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Influence of nitrogen levels and plant geometry on growth, flowering and seed production in pansy (*Viola tricolor* Hortensis) variety snow white

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Abstract
A field experiment on the effect of nitrogen and plant geometry on growth, flowering and seed production in pansy (*Viola tricolor*) variety ‘Snow White’ was conducted. Four doses of nitrogen (0, 15, 20 and 25 g/m^2) and three levels of spacing (15x15cm, 15x20cm and 15x25cm) were tested in Factorial Randomized Block Design with three replications. The analyzed data indicated that the values of plant height, number of leaves per plant, leaf area, flower diameter, number of capsules per plant and seed yield were the highest at 20g N/m^2. The values of plant spread, early flowering, number of flowers, flower duration, pedicel length and number of seeds per capsule were the maximum at 25 g N/m^2 and was statistically at par with 20g N/m^2. The maximum plant spread, number of leaves, number of flowers per plant, flower duration, flower diameter, number of capsules and seed yield per plant was recorded at the widest spacing (15x25 cm). Significant effect of interaction was observed in all the parameters except 1000-seed weight.

Keywords: annuals, nitrogen levels, plant spacing, plant physiology, seed production

Introduction

Pansy (*Viola tricolor* hortensis) a member of family violaceae, is a perennial but is usually treated as an annual in the plains and as biennial in the hills. The plants are low growing, compact and trailing having long leaves with cut edges. It is one of the most beautiful seasonal due to its pretty shape and variety of colors *viz.* white, yellow, orange, rose, red, blue, pink, and purple. Some have "faces" or dark blotches on the petals, and some do not. It is known as a hardy annual which grows and flower best at temperatures below 18 degrees F, and may bloom for several months and so can survive temperatures down to 2 to 5 degrees F during winter. Pansies grow best in full sun although they can tolerate shady conditions better than other sun-seeking annuals. These are used in landscape architecture as pot plants, mixed borders in edging, in beddings, rock gardens, window boxes and hanging baskets in addition to seed production.

In India, total area under floriculture is 2,49,000 ha (NHB, 2015) while the area under seed production is 1000 hectares. Commercial cultivation of flowering annuals for producing the seeds is fast expanding across the country due to promising economic returns, diverse geographical conditions and availability of cheap labour. Seed production of marigold, verbena, pansy, stock *etc.* holds promise for peri urban locations of North India. Moreover these annual seeds are exported to other countries such as USA, Europe, Australia, Japan *etc.* In Muzaffarnagar province of North Indian state Uttar Pradesh, there is a great demand of quality seeds of pansy as quality of seed plays a crucial role in overall performance and production of crop plants. Though, climatic conditions are also favourable for flower seed production but bulk production of quality seed is a difficult task for flower growers due to lack of technology. Quality production depends upon the proper growth and development of plants which can be improved through various management practices.

Among various management practices, application of appropriate dose of nitrogen is very important. Nitrogen is an essential nutrient which plays a dominant role in growth processes as it is an integral part of chlorophyll molecule, a constituent of enzyme molecules, protein and nucleic acids (Marschner, 1986) [10]. The nitrogen requirement depends on yield goal, crop to be grown and numerous environmental factors (Powers and Schepers, 1989) [11]. According to some works, it is possible to note the influence of nitrogen on growth and flowering. The highest plant height and spread was resulted with the application of nitrogen at 20g and 40g per square meter in balsam (Kumar and Kaur, 1996) [9] and pansy (Kaur and Kumar, 1998) [8], respectively. Higher doses of nitrogen proved better than lower doses in relation to flower production in China aster (Singh and Sangama, 2000) [15].

Beside nutrition, another important factor determining high plant growth, flower and seed yield is plant spacing. Plants get sufficient, light, water and air for their normal growth and development at proper plant spacing. Some earlier works reported delayed flowering in French marigold at closer spacing as compared to wider spacing (Karuppaiah and Krishna, 2005) [7], these results were similar with the findings of Singh (1996) in tuberose but contradictory with Hugar (1997) [2] who observed early flower initiation at closer spacing in gaillardia. However, Jinendra (1997) [6] did not notice any effect of spacing on days to flowering in pansy. Significant influence of spacing was observed in number of flowers per plant, capsules per plant and seed yield in pansy (Kaur and Kumar, 1998) [8] while 1000 seed weight was not affected by spacing levels in gaillardia (Huger, 1997) [2].

Then above literature demonstrates that growth rate, flowering and seed production parameters are affected variously by nitrogen and spacing. Keeping all these points in view, a research framework was made with the purpose to promote the growth, flowering and seed production in pansy variety ‘Snow White’, under the agro-ecological conditions of Muzzaffarnagar (U.P).

Materials and methods

The research was conducted at the Experimental Farm of Department of Horticulture, Ch. Chottu Ram Post Graduation College, Muzaffarnagar (U.P). The research field was located in the sub-tropical zone at 29^{O}28’ North latitude, 77^{O}44’ East longitude and 245.82 m average mean sea level where the temperature rises upto 45^{O}C or more during summer (May-June) and falls to 3^{O}C or lower during extreme winters.

The field was well prepared through deep plough, good harrowing, leveling and thereafter, the experimental land was divided into main and sub plots. Representative soil samples of the experimental site were collected from 0-15 cm depth, air dried sieved through 2mm sieve and analyzed for physio-chemical properties. The results indicated that the soil was loamy in texture, deficient in nitrogen, moderate in phosphorus, fairly rich in potash and slightly alkaline in pH (7.7).

Four doses of nitrogen (0, 15, 20 and 25 g/m^2) and three levels of spacing (15x15 cm, 15x20 cm and 15x25 cm) were tested. The experiment was laid out in factorial randomized block design with three replications. Seeds of pansy variety ‘Snow White were procured from Dr Y S Parmar University, Solan, Himachal Pradesh, India. Nursery was raised in mid September and seedlings were transplanted at 4-5 leaf stage after one month of sowing (mid October) at different spacings. Nitrogen doses were applied in the form of urea (N 46%) in two split times. First time, they were applied prior planting during land preparation and at the second time, they were added after 45 days of transplanting as top dressing.

The data obtained during the experiment was subjected to statistical analysis.

Results and discussion

Growth parameters

All the vegetative growth parameters were significantly affected by the influence of nitrogen levels and plant spacing. Data (Table 1.) pertaining to growth parameters showed maximum plant height (44.46 cm) with more number of leaves (190.09) and leaf area (10.24 cm^2) at 20 g/m^2 nitrogen while highest plant spread (37.87cm) obtained at 25 g N/m^2 which was at par with 20g N/m^2 (37.07 cm). However, minimum values were recorded in control with zero dose of nitrogen. This may be attributed to the fact that nitrogen is an integral part of chlorophyll which is composed of four pyrole rings, each containg one nitrogen and four carbon atoms and is the primary absorber of light energy needed for photosynthsesis which ultimately enhances vegetative growth (Tisdale *et al*., 1997) [18] and so it is a constituent of proteins, nucleic acid and nucleotides that are essential to the metabolic function of a plant. The results of Kumar and Kaur (1996) [9] who also reported increased vegetative growth with the increasing levels of nitrogen in balsam, are in concurrence with the present findings.

Results pertaining to plant spacing indicated that the greatest plant height (43.14 cm) was observed at closet spacing (15x15 cm) which decreased with the increasing levels of spacing. On the contrary, plant spread (35.68 cm) and number of leaves (192.28) was more at widest spacing (15x25 cm). However, leaf area (10.00 cm^2) was maximum at 15x20 cm spacing and found statistically at par with widest spacing (9.76 cm^2). The more plant height in closer spacings might be due to heavy competition between plants for light resulted in elongation of main stem and also might be due to the fact that the plants tend to grow vertically when they are crowded owing to shadowing effect of the plants on one another (Ramchandrudu and Thangam, 2007) [12]. The more plant spread, number of leaves and leaf area at wider spacing may be attributed to less competition for light, space and nutrients among the plants. - Similar results were observed in gaillardia by Hugar (1997) [2], in coreopsis by Dhatt and Kumar (2007) [1] and in marigold by Sharma *et al.* (2009) [14].

Amongst interactions, plant height reached its maximum (48.40 cm) at 15x15 cm spacing applied with 20 g N/m^2 while number of leaves per plant (204.11) was increased at 15x25 cm spacing applied with 20 g N/m^2. Although N3xS3 (25 g N/m2 at 15x25 cm spacing) interaction proved better over other treatment combinations in relation to plant spread and leaf area, it was statistically at par with N2xS3 (20g N/m^2 at 15x25 cm spacing) interaction. Positive response of growth parameters to nitrogen and spacing interactions might be due to less competition for nutrients at wider apacing as a result more availability of nitrogen to the plants. Similar results were also reported by Jinendra (1997) [6] in daisy.

Flowering parameters

All the flowering parameters were significantly affected by the application of nitrogen (Table 2). Highest dose of nitrogen (25 g/m^2) induced early flowering (51.87 days) with more number of flowers (131.44), flower duration (14.62 days) and pedicel length (12.70 cm), however, it was statistically at par with 20 g N/m^2 which also produced maximum flower diameter (3.74 cm). The minimum values were recorded in control. This may be due to more nutrients and synthesis of carbohydrates which are translocated towards the reproductive parts of plant for its development (Jat *et al*., 2007) [3]. These findings have been supported by the results of Sharma *et al*. (2009) [14].

Significant variation due to spacing levels was noticed in number of flowers per plant, flower duration and diameter which were maximum (124.79, 14.12 days and 3.68 cm, respectively) at the widest spacing (15 x 25 cm). Favourable conditions like availability of nutrients, sunlight and soil moisture to individual plants at wider spacing might have increased the plants canopy and thereby increasing the flower production parameters. Similar trends with different spacings have also been reported in pansy by Jhon *et al.* (1984) [4]. However, non-significant effect of spacing was observed in pedicel length, and days to first flowering which was also reported non-significant in coreopsis (Dhatt and Kumar, 2007) [1].

Combined effects of nitrogen and spacing were significant in respect of all flowering parameters. Earliest flowering, maximum number of flowers per plant, more flower duration and pedicel length recorded at N3xS3 interaction (25g N/m^2 and 15x25 cm spacing), was at par with N_2xS_3 (20g N/m^2 and 15x 25 cm spacing) treatment combination. However, bigger sized flowers were obtained at 20 g N/m^2 with 15x 25 cm pacing followed by control (0 nitrogen and 15x25 cm spacing). These results are in close conformity with the findings of earlier workers (Jinendra, 1997) [6] in daisy.

Seed production parameters

All seed yield components were significant due to nitrogen levels and plant spacing except 1000-seed weight (Table 3). Number of capsules per plant (46.00), seeds per capsule (53.51) and seed yield (1.99g) per plant were significantly influenced by the application of nitrogen up to 20g N/m^2 and further increase in nitrogen levels was not beneficial. This may be ascribed to better vegetative growth at appropriate nitrogen rate which causes efficient photosynthetic activities for more accumulation and translocation of photosynthates from source to sink resulting in more number of capsules and ultimately giving rise to higher seed yield per plant (Tigadi, 2005) [17]. The results are in accordance with the findings of Jhon *et al.* (1984) [4] and Kaur and Kumar (1998) [8]. Non significant variation in 1000-seed weight was also observed by Sunitha H M *et al*., (2007) [16].

Amongst spacings, highest number of capsules (40.42) and seed yield per plant (1.70 g) was obtained at the widest spacing (15x25 cm) followed by 15x 20 cm spacing. The higher seed yield is attributed to better plant growth in terms of spread and flowers. Further, it was also related to better and efficient translocation and utilization of photosynthates, adequate availability of nutrients, moisture, light and space in lower plant population densities. Kaur and Kumar (1998) [8] reported similar results in pansy.

Effect of nitrogen and spacing combinations was significant for number of capsules and seed yield per plant, however, it was non- significant for number of seeds per capsule and 1000-seed weight. Highest number of capsules (49.64) and seed yield per plant (2.09 g) were recorded at 20g N/m^2 when planted at wider spacing (15x25 cm), while the minimum values were observed in the control. These results are in close confirmation with the findings of Jhon *et al.* (1986) [5].

Table 1: Effect of nitrogen levels and spacing on vegetative growth parameters in pansy variety 'Snow White'

Treatments	Plant height (cm)				Plant spread (cm) Number of leaves per plant Leaf area (cm^2)											
	S_1 15x15	S_2 15x20	S_3 15x25	Mean	S_1 15x15	S_2 15x20	S_3 15x25	Mean	S_1 15x15	S_2 15x20	S_3 15x25	Mean	S_1 15x15	S_2 15x20	S_3 15x25	Mean
Control	33.92	32.50	31.78	32.73	22.66	27.50	29.13	26.43	154.12	165.60	179.00	166.24	7.30	8.80	8.90	8.33
N_1(15g/m^2)	42.35	38.10	37.34	39.26	31.57	32.84	34.50	32.97	165.85	179.00	189.00	177.94	8.50	9.30	9.40	9.07
N_2(20g/m^2)	48.40	43.68	41.30	44.46	35.90	37.10	38.20	37.07	176.06	190.10	204.11	190.09	10.10	10.35	10.23	10.24
N_3(25g/m2)	47.90	42.50	39.20	43.20	34.96	37.74	40.90	37.87	169.02	178.00	197.00	181.34	10.00	10.10	10.50	10.20
Mean	43.14	39.20	37.41		31.27	33.80	35.68		166.26	178.18	192.28		8.98	10.00	9.76	
$CD_{(P=0.05)}$																
N (Nitrogen)		3.11				2.41				9.55				0.87		
S(spacing)		2.69				2.08				8.27				0.75		
Nitrogenx spacing		5.38				4.17				16.54				1.51		

Table 2: Effect of nitrogen levels and spacing on flowering parameters in pansy variety 'Snow White'

Treatments	Days to first flowering				Number of Flowers per Plant				Flower Duration (Days)				Flower Diameter (cm)				Pedicel Length (cm)			
	S_1 15x15	S_2 15x20	S_3 15x25	Mean	S_1 15x15	S_2 15x20	S_3 15x25	Mean	S_1 15x15	S_2 15x20	S_3 15x25	Mean	S_1 15x15	S_2 15x20	S_3 15x25	Mean	S_1 15x15	S_2 15x20	S_3 15x25	Mean
Control	70.32	68.20	66.80	68.44	59.66	69.34	84.52	71.17	10.00	11.31	12.12	11.14	3.27	3.33	3.45	3.35	10.67	10.00	10.74	10.47
N_1(15g/m^2)	60.10	58.02	57.30	58.47	76.76	90.20	110.35	92.44	12.50	13.41	14.00	13.30	2.97	3.77	3.81	3.52	11.43	11.60	11.77	11.60
N_2(20g/m^2)	54.04	53.20	51.10	52.78	103.65	123.00	151.62	126.09	13.33	14.92	15.06	14.44	3.60	3.79	3.83	3.74	12.47	12.63	12.87	12.66
N_3(25g/m2)	53.10	52.30	50.20	51.87	110.34	131.30	152.67	131.44	13.60	14.99	15.28	14.62	3.55	3.54	3.63	3.57	12.57	12.66	12.88	12.70
Mean	59.39	57.93	56.35		87.60	103.46	124.79		12.36	13.66	14.12		3.35	3.61	3.68		11.79	11.72	12.07	
$CD_{(P=0.05)}$																				
N (Nitrogen)		4.91				9.57				1.00				0.18				0.75		
S(spacing)		NS				8.29				0.86				0.15				NS		
Nitrogenx Spacing		8.51				16.57				1.73				0.31				1.31		

Table 3: Effect of nitrogen levels and spacing on seed production in pansy variety 'Snow White'

Treatments	Number of Capsules per Plant				Number of Seeds per Capsules				1000-Seed Weight (g)				Seed Yield per Plant			
	S_1 15x15	S_2 15x20	S_3 15x25	Mean	S_1 15x15	S_2 15x20	S_3 15x25	Mean	S_1 15x15	S_2 15x20	S_3 15x25	Mean	S_1 15x15	S_2 15x20	S_3 15x25	Mean
Control	22.1	24.28	23.81	23.4	49.44	50.17	50.31	49.97	1.08	1.10	1.10	1.09	0.94	1.00	1.03	0.99
N_1(15g/m^2)	33.65	34.22	38.72	35.53	50.40	51.45	52.65	51.50	1.09	1.11	1.11	1.10	1.47	1.57	1.58	1.54
N_2(20g/m^2)	42.72	45.64	49.64	46.00	52.68	53.85	53.99	53.51	1.10	1.11	1.13	1.11	1.90	1.97	2.09	1.99
N_3(25g/m2)	36.12	44.71	49.50	43.40	53.55	54.21	54.14	53.97	1.10	1.12	1.13	1.12	1.02	1.92	2.08	1.67
Mean	33.65	37.21	40.42		51.52	52.42	52.77		1.09	1.11	1.12		1.33	1.62	1.70	
$CD_{(P=0.05)}$																

N (Nitrogen)		3.75			2.75				NS				0.09		
S(spacing)		3.25			NS				NS				0.08		
Nitrogenx Spacing		6.5			NS				NS				0.15		

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