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Evaluation of Split Doses of Nitrogen at Different Growth Stages of Tuberose (*Polianthes tuberosa* L.) for Improving Flowering and Vase-life

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Abstract
A study was carried out to standardize nitrogen application at different stages of tuberose (*Polianthes tuberosa* L.) (cv. Double) for improving growth, flowering and vase life in a farmer's field at Gunjanagar VDC, Chitwan, Nepal, during May to September, 2012. The experiment was laid out in randomized complete block design with 10 treatments of nitrogen in split doses and replicating thrice. The cut flower and vase life characteristics of tuberose were studied and the economics of production was also analysed. Significant difference was found between treatments of split doses of nitrogen in flowering and post-harvest characteristics of this flower. Three equal split doses of nitrogen, 33% N basal + 33% N at 30 days after planting + 33% N at 50 days after planting resulted in the earliest spike initiation (60 days) and the first flower opening (95.17 days). The same treatments recorded longest vase life (16.47 days). The longest (91.69 cm), heaviest (87.97g) and thickest (0.89 cm) spikes with longest rachis (38.77 cm) were produced by three equal split doses of nitrogen, 33% N basal + 33% N at 50 days after planting + 33% N at 70 days after planting. The same treatments produced maximum net income (NRs. 214,250/-) and benefit-cost (B:C) ratio (1.29) per hectare. Thus, three equal split doses of nitrogen, 33% N basal + 33% N at 50 days after planting + 33% N at 70 days after planting are appropriate for commercial cultivation of tuberose in Nepal.

Key words: economics of cultivation, nitrogen, post-harvest, rachis, spike characteristics

Introduction
Tuberose (*Polianthes tuberosa* L), a native of Mexico belonging to the family Amarylidaceae, produces attractive, elegant and fragrant white flowers (De Hertogh & Le Nard 1993) having excellent keeping quality and standing long transportation (Desai 1957). It occupies a very special position among the ornamental bulbous plants because of its prettiness, elegance and fragrance. It has good economic potential for loose/cut flower trade and essential oil industry (Alan *et al.* 2007). The flowers are used in wedding ceremonies, garlands, decoration and various traditional rituals. The bulbs are considered as diuretic and emetic. Bulb paste mixed with butter and turmeric is used for removing acne or pimples and roots are used as soap substitutes.

Tuberose is one of the most important cut flowers in Nepal. Demand of this flower has increased from 1000-1500 sticks/day in the year 1995 to 4000-6000 in the year 2012 (FAN 2012). There is still a gap between demand and national production and Nepal is also seeking the international market for it. To meet the international market standards, there is need of developing new technology for cultivation of high quality tuberose.

Tuberose is a new crop for Nepalese floriculturists. The important problems faced by commercial growers of it are low yield and inferior quality of cut flower. Productivity of cut flower is low as compared to other countries. There is a lack of technical information regarding nutritional aspect of this crop with respect to growth, flowering and vase life behaviors. In Nepal, no research work has been done on the plant nutritional aspects of tuberose. Due to lack of sufficient knowledge and appropriate technology, Nepalese farmers are not able to produce quality tuberose.

Fertilizers have great influence on growth, building and flower production in tuberose (Polara *et al.* 2004) and nitrogen has significant effect on spike production and floret quality (Singh *et al.* 2004). Urea is the common source of nitrogen in Nepal and splitting doses of urea is very important due to its highly mobile nature. Singh and Uma (1996) reported that the best tuberose quality and quantity yields were obtained at three split applications of nitrogen.

There are no literatures on splitting doses of nitrogen fertilizer for improved yield and quality production in Nepalese condition. Tuberose has varying response to different nitrogen management practices with respect to the yield and quality of the produce. Splitting of nitrogen fertilizer has been proved effective in many aspects and played an important role in promoting quality of cut flower and vase life. Singh (2000 a) found significant effect of splitting nitrogen doses on spike length, rachis length, days to spike initiation and days to flowering of this plant. Singh *et al.* (1993) observed the beneficial effect of split doses of nitrogen application on growth and flowering of gladiolus.

In consideration of the above facts, this study was undertaken in Chitwan district to identify suitable doses of nitrogen at different growth stages for commercial tuberose cultivation.

Methodology

An experiment was conducted at farmer's field at Gunjanagar VDC of Chitwan district from May 2012 to September 2012. Purposive selection of site was done because this location is one of the pocket areas of cut flower production. The location of the site is 27.628^0 N latitude and 84.303^0 E longitudes with an elevation of 273 m from mean sea level. The experiment was conducted in randomized complete block design with 10 treatments and 3 replications. Each plot was 1x1 m^2 in size and the total experimental area was 140.25m^2. The land was thoroughly ploughed twice with a tractor to obtain good tilth. A spacing of 50 cm in between sub-plots was maintained for irrigation and working space. Well decomposed farm yard manure @ 25 tons/ha was applied at the time of land preparation.

Bulbs of uniform size (2cm-2.5cm diameter and 15.5g-17.7g weight) were planted at a depth of 5 cm at a spacing of 20x25 cm. Full doses of phosphorus (200kg/ha) and potassium (200 kg/ha) were applied at the time of planting. Nitrogen (200kg) was applied as two or three split doses (50%+50%, 50%+25%+25% and 33%+33%+33%) and applied at different growth stages (basal, 30 days after planting, 50 days after planting and 70 days after planting). Full dose of nitrogen at planting was used as control. Urea (46% N), SSP (16%P_2O_5) and MOP (60%K_2O) were used as sources of NPK.

Five representative plants from the inner rows of each plot were labeled and tagged in each replication and were used for recording of phenological, cut-flower and post-harvest parameters. The collected data were entered, tabulated and processed in Microsoft Excel. The recorded data on different parameters were analyzed using MSTAT-C and the means were separated using Duncan's Multiple Range Test (DMRT).

Results and Discussion

Days to 50 percent spike initiation

The earliest 50% spike initiation was recorded in 33% N basal + 33% N at 30 DAP + 33% N at 50 DAP (60 days). The treatment comprising 33% N basal + 33% N at 50 DAP + 33% N at 70 DAP took the longest time for 50% spike initiation (111.37 days). The high level of nitrogen increased vegetative growth thereby delaying the reproductive phase of the plant. This finding is in agreement with the findings of Singh (2000 a), who found that, 3 equal splits of nitrogen significantly hastened the days to spike initiation in gladiolus.

Table 1. Effect of splitting doses of nitrogen on phenological characteristics of tuberose (cv. Double) in Chitwan, 2012

Treatments	Days to 50% spike initiation	Days to first floret opening
100% N basal (CONTROL)	68.00^{c}	103.37^{abc}
50% N basal + 50 % N at 30 DAP	72.67^{bc}	105.75^{ab}
50% N basal + 50 % N at 50 DAP	68.67^{c}	101.02^{bcd}
50% N basal + 50 % N at 70 DAP	77.33^{ab}	109.07^{ab}
50% N basal + 25 % N at 30 DAP + 25 % N at 50 DAP	62.67^{d}	95.88^{cd}
50% N basal + 25 % N at 30 DAP + 25 % N at 70 DAP	76.00^{ab}	106.00^{ab}
50% N basal + 25 % N at 50 DAP + 25 % N at 70 DAP	78.33^{ab}	105.75^{ab}
33% N basal + 33% N at 30 DAP + 33% N at 50 DAP	60.00^{d}	95.17^{d}
33% N basal + 33% N at 30 DAP + 33% N at 70 DAP	77.33^{ab}	109.40^{a}
33% N basal + 33% N at 50 DAP + 33% N at 70 DAP	79.33^{a}	111.37^{a}
CD (P=0.05)	5.15	7.30
SEM ±	1.73	2.46
CV %	4.17	4.08
Grand Mean	72.03	104.28

Treatment means followed by common letter (s) within column are not significant among each other based on DMRT at 5% level of significance. Abbreviations N=Nitrogen, DAP=Days after planting, SEM = Standard Error of Mean, CD = Critical Difference and CV = Coefficient of Variation.

Days to first floret opening

The data on days to 50% spike initiation and days to first floret opening showed the similar trend. Significantly fewer days were taken for first floret opening (95.17 days) by the treatment comprising of 33% N basal + 33% N at 30 DAP+ 33% N at 50 DAP. Basal dose 33% N, 33% N at 50 DAP and 33% N at 70 DAP took the longest time for first floret opening (111.37days). This finding is in line with the findings of Singh (2000 a), who reported that, three equal splits of nitrogen (at planting, 30 DAP and 60 DAP) significantly hastened flowering process (68.95 days) in gladiolus. Rathore and Singh (2013), in tuberose, reported delayed flowering with corresponding increase in nitrogen dose, which is in conformity with present finding. Increasing level of nitrogen advanced the time of flowering and greatly increased flower spike length, in gladiolus (Bhattacharjee 1981), while Shah *et al.* (1984) reported that increasing N rates delayed flowering but augmented plant growth, number of leaves, spike length and number of florets per spike in gladiolus.

This delay or advancement of flowering, caused by splitting of nitrogen, can be used to manipulate the harvesting time which is very crucial for getting good price of harvest. If we want an early harvest, we should stop applying nitrogen after 50 DAP, whereas if we want a late harvest we can apply one split dose of nitrogen at 70 DAP.

Length of spike

The longest spike (91.69 cm) was produced in the treatment 33% N basal + 33% N at 50 DAP + 33% N at 70 DAP. The shortest spike was produced in control plot (100% N basal) which was at par with 50% N basal + 50 % N at 30 DAP (78.98cm). Increase in spike length due to nitrogen application may be attributed to the role of nitrogen in cell division as well as in protein synthesis which ultimately enhances growth of the plants (Hilman & Galston1961). Length of spike depends on the vegetative growth. Length of spike increases with increase in height of the plant, which could be attributed to the optimum level of N through split doses at the time of exponential growth of the plant. Singh (2000 b), in tuberose, reported that, three equal splits of 200 kg nitrogen at basal, 60 DAP and 90 DAP produced the longest spikes, which is in agreement with above findings. Similar results in flower crops have been reported by various authors (Khalaj and Edrisi (2012), Lehri *et al.* (2011), Rathore and Singh (2013), Bhattacharjee (1981), and Mahmoodinezhadedezfully *et al.* (2012)).

Table 2. Effect of splitting doses of nitrogen on cut-flower characteristics of tuberose (cv. Double) in Chitwan, 2012

Treatments	Length of Spike	Weight of Spike	Girth of Spike	Rachis Length	Number of Florets
100% N basal (CONTROL)	75.11^{d}	68.35^{e}	0.72^{d}	27.77^{d}	26.22
50% N basal + 50% N at 30 DAP	78.98^{cd}	70.10^{de}	0.73^{d}	28.67^{d}	28.00
50% N basal + 50% N at 50 DAP	81.09^{bc}	75.39^{cd}	0.76^{cd}	30.40^{cd}	26.72
50% N basal + 50% N at 70 DAP	81.61^{bc}	76.12^{cd}	0.77^{bcd}	30.83^{cd}	26.83
50% N basal + 25% N at 30 DAP + 25% N at 50 DAP	82.02^{bc}	78.14^{bc}	0.80^{bc}	33.77^{bc}	28.34
50% N basal + 25% N at 30 DAP + 25% N at 70 DAP	84.22^{bc}	82.43^{abc}	0.82^{bc}	33.63^{bc}	26.67
50% N basal + 25% N at 50 DAP + 25% N at 70 DAP	90.69^{a}	86.40^{a}	0.88^{a}	37.10^{ab}	28.77
33% N basal + 33% N at 30 DAP + 33% N at 50 DAP	83.69^{bc}	78.66^{bc}	0.80^{bc}	34.37^{bc}	28.36
33% N basal + 33% N at 30 DAP + 33% N at 70 DAP	85.23^{b}	83.68^{ab}	0.83^{b}	34.23^{bc}	27.78
33% N basal + 33% N at 50 DAP + 33% N at 70 DAP	91.69^{a}	87.97^{a}	0.89^{a}	38.77^{a}	30.18
CD (P=0.05)	5.23	6.53	0.54	4.01	ns
SEM ±	1.76	2.20	0.02	1.35	1.81
CV %	3.66	4.84	3.19	7.1	11.29
Grand Mean	83.43	78.72	0.8	32.95	27.79

Treatment means followed by common letter (s) within column are not significant among each other based on DMRT at 5% level of significance. Abbreviations N=Nitrogen, DAP=Days after planting, SEM = Standard Error of Mean, CD = Critical Difference, CV = Coefficient of Variation,
ns=non-significant

Weight of spike

The maximum spike weight (87.97g) was produced by 33% N basal + 33% N at 50 DAP + 33% N at 70 DAP, whereas the minimum spike weight was recorded in control plot (100% N basal) which was statistically at par with 50% N basal + 50 % N at 30 DAP (70.10g). This might be due to higher length and girth of the spike.

Girth of spike

The maximum girth of spike (0.89 cm) was recorded by 33% N basal + 33% N at 50 DAP + 33% N at 70 DAP. This might be due to availability of nitrogen at the time of spike initiation and growth. The thinnest spikes (0.72 cm) were produced in the control plot (100% N basal).

Khalaj and Edrisi (2012), in tuberose, reported that three splits (basal, 30 DAP and 60 DAP) of nitrogen (250 kg/ha) produced the maximum diameter of spike. The increase in girth of spike with splitting of nitrogen might be due to availability of optimum amount of nitrogen during spike initiation. Rashid (2008) also reported that 205 kg nitrogen in three equal splits (30 DAP, 65 DAP and 100 DAP) produced maximum spike diameter in tuberose.

Rachis length

The rachis length showed similar trend as in spike length, girth and weight. The maximum rachis length (38.77 cm) was recorded in treatment comprising 33% N basal + 33% N at 50 DAP + 33% N at 70 DAP. The minimum rachis length (27.77cm) was recorded in the control plot (100% N basal). Rachis length and spike length were closely related. The longer spike had longer rachis, whereas shorter spikes had shorter rachis. According to Rashid (2008) three equal splits of nitrogen (30 DAP, 65 DAP and 100 DAP) produced longest rachis in tuberose. Mohanty *et al.* (2002) also observed similar result in this plant. Singh (2000 b) observed that three equal splits (planting, 60 DAP and 90 DAP) of 350 kg nitrogen produced the longest rachis, whereas Singh (2000 a) recorded longest rachis produced with one or two splits of nitrogen in gladiolus.

Number of florets

Number of florets was not affected by splitting doses of nitrogen. The maximum number of florets per spike (30.18) were recorded in the plot applied with 33% N basal + 33% N at 50 DAP + 33% N at 70 DAP whereas the minimum number of florets per spike (26.22) were recorded in the control plot (100% N basal). This result is in agreement with the finding of Singh (2000 a), who also reported that splitting of nitrogen had no significant effect on number of florets of gladiolus. Number of floret is genetically mediated character thus nitrogen had no visible effects on it.

Days to basal floret withering

The maximum days required for basal floret withering (11.29 days) was recorded in the plot applied with 33% N basal + 33% N at 30 DAP + 33% N at 50 DAP, whereas the basal floret of the plot applied with 33% N basal + 33% N at 50 DAP + 33% N at 70 DAP lasted for the shortest time (6.62 days). The longer life of basal floret was obtained with treatments with no application of nitrogen after spike initiation, whereas shorter life of basal floret was observed with treatments having at least one split of nitrogen after spike initiation.

Table 3. Effect of splitting doses of nitrogen on post-harvest characteristics of tuberose (cv. Double) in Chitwan, 2012

Treatments	Days to basal floret withering	Number of open florets	Percentage of open florets	Vase life
100% N basal (CONTROL)	8.17[bc]	8.50	32.83	12.11[c]
50% N basal + 50 % N at 30 DAP	8.87[abc]	8.83	31.85	13.17b[c]
50% N basal + 50 % N at 50 DAP	9.00[abc]	10.67	40.08	14.22[b]
50% N basal + 50 % N at 70 DAP	8.02[c]	10.22	38.02	13.38b[c]
50% N basal + 25 % N at 30 DAP + 25 % N at 50 DAP	10.68[ab]	11.11	39.27	16.11[a]
50% N basal + 25 % N at 30 DAP + 25 % N at 70 DAP	8.33[bc]	10.33	38.82	13.38[bc]
50% N basal + 25 % N at 50 DAP + 25 % N at 70 DAP	7.42[c]	11.89	41.50	13.22[bc]
33% N basal + 33 % N at 30 DAP + 33 % N at 50 DAP	11.29[a]	10.11	35.40	16.47[a]
33% N basal + 33 % N at 30 DAP + 33 % N at 70 DAP	6.89[c]	10.89	38.95	12.72[c]
33% N basal + 33 % N at 50 DAP + 33 % N at 70 DAP	6.62[c]	13.11	43.53	13.11[bc]
CD (P=0.05)	2.33	ns	ns	1.16
SEM±	0.79	0.92	2.84	0.39
CV %	15.95	15.07	12.94	4.9
Grand Mean	8.53	10.57	38.02	13.79

Treatment means followed by common letter (s) within column are not significant among each other based on DMRT at 5% level of significance. Abbreviations N=Nitrogen, DAP=Days after planting, SEM = Standard Error of Mean, CD = Critical Difference, CV = Coefficient of Variation,
ns=non-significant

Vase life

Vase life was also significantly affected by splits of nitrogen. Days to 100% withering of open florets was considered the end of vase life. Maximum vase life (16.47 days) was recorded by the spikes of the plot applied with 33% N basal + 33% N at 30 DAP + 33% N at 50 DAP whereas minimum vase life (12.11 days) was recorded in the control plot (100% N basal).

These results might be due to the interaction of nitrogen at high levels with number of nutrition elements. According to Woltz (1968), the high doses of nitrogen produce soft and tender stalk, which causes deleterious effects on vase life of cut flowers. It was found that, one split dose of nitrogen at 70 DAP has deleterious effect on the vase life of tuberose, whereas one split dose of nitrogen at 50 DAP had positive effect. Khalaj and Edrisi (2012) reported that the higher doses on nitrogen had inverse effect on the vase life of tuberose. Rathore and Singh (2013) reported that, an application of 220 kg nitrogen/ha produced significantly longer vase life in tuberose, whereas higher dose reduced vase life. Bernstein and Ioffe (2005) and Eidyan *et al*, (2009) also reported inverse effect of high nitrogen dose in vase life of *Ranunculus asiaticus* and tuberose respectively.

Number of open florets

Splitting of nitrogen has no significant effect on number of open florets per spike. Three equal splits of nitrogen (33% at planting, 33% at 50 DAP and 33% at 70 DAP) recorded the shortest vase life, however, with the maximum number of open florets.

Percentage of open florets

Similarly, percentage of open florets was not significantly affected by splits of nitrogen. The maximum percentage (43.53%) of open florets was recorded in the plot applied with 33% at planting, 33%

at 50 DAP and 33% at 70 DAP whereas lowest percentage (31.85%) of open florets was recorded in the plot treated with 50% N basal + 50 % N at 30 DAP. Only few basal flowers opened during the vase life of tuberose. This might be genetically mediated character and thus is not affected by splits of nitrogen.

Number of open florets was closely related to number of florets per spike, however, no statistical difference was found within treatments. The spikes having more number of florets had more number of opened florets at the end of vase life.

Economic analysis

The main product of tuberose is its magnificent spikes. Since, each treatment was grown in the same area, the gross return from spikes varied according to grades of the spikes. The results revealed that treatment comprising 33% N basal + 33% N at 50 DAP + 33% N at 70 DAP and treatment comprising 50% N basal + 25 % N at 50 DAP + 25 % N at 70 DAP, gave the highest return per unit area (B:C ratio: 1.29) than other treatments due to higher market price of the spikes.

Splitting of nitrogen at different growth stages of tuberose was found to be beneficial for commercial cultivation. Considering the economic analysis as well as the cut-flower characteristics, three equal splits of nitrogen, 33% at planting, 33% at 50 DAP and 33% at 70 DAP, is appropriate for the national market. For the international market, where vase life is also a very important parameter, three equal splits of nitrogen; 33% at planting, 33% at 30 DAP and 33% at 50 DAP, is appropriate. Manipulating the time of harvest is crucial for commercial success of flower cultivation and it can be done by splitting doses of nitrogen. If we want an early harvest, three equal splits of nitrogen; 33% at planting, 33% at 30 DAP and 33% at 50 DAP, is appropriate, whereas, if we want a late harvest, three equal splits of nitrogen; 33% at planting, 33% at 50 DAP and 33% at 70 DAP, is appropriate.

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