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EFFECT OF CHEMICAL FERTILIZERS AND BIO-INOCULANTS ON GROWTH AND FLOWERING OF DAHLIA (*Dahlia variabilies* Desf.) cv. 'Pink Attraction'

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ABSTRACT

The present study, conducted at the Experimental Farm, Division of FMAP, SKUAST-Kashmir, Shalimar, was aimed at to evaluate the effect of three nitrogen levels (50, 75 and 100 kg ha^{-1}), two phosphorus levels (100 and 125 kg ha^{-1}) and three biofertilizers (*Bacillus* sp., *Pseudomonas* sp. and *Azotobacter* sp.) on vegetative and floral characteristics of dahlia (*Dahlia variabilies* Desf.) cv. 'Pink Attraction'. Amongst the nitrogen treatments, 50 kg N ha^{-1} application resulted in minimum number of days for tuber emergence, days for 1st floral bud appearance, days to full opening of 1st flower but longer flowering duration. Further, maximum plant height, number of primary branches plant^{-1}, length of primary branches, leaf area and flower diameter, highest fresh flower weight and longest vase life was observed in treatment 75 kg N ha^{-1}. In comparison to 125 kg P ha^{-1} treatment, the application of 100 kg P ha^{-1} resulted in early tuber sprouting and 1st floral bud appearance with maximum plant height, flower diameter, peduncle length, blooming period, flower number plant^{-1}, fresh flower weight and flower vase life. Amongst the biofertilisers, *Azotobacter* proved superior in improving plant height, length of primary branches, flower diameter, peduncle length and number of flowers plant^{-1}. The interaction of three factors was significant. The 1st order interaction among N, P and biofertilizers were significant for several vegetative and floral characters. The use of $N_{75}P_{100}$, N_{75} + *Azotobacter* and P_{100} + *Azotobacter* showed significant improvement in various growth and flower parameters. Of the all treatment combinations evaluated, the application of 75 kg N ha^{-1} + 100 kg P ha^{-1} + *Azotobacter* gave maximum plant height (77.98 cm), number of primary branches plant^{-1} (10.53), length of primary branches (58.55 cm), leaf area (88.33 cm^2), flower diameter (10.31 cm), flowering duration (101.73 day), flower fresh weight (17.82 g flower^{-1}) and longest vase life (5.93 days).

Key words: *Azotobacter*, *Bacillus*, biofertilizer, dahlia, nitrogen, phosphorus, *Pseudomonas*

INTRODUCTION

Dahlia (*Dahlia variabilis* Desf) is a popular bulbous ornamental plant used for garden display, exhibition, massed plantings, for edging a border and for growing in containers. The Netherlands is the largest producer of tuberous rooted dahlias followed by Japan, France, South Africa, UK, Italy, Germany and USA (De Hertogh and Le Nard, 1993). In India commercial cultivation of dahlia is limited to the hills and plains of eastern and northern parts including the Jammu and Kashmir State.

Proper nutrition and fertilization are essential for optimum crop growth and development. Higher doses of inorganic fertilisers increase the cost of cultivation and often deleteriously affect soil health. The use of alternative nutrient sources such as organic wastes and biofertilizers in combination with inorganic fertilizers not only reduces soil pollution but also improves soil quality and is economically viable and ecologically sound. Biofertilizers containing beneficial bacteria and fungi improve soil chemical and biological characteristics, nutrient availability and solubility and crop production. Some bacteria provide plant growth promoting substances and play major role in phosphate solubilization (Abou-Aly *et al.,* 2006). Biofertilizers improve the quantitative and qualitative features of many plants (Ojaghloo *et al.*, 2007; Mubassara *et al.*, 2008; Yosefi *et al*., 2011). Inoculation of soil with beneficial bacteria helps in providing more balance nutrition for plants and improves root uptake of nitrogen and phosphorus due to interaction between phosphate solubilizing and nitrogen fixing bacteria (Belimov *et al*., 1995). Phosphorus solubilizing microorganisms (PSMs) also produce metal chelating agents i.e., siderophores, which have a great impact on plant growth promotion, iron nutrition and phytopathogen suppression (Chincholkar *et al.,* 2000). Siderophore producing rhizobacteria have been recognized as potential biocontrol agents for controlling plant diseases by suppressing major phytopathogens and providing iron nutrition to the crops, thereby promote plant health/growth (Sayyed *et al.*, 2013). Effect of biofertilizers on tuberous root-ornamental crops has not been thoroughly evaluated under temperate conditions in India. Accordingly, the present investigation was aimed to study the effect of bio-fertilizers in conjunction with reduced doses of nitrogen and phosphorus on growth and floral characteristics of dahlia under temperate conditions of Kashmir.

MATERIALS AND METHODS

The present study was carried out at the experimental farm of the Division of FMAP, SKUAST-K, Shalimar (J&K) during *kharif* 2006. The soil texture of site was clay loam with organic carbon 1.2%, available N, P and K 370, 40 and 269 kg ha^{-1}, respectively, pH 6.46 and electrical conductivity of 0.5 ds m^{-2}. The experimental plot was divided into 3 blocks each having 18 plots of 1 m x 1 m size. The treatments comprised of three levels of nitrogen (50, 75 and 100 kg ha^{-1}), two levels of phosphorus (100 and125 kg ha^{-1}) and three genera of bio-fertilizers (*Bacillus* spp., *Pseudomonas* spp. and *Azotobacter*).The experiment was laid in factorial randomised block design with each treatment replicated thrice. Half of nitrogen and full dose of P in each treatment was applied just before the plantation of tubers. FYM @ 5 kg m^{-2} and potassium in the form of muriate of potash @ 10 g m^{-2} (100 kg ha^{-1}) was applied uniformly in all the treatments as basal dose. Nitrogen and phosphorus were applied in the form of urea and single super phosphate, respectively. The remaining half of nitrogen was applied 40 days after planting of tubers. Bio-fertilizers were applied at planting time along with moist soil @ 8.0 kg ha^{-1} (0.8 g plot^{-1}). Uniform sized tubers with at least one eye were treated with carbendazim (0.2%) and planted 20 cm deep at a spacing of 50 cm x 50 cm, accommodating 4 tubers plot^{-1}. The field was irrigated 5 days after planting and thereafter as and when required. Only two shoots per plant were maintained. Plants were staked just after emergence and pinched when 20 cm tall. Two sprays with 0.1% carbendazim at 15 days interval were applied to avoid any possible disease incidence. Weeding cum hoeing was done as and when required. Tubers were lifted in the month of December when foliage turned black. Data was subjected to analysis of variance using Minitab statistical package and means compared using least significant difference method.

RESULTS AND DISCUSSION

Effect of N, P and bio-fertilizers on vegetative parameters

N, P and bio-fertilizer application significantly affected majority of vegetative characters (Table 1). The tubers were earliest to emerge in 50 kg N ha^{-1} treatment but last to emerge in 100 kg N ha^{-1} treatment. Amongst the N treatment, maximum plant height, number of primary branches plant^{-1}, length of primary branches and leaf area was observed in treatment 75 kg N ha^{-1}. Nitrogen has a direct role in plant growth and is used optimally when supplied in a balanced amount. The findings are in conformation with Maqsood *et al*. (2004) in case of dahlia. Plant height, number of primary branches plant^{-1}, length of primary branches and leaf area did not respond to higher level of P and recorded maximum gains at 100 kg P ha^{-1}. High phosphate levels in root medium can depress growth due to the

Table 1: Effect of biofertilizers and inorganic fertilizers on vegetative characters of *Dahlia variabilis* Desf. cv. 'Pink Attraction'

Treatments	Days to tuber emergence	Plant height (cm)	No. of primary branches plant^{-1}	Length of primary branches (cm)	Leaf area (cm^2)
Nitrogen (kg ha^{-1})					
N_{50}	22.80	61.63	7.18	52.03	61.74
N_{75}	23.23	70.78	9.65	54.18	77.41
N_{100}	23.98	70.70	9.46	53.56	76.68
$LSD_{0.05}$	0.81	1.32	0.20	0.66	0. 78
Phosphorus (kg ha^{-1})					
P_{100}	22.80	68.25	8.63	53.50	72.07
P_{125}	23.87	67.16	8.59	53.01	71.82
$LSD_{0.05}$	0.67	1.08	ns	ns	Ns
Biofertilizers					
Bacillus sp.	23.30	68.25	8.60	53.71	72.61
sp.	23.32	65.28	8.61	51.75	73.68
Azotobacter	23.39	69.57	8.62	54.30	69.53
$LSD_{0.05}$	ns	1.32	ns	0.66	0.78

ns = Non-significant

reduction in uptake and translocation of Cu, Zn and Fe (Mengel and Kirkby, 1996). The results are in close agreement with Sharma *et al*. (2003) in gladiolus.

The number of days taken to tuber emergence and number of primary branches plant^{-1} were not significantly affected by biofertilizers; however plant height and length of primary branches were significantly higher in *Azotobacter* application in comparison to other biofertilizer treatments (Table 1). Minimal bacterial population at the time of planting of tubers might be responsible for non-significant effect of biofertilizers on tuber emergence. The usefulness of biofertilizers in improving the vegetative parameters has also been reported by Gupta *et al*. (1999) in case of marigold.

The 1st order interaction of N, P and biofertilizers on various vegetative parameters in dahlia revealed maximum plant height (73.72 cm), number of primary branches (10.02), length of primary branches (55.20 cm) and leaf area (82.88 cm^2) in treatment $N_{75}P_{100}$ combination. However, $N_{50}P_{100}$ recorded lowest value for these parameters (Table 2). Nitrogen and phosphorus elements are essential for plant growth and development. A balanced supply of these nutrients augments their uptake, so improve the overall plant growth. A beneficial NxP interaction has earlier been reported by Zile Singh *et al*. (1996).

The interaction between nitrogen and biofertilizers was quite significant. N_{50} + *Azotobacter* advanced tuber sprouting while N_{100} + *Aztobacter* delayed it. Plant height (75.25 cm) and the number (9.90) and length (57.95 cm) of primary branches attained maximum value in N_{75} + *Azotobacter*. Plant height, number and length of primary branches were minimum when *Pseudomonas* was applied in combination with N_{50} or N_{75}. The leaf area was maximum in N_{75} + *Pseudomonas* and minimum in N_{50} + *Bacillus*. Phytohormones secreted by the biofertilizers might be responsible for improved plant growth. GA_3 secreted by *Pseudomonas* sp. in N_{75} might have caused the leaf expansion while that secreted by *Azotobacter* might have been nullified by ABA secreted by the same organism.

P: biofertilizer interaction revealed early tuber sprouting in P_{100} + *Bacillus* but delayed sprouting in P_{125} + *Bacillus*. Plant height (69.71 cm) and length of primary branches (54.64 cm) were maximum in P_{100} + *Azotobacter* but leaf area was maximum (76.20 cm^2) in P_{125} + *Pseudomonas*. However, the effect of P and biofertilizer interaction on the number of primary branches was non-significant. Secretion of growth substances and improved uptake of nutrients due to *Azotobacter* sp. might be responsible for a beneficial interaction between P and *Azotobacter*. Kathiresan and Venkatesha (2002) reported positive interaction between P and Biofertilzers in gladiolus.

Table 2: Effect of N:P, N:B and P:B interactions on vegetative characters of *Dahlia variabilis* Desf. cv. 'Pink Attraction'

Treatment combinations	Days to tuber emergence	Plant height (cm)	No. of primary branches plant^{-1}	Length of primary branches (cm)	Leaf area (cm^2)
Nitrogen x phosphorus					
N_{50} P_{100}	22.36	60.52	7.20	51.39	54.35
N_{50} P_{125}	23.24	62.74	7.16	52.67	69.12
N_{75} P_{100}	22.71	73.72	10.02	55.20	82.88
N_{75} P_{125}	23.76	67.84	9.29	53.16	70.48
N_{100} P_{100}	23.33	70.50	8.67	53.92	78.97
N_{100} P_{125}	24.62	70.89	9.33	53.20	75.86
$LSD_{0.05}$	1.16	1.87	0.28	0.93	1.11
Nitrogen x biofertilizer					
N_{50} B_1	23.40	62.15	7.37	53.05	63.65
N_{50} B_2	22.77	60.56	7.00	51.25	64.50
N_{50} B_3	22.23	62.18	7.17	51.78	57.06
N_{75} B_1	22.60	72.59	9.77	54.04	77.31
N_{75} B_2	23.33	64.50	9.30	50.55	78.97
N_{75} B_3	23.37	75.25	9.90	57.95	73.76
N_{100} B_1	23.90	70.20	8.67	54.05	76.87
N_{100} B_2	23.47	70.78	9.53	53.45	77.58
N_{100} B_3	24.57	71.23	8.80	53.18	77.77
$LSD_{0.05}$	1.42	2.29	0.35	1.14	1.35
Phosphorus x biofertilizer					
P_{100} B_1	22.60	67.79	8.71	53.89	70.15
P_{100} B_2	22.80	67.26	8.53	52.64	71.17
P_{100} B_3	23.30	69.71	8.64	54.64	74.87
P_{125} B_1	24.00	68.73	8.49	53.53	75.07
P_{125} B_2	23.84	63.31	8.69	50.86	76.20
P_{125} B_3	23.78	69.43	8.60	53.97	64.19
$LSD_{0.05}$	1.16	1.87	ns	0.93	1.11

ns = Non-significant, B_1 = *Bacillus* sp.; B_2 = *Pseudomonas* sp.; B_3 = *Azotobacter* sp.

The use of N and P in combination with biofertilizers significantly but positively influenced various vegetative characters (Table 3) with minimum number of days (21.73) to tuber sprouting seen in 50 kg N + 100 kg P ha^{-1} + *Azotobacter* treatment and maximum (24.87) in 100 kg N + 125 kg P ha^{-1} +*Bacillus* treatment. Maximum plant height (77.98 cm), number of branches plant^{-1} (10.53), length of primary branches (58.55 cm) and leaf area (88.33 cm^2) was observed in 75 kg N + 100 kg P ha^{-1} + *Azotobacter* treatment. This treatment combination appears to have favoured balanced supply of nutrient, water and growth hormones to the plants, thereby improved the overall vegetative performance. Similar results have been reported by Mostafa and Abo-Baker (2010) in case of sunflower.

Effect of N, P and bio-fertilizers on floral parameters

Most of the floral parameters were significantly influenced by combined use of biofertilizers and inorganic fertilizers (Table 4). The appearance of 1st floral bud and full opening of 1st flower occurred earliest in 50 kg N ha^{-1} treatment. The flower diameter was maximum (8.95 cm) in 75 kg N ha^{-1} treatment. However, the peduncle length did not vary significantly under various levels of nitrogen. The duration of flowering was maximum in 50 kg N ha^{-1} treatment but fresh weight (12.60 g) and vase life of flowers (5.23 day) were maximum in 75 kg N ha^{-1} treatment. The superior floral characters in treatment 75 kg N ha^{-1} may be attributed to the better vegetative performance in this treatment. These observations are in line with Ramesh Baboo *et al*. (2006) in gladiolus.

Table 3: Interaction effect of N, P and biofertilizers on vegetative characters of *Dahlia variabilis* Desf. cv. 'Pink Attraction'

Treatment combination	Days to tuber emergence	Plant height (cm)	No. of primary branches plant^{-1}	Length of primary branches (cm)	Leaf area (cm^2)
N_{50} P_{100} B_1	22.67	63.10	7.60	54.29	52.40
N_{50} P_{100} B_2	22.67	58.45	6.93	50.67	54.34
N_{50} P_{100} B_3	21.73	60.01	7.07	49.20	56.30
N_{50} P_{125} B_1	24.13	61.19	7.13	51.80	74.90
N_{50} P_{125} B_2	22.87	62.68	7.07	51.83	74.66
N_{50} P_{125} B_3	22.73	64.35	7.27	54.37	57.81
N_{75} P_{100} B_1	22.20	70.31	10.00	53.21	79.50
N_{75} P_{100} B_2	22.60	72.86	9.53	53.83	80.81
N_{75} P_{100} B_3	23.33	77.98	10.53	58.55	88.33
N_{75} P_{125} B_1	23.00	74.87	9.53	54.86	75.12
N_{75} P_{125} B_2	24.85	56.13	9.07	47.27	77.13
N_{75} P_{125} B_3	23.40	72.51	9.27	57.35	59.18
N_{100} P_{100} B_1	22.93	69.92	8.53	54.17	78.55
N_{100} P_{100} B_2	23.13	70.46	9.13	53.43	78.37
N_{100} P_{100} B_3	23.93	71.13	8.33	54.17	79.98
N_{100} P_{125} B_1	24.87	70.13	8.80	53.93	75.20
N_{100} P_{125} B_2	23.80	71.12	9.93	53.47	76.80
N_{100} P_{125} B_3	25.20	71.44	9.27	52.20	75.57
$LSD_{0.05}$	1.99	3.24	0.49	1.61	1.92

*B_1 = *Bacillus* sp.; B_2 = *Pseudomonas* sp.; B_3 = *Azotobacter* sp.

Phosphorus significantly affected various floral parameters of dahlia (Table 4). Early flower bud appearance and flower opening was observed under 100 kg P ha^{-1} treatment but delayed by higher phosphorus dose of 125 kg P ha^{-1}. The flower diameter was maximum (9.11 cm) in 100 kg P ha^{-1} treatment which was at par with 125 kg P ha^{-1} treatment. Peduncle length was maximum at 100 kg P

Table 4: Effect of biofertilizers and inorganic fertilizers on floral characters of *Dahlia variabilis* Desf. cv. 'Pink Attraction'

Treatments	Days to appearance of 1st floral bud (DAP)	Days to full opening of 1st flower (DAP)	Flower diameter (cm)	Peduncle length (cm)	Duration of flowering (days)	No. of flowers plant^{-1}	Fresh flower weight (g)	Vase life (days)
<u>*Nitrogen (kg ha^{-1})*</u>								
N_{50}	84.87	100.36	8.75	14.31	91.71	76.52	11.29	5.11
N_{75}	88.10	103.01	8.95	14.58	89.14	79.41	12.60	5.23
N_{100}	95.42	112.73	8.84	14.45	79.54	80.07	12.07	4.46
$LSD_{0.05}$	1.28	1.25	0.19	Ns	1.23	1.39	0.54	0.21
<u>*Phosphorus (kg ha^{-1})*</u>								
P_{100}	86.73	101.31	9.11	15.21	90.30	82.63	13.51	5.25
P_{125}	92.19	109.42	8.96	13.69	83.29	74.70	10.82	4.61
$LSD_{0.05}$	1.03	1.02	0.15	0.24	1.00	1.13	0.44	0.17
<u>*Biofertilizers*</u>								
Bacillus sp.	89.63	104.97	8.72	14.46	87.27	78.50	12.30	4.94
Pseudomonas sp.	89.40	105.36	8.68	14.19	86.34	77.17	12.09	5.02
Azotobacter sp.	89.34	105.78	9.15	14.69	86.78	80.34	12.10	4.83
$LSD_{0.05}$	ns	ns	0.19	0.30	ns	1.39	ns	ns

ha^{-1} treatment. Phosphorus plays an important role in regulating the reproductive stage and profoundly influences the flowering of plants. The results are in conformity with Kumar and Misra (2003) in gladiolus. Number of flowers plant^{-1} (82.63), fresh weight of flower (13.51 g) and vase life (5.25 day) and duration of flowering (90.30 day) showed higher values in 100 kg P ha^{-1} treatment. These findings are in conformity with Sehrawat *et al.* (2003) in gladiolus.

Bio-fertilizers had significant effect on flower diameter, peduncle length and number of flowers plant^{-1} but non-significant influence on number of days to appearance/full opening of first floral bud, duration of flowering, fresh flower weight and vase life. *Azotobacter* application yielded maximum number of flowers plant^{-1} (80.34), largest flower diameter (9.15 cm) and longest peduncles (14.69 cm). Efficient nutrient uptake by plants under the influence of bio-fertilizers might have improved floral quality parameters. An increase in vase life of flowers in gladiolus has been reported by Ranjan Srivastava and Mansee Govil (2006) due to the application of PSB.

The 1st order interaction among N, P and biofertilizers was significant for various floral characters (Table 5) with minimum days to appearance of 1st floral bud (82.64) and full opening of 1st flower (95.36) observed in $N_{75}P_{100}$ combination. This treatment combination proved superior to others in flowering duration (96.42 days), flower number/plant (84.90), flower fresh weight (14.53 g) and vase life (5.79 days). The peduncle length was maximum in $N_{100}P_{100}$ treatment but was at par with $N_{75}P_{100}$. The findings are in conformity with the results obtained by Mallick *et al.* (2001) in gladiolus.

Table 5: Effect of N:P, N:B and P:B interactions on floral characters of dahalia cv. 'Pink Attraction'

Treatment combinations	Days to appearance of 1st floral bud (DAP)	Days to full opening of 1st flower (DAP)	Flower diameter (cm)	Peduncle length (cm)	Duration of flowering (days)	No. of flowers plant^{-1}	Fresh flower weight (g)	Vase life (days)
Nitrogen x Phosphorus								
$N_{50}P_{100}$	84.07	97.67	9.33	14.94	93.60	78.29	13.54	5.18
$N_{50}P_{125}$	85.64	103.04	8.57	13.69	89.82	74.76	11.05	5.04
$N_{75}P_{100}$	82.64	95.36	9.28	15.34	96.42	84.90	14.53	5.79
$N_{75}P_{125}$	93.56	110.67	8.62	13.82	81.87	74.11	10.68	4.67
$N_{100}P_{100}$	93.47	110.91	8.72	15.36	80.89	84.71	12.45	4.79
$N_{100}P_{125}$	97.38	114.56	8.58	13.55	78.19	75.24	10.73	4.13
$LSD_{0.05}$	1.81	1.77	0.27	0.42	1.73	1.96	0.77	0.30
Nitrogen x Biofertilizer								
$N_{50}B_1$	83.97	97.73	8.87	14.65	94.30	76.37	12.91	4.92
$N_{50}B_2$	83.77	98.87	8.54	14.50	93.17	77.57	13.00	5.40
$N_{50}B_3$	86.83	104.47	9.43	13.78	87.10	75.63	10.97	5.02
$N_{75}B_1$	89.53	104.43	8.64	14.63	86.43	79.43	12.04	5.40
$N_{75}B_2$	89.27	104.63	8.75	13.91	86.70	76.27	11.56	5.02
$N_{75}B_3$	89.50	99.97	9.46	15.20	94.78	82.53	14.22	5.23
$N_{100}B_1$	95.40	112.73	8.65	14.10	80.52	79.70	11.95	4.52
$N_{100}B_2$	95.17	112.57	8.73	14.17	79.17	77.67	11.70	4.65
$N_{100}B_3$	95.70	112.90	8.56	15.09	78.93	82.86	11.12	4.23
$LSD_{0.05}$	2.22	2.16	0.33	0.51	2.12	2.40	0.94	0.37
Phosphorus x Biofertilizer								
$P_{100}B_1$	85.29	99.40	8.78	15.12	92.00	82.31	13.48	5.44
$P_{100}B_2$	87.84	102.27	8.79	14.82	89.49	81.44	13.13	5.29
$P_{100}B_3$	87.04	102.27	9.74	15.70	89.42	84.15	13.91	5.02
$P_{125}B_1$	93.98	110.53	8.65	13.81	82.55	74.69	10.69	4.44
$P_{125}B_2$	90.96	108.44	8.55	13.57	83.20	72.89	11.04	4.76
$P_{125}B_3$	91.64	109.29	8.56	13.68	84.13	76.53	10.73	4.64
$LSD_{0.05}$	1.81	1.77	0.27	0.42	1.73	1.96	0.77	0.30

B_1 = *Bacillus* sp.; B_2 = *Pseudomonas* sp.; B_3 = *Azotobacter* sp.

Floral parameters were significantly influenced by combined use of N and biofertilisers. Nitrogen @ 50 kg ha^{-1} along with *Bacillus* sp./*Pseudomonas* resulted in the earliest appearance of floral buds and full flower opening. Flower diameter (9.46 cm), peduncle length (15.20 cm), duration of flowering (94.78 days) and fresh weight of flower (14.22 g) had a maximum value in plants which received N_{75} plus *Azotobacter* sp. treatment. The synergism between nitrogen and bio-fertilizers might be the result of beneficial N:bio-fertilizers interactions. The results are in close agreement with the findings of Gupta *et al.* (1999) in marigold and Singh (2005) in rose.

Significant variations were observed in various floral traits due to the joint use of P and bio-fertilizers. Phosphorus @ 100 kg ha^{-1} in combination with *Bacillus* sp. resulted in early blooming (85.29 days), longest blooming period (92.0 days) and maximum vase life of flowers (5.44 days). The flower diameter (9.74 cm), peduncle length (15.70 cm), number of flowers $plant^{-1}$ (84.15) and fresh flower weight (13.91 g) were maximum in P_{100} plus *Azotobacter* sp. Improved solubility of P, due to bio-fertilizers, which has a direct role in flowering might be responsible for a positive P and bio-fertilizer interaction. The results are in conformity to the findings of Narasimharaju and Haripriya (2001) in Crossandra.

The interaction between nitrogen, phosphorus and bio-fertilizers with respect to floral characters was significant (Table 6). The combined use of 75 kg N + 100 kg P ha^{-1} + *Azotobacter* sp. took less number of days for the appearance of 1st floral bud (80.73) and its full opening (92.13). Though 50 kg N + 100 kg P ha^{-1} + *Azotobacter* produced larger flowers (10.31 cm) but was at par with 75 kg N + 100 kg P ha^{-1} + *Azotobacter*. Similarly, the number of flower $plant^{-1}$ and peduncle length was maximum in 100 kg N + 100 kg P ha^{-1} + *Azotobacter* but was at par with 75 kg N + 100 kg P ha^{-1} + *Azotobacter*. Flowering duration (101.73 days), fresh flower weight (17.82 g) and vase life (5.93 day) was maximum in 75 kg N + 100 kg P ha^{-1} + *Azotobacter* treatment. The favourable action of bio-inoculants

Table 6: Interaction effect of N, P and biofertilizers on floral characters of *Dahlia variabilis* Desf. cv. 'Pink Attraction'

Treatment combination	Days to appearance of 1st floral bud (DAP)	Full opening of 1st flower (DAP)	Flower diameter (cm)	Peduncle length (cm)	Duration of flowering (days)	No. of flowers $plant^{-1}$	Fresh flower weight (g)	Vase life (days)
$N_{50}P_{100}B_1$	81.47	93.20	9.05	15.60	99.40	80.40	15.20	5.33
$N_{50}P_{100}B_2$	82.07	94.27	8.62	15.41	95.73	80.73	14.48	5.50
$N_{50}P_{100}B_3$	88.67	105.53	10.31	13.80	85.67	73.73	10.93	4.70
$N_{50}P_{125}B_1$	86.47	102.27	8.69	13.71	90.33	72.33	10.62	4.50
$N_{50}P_{125}B_2$	88.47	103.47	8.47	13.59	90.60	74.40	11.52	5.30
$N_{50}P_{125}B_3$	88.00	103.40	8.55	13.77	88.53	77.53	11.02	5.33
$N_{75}P_{100}B_1$	82.87	95.93	8.64	14.88	93.33	83.20	13.40	5.80
$N_{75}P_{100}B_2$	84.33	98.00	8.90	14.51	94.20	81.73	12.37	5.63
$N_{75}P_{100}B_3$	80.73	92.13	10.31	16.63	101.73	89.20	17.82	5.93
$N_{75}P_{125}B_1$	96.20	112.93	8.64	14.39	79.53	75.67	10.68	5.00
$N_{75}P_{125}B_2$	94.20	111.27	8.61	13.32	79.20	70.80	10.75	4.40
$N_{75}P_{125}B_3$	90.26	107.80	8.63	13.76	86.87	75.87	10.62	4.60
$N_{100}P_{100}B_1$	91.53	109.07	8.67	14.87	83.27	83.33	13.13	5.20
$N_{100}P_{100}B_2$	97.13	114.53	8.87	14.54	78.53	81.87	12.53	4.73
$N_{100}P_{100}B_3$	91.73	109.13	8.62	16.66	80.87	89.51	11.69	4.43
$N_{100}P_{125}B_1$	99.27	116.40	8.64	13.33	77.77	76.07	10.77	3.83
$N_{100}P_{125}B_2$	93.20	110.60	8.60	13.80	79.80	73.47	10.87	4.57
$N_{100}P_{125}B_3$	99.67	116.67	8.50	13.53	77.00	76.20	10.55	4.00
$LSD_{0.05}$	3.14	3.06	0.47	0.73	3.00	3.40	1.33	0.52

B_1 = *Bacillus* sp.; B_2 = *Pseudomonas* sp.; B_3 = *Azotobacter* sp.

in combination with optimum levels of N and P by producing phytoharmones and vitamins and by improving the uptake of macro and micro nutrients might be the answer for the improved flower quality due to the combined use of N, P and bio-fertilizers. Increased vase life could be because of better quality flowers. Positive interaction of N and P with biofertilisers had been reported by Singh (2005) in rose and Gupta (1999) in marigold.

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