40 df	27.17 ad	28.33 ad	10.02 b	15.23 ab	2.303 af	0.340 ad	2.807 a	6.00 a	145.0 ab
N150 D1	66.31 ac	24.73 cf	25.40 de	7.728 hi	16.29 ab	1.987 fi	0.257 df	2.477 ad	4.67 ac	104.7 ad
N150 D2	61.75 df	23.98 df	26.47 ce	8.307 dh	11.23 c	2.037 ci	0.270 cf	2.497 ad	5.33 ab	127.3 ac
N150 D3	63.98 ae	26.24 bf	27.27 bd	8.420 dh	17.10 ab	2.113 ah	0.370 ab	2.483 ad	5.33 ab	126.3 ac
N150 D4	63.53 be	30.57 a	30.80 a	9.240 bd	14.41 bc	2.340 ac	0.397 a	2.587 ad	6.00 a	139.0 ab
N200 D1	67.71 ab	27.10 ad	25.93 de	8.500 dh	16.06 ab	2.300 af	0.240 ef	2.263 be	4.00 ac	94.33 ad
N200 D2	63.79 be	25.40 cf	28.60 ad	9.173 bd	15.05 ab	2.133 ah	0.290 bf	1.943 e	4.00 ac	93.33 bd
N200 D3	61.57 df	24.73 cf	29.40 ac	9.087 be	14.73 b	2.220 ag	0.270 cf	2.387 ae	4.67 ac	108.7 ad
N200 D4	64.20 ae	27.68 ac	30.07 ab	9.574 bc	16.75 ab	2.330 ad	0.353 ac	2.673 ac	6.00 a	147.0 a
N250 D1	68.21 a	26.60 be	26.93 b	8.107 eI	16.16 ab	2.357 ab	0.300 af	2.163 ce	2.67 c	64.00 d
N250D2	61.87 df	24.99 cf	26.87 be	8.420 dh	15.11 ab	2.307 ae	0.270 ae	2.220 ce	4.00 ac	80.00 cd
N250 D3	64.43 ae	29.32 ab	28.60 ad	9.020 ce	14.94 ab	2.377 a	0.327 af	2.453 ad	4.67 ac	104.3 ad
N250D4	64.37 ae	29.75 ab	30.20 ab	11.19 a	16.37 ab	2.343 ac	0.327 ae	2.740 ab	5.33 ab	129.3 ac

N0= 0 kg/ha, N50= 50 kg/ha, N100= 100 kg/ha, N150= 150 kg/ha; N200=200 kg/ha; N250= 250 kg/ha
D1= 10 x 10 cm; D2= 15 x 15 cm; D3=20 x 20 cm; D4= 25 x 25 cm