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Horticulture

Growth, Yield and Quality of Chrysanthemum (*Chrysanthemum morifolium* Ramat.) cv. Dolly Orange as influenced by Biofertilizers in combination with Phosphorous

Anop Kumari, R.K. Goyal, S.K. Sehrawat, Mahesh Choudhary and S.S. Sindhu[1]

Department of Horticulture, College of Agriculture,
[1]Department of Microbiology, College of Basic Sciences & Humanities,
CCS Haryana Agricultural University, Hisar, 125 004, Haryana, INDIA

Corresponding author: anopflori.25@gmail.com

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Abstract

A pot experiment was conducted in the screen-house of the Department of Horticulture, College of Agriculture, CCS Haryana Agricultural University, Hisar during 2011-12 and 2012-13 to investigate the potential effect of biofertilizers (PSB and mycorrhiza) and different levels of phosphorus (0, 10, 15 and 20 g/m2) on growth, yield and quality of chrysanthemum. The conjunctive effect of biofertilizers and different levels of phosphorus was found to be significant for both the years. The maximum plant height (31.77 and 33.33 cm), fresh weight of plant (100.90 and 96.77 g) and dry weight of plant (10.85 and 10.15 g) were recorded with PSB + phosphorus 15 g/m2 in the year 2011-12 and 2012-13, respectively. The minimum number of days taken for bud initiation (61.67 and 63.33 days) and number of days to first flowering (75.00 and 75.67 days) were also obtained with PSB + phosphorus 15 g/m2 in both the years, respectively. The maximum number of buds per plant (32.33 and 32.00), number of flowers per plant (29.00 and 29.33), the longest flower stalk (6.33 and 6.33 cm) were noticed with PSB + phosphorus 15 g/m2 in the year 2011-12 and 2012-13, respectively. The maximum number of days taken for bud initiation (79.00 and 80.33 days) was recorded with mycorrhiza application (alone) during both the years, respectively. The interaction effect between the biofertilizers and levels of phosphorous on number of suckers per plant was found to be non-significant during both the years of experimentation.

Highlights

- Application of chemical fertilizers increase the soil and water pollution and accumulation of some heavy metals such as cadmium, they can threat human health.
- In recent years, phosphate solubilizing bacteria (PSB) and vesicular arbuscular mycorrhiza (VAM) fungi have become important biotechnological tools and are being employed to reduce the input of chemical fertilizers and irrigation.
- Use of biofertilizers coupled with reduced chemical fertilizer can improve the physico-chemical and biological properties of soil as well as it resulted in the improvement of growth, yield and quality parameters.

Keywords: Chrysanthemum, Growth, Flowering, Mycorrhiza, PSB

Chrysanthemum (Chrysanthemum morifolium Ramat.) belongs to the family Asteraceae, occupies a prime position in a floriculture industry. Chrysanthemum plant is not very attractive but it produces most showy flowers. It has a wide range of flower shape, size and colour and is highly suitable for pot culture and bedding purposes. The quality of flowers is greatly influenced by the quantity of nutrients and source of nutrients. At present, these nutrients are supplied through chemical fertilizers. Chemical fertilizers have become very costly and its indiscriminate use has led to deterioration of soil health. Moreover, the long-term use of chemical fertilizers tends to the soil structure degradation (Singh *et al.,* 2008). This situation emphasized the need for developing alternate production systems that are friendlier to the environment and is more judicious in managing soil health. Biofertilizers or more appropriately called microbial inoculants are the preparations containing live or latent cells of efficient strains of microorganisms. These biofertilizers are a cost effective renewable energy source and plays a crucial role in reducing the inorganic fertilizer application and at the same time increasing the quality and yield of flowers besides maintaining soil fertility. The use of biofertilizers in conjugation with chemical fertilizers not only enhance the efficiency of chemical fertilizers but also partly supply nutrients, at the same time improve the soil physical, chemical and biological properties. Keeping this in view the present investigation was undertook to study the effect of biofertilizers in combination with phosphorous on growth, yield and quality of chrysanthemum (Chrysanthemum morifolium Ramat.) cv. Dolly Orange.

Materials and Methods

The present experiment was carried out in the screen-house of the Department of Horticulture, College of Agriculture, CCS Haryana Agricultural University, Hisar during the year 2011-12 and 2012-13. Hisar is situated at 29° 10′ North latitude and 75° 46′ East longitude with an elevation of 215.2 meters above mean sea level. The tract falls in the semi-arid subtropical region having the characteristic extremes of weather conditions with hot dry winds during summers and severe cold in winters. For experimental purpose, soil was collected from pure sand dune near to Hisar and mixed thoroughly. Each pot was lined with polythene sheet and filled with 5 kg of soil. The experimental soil was sandy in texture having 0.19% organic carbon, 95.00 kg/hectare available nitrogen, 10.00 kg/hectare available phosphorus and 102.00 kg/hectare available potassium. One month old rooted cuttings of chrysanthemum cv. "Dolly Orange" having almost equal size and vigour were transplanted in the centre of pot in the month of September. Soil was firmly pressed around the plant and light watering was done immediately. Four levels of phosphorus [P0-Control, P1- 10 g/m2 or 50 ppm, P2- 15 g/m2 or 75 ppm and P3- 20 g/m2 or 100 ppm), two biofertilizers [BF0-Control, MY- Mycorrhiza (Glomus sp.) and PSB- P36 (Pseudomonas sp.) and their combination (T1- P0 BF0, T2- P1 BF0, T3- P2 BF0, T4- P3 BF0, T5- MY P0, T6-MY P1, T7- MYP2, T8- MY P3, T9- PSB P0, T10- PSB P1, T11- PSB P2, T12- PSB P3) were applied in three replications having CRD experimental design. In addition to above treatments, nitrogen @ 30 g/m2 or 150 ppm and potash @ 20 g/m2 or 100 ppm were also applied. Half dose of nitrogen and full dose of phosphorous and potash were applied as a basal dose just before planting of rooted cuttings, while the remaining half of the nitrogen was applied after 30 days of planting by top dressing method. Pseudomonas strain was applied to rhizosphere of the plant after 6 days of plantation as per treatments. For adding the mycorrhizal inoculum, the upper layer of soil up to a depth of 5 cm was removed and mycorrhizal inoculum consisting of root pieces and spores was spread as a layer over the surface. Data on various growth, yield and quality parameters viz., plant height, fresh weight of plant (g), dry weight of plant (g), number of days taken to bud initiation, number of buds per plant, days to first flowering, flower stalk length (cm), number of flowers per plant and number of suckers per plant were recorded and statistically analyzed.

Results and Discussion

Plant height (cm)

It is cleared from the data (Table 1) that plant height was significantly influenced by different levels of phosphorous. The tallest plant (29.27 and 30.32 cm) was noticed with

Table 1. Response of biofertilizers in combination with phosphorous on plant height (cm) in chrysanthemum

Year	2011-12						2012-13				
Treatments	Levels of phosphorus (g/m^2)						Levels of phosphorus (g/m^2)				
	0	10	15	20	Mean		0	10	15	20	Mean
Control	22.70	24.13	27.17	27.57	25.39		22.33	24.90	27.57	26.70	25.38
Mycorrhiza	25.27	27.77	28.87	28.53	27.61		25.60	27.60	30.07	30.07	28.33
PSB	26.77	29.73	31.77	28.80	29.27		27.17	29.40	33.33	30.43	30.08
Mean	24.91	27.21	29.27	28.30			25.03	27.30	30.32	29.07	

C.D. at 5%

Phosphorous	1.63	0.90
Biofertilizers	1.41	0.78
Phosphorous x Biofertilizers	2.53	1.14

Table 2. Response of biofertilizers in combination with phosphorous on fresh weight of plant (g) in chrysanthemum

Year	2011-12						2012-13				
Treatments	Levels of phosphorus (g/m^2)						Levels of phosphorus (g/m^2)				
	0	10	15	20	Mean		0	10	15	20	Mean
Control	60.40	64.95	77.22	80.85	70.85		66.22	69.68	85.78	80.85	75.63
Mycorrhiza	63.33	73.10	91.75	80.48	77.17		67.80	72.50	90.13	83.75	78.55
PSB	65.45	70.23	100.90	84.77	80.33		70.77	73.77	96.77	88.28	82.40
Mean	63.06	69.43	89.96	82.03			69.29	71.98	90.89	86.02	

C.D. at 5%

Phosphorous	3.37	2.23
Biofertilizers	2.92	1.92
Phosphorous x Biofertilizers	5.83	3.84

Table 3. Response of biofertilizers in combination with phosphorous on dry weight of plant (g) in chrysanthemum

Year	2011-12						2012-13				
Treatments	Levels of phosphorus (g/m^2)						Levels of phosphorus (g/m^2)				
	0	10	15	20	Mean		0	10	15	20	Mean
Control	6.20	6.95	8.48	7.54	7.29		6.05	6.88	8.80	7.17	7.23
Mycorrhiza	6.67	6.80	8.71	8.42	7.65		6.35	7.25	8.45	8.05	7.53
PSB	6.71	7.02	10.85	8.90	8.37		6.65	6.75	10.15	8.55	8.03
Mean	6.44	6.93	9.35	8.29			6.35	6.96	9.13	7.92	

C.D. at 5%

Phosphorous	0.46	0.25
Biofertilizers	0.40	0.22
Nitrogen x Biofertilizers	0.80	0.44

Table 4. Response of biofertilizers in combination with phosphorous on number of days taken to bud initiation in chrysanthemum

Year	2011-12						2012-13				
Treatments	Levels of phosphorus (g/m²)						Levels of phosphorus (g/m²)				
	0	10	15	20	Mean		0	10	15	20	Mean
Control	77.00	72.33	62.33	68.33	70.00		78.67	75.00	64.33	70.00	72.00
Mycorrhiza	79.00	73.00	70.67	75.67	74.58		80.33	76.00	73.67	75.67	76.42
PSB	65.30	63.00	61.67	64.67	63.66		70.33	67.33	63.33	66.00	66.75
Mean	73.77	69.44	64.89	69.56			76.44	72.78	67.11	70.56	

C.D. at 5%

Phosphorous	1.72	1.67
Biofertilizers	1.99	1.93
Phosphorous x Biofertilizers	3.45	3.43

Table 5. Response of biofertilizers in combination with phosphorous on number of buds per plant in chrysanthemum

Year	2011-12						2012-13				
Treatments	Levels of phosphorus (g/m²)						Levels of phosphorus (g/m²)				
	0	10	15	20	Mean		0	10	15	20	Mean
Control	16.33	20.67	25.67	23.33	21.50		18.00	21.00	28.67	24.33	23.00
Mycorrhiza	17.00	22.33	29.36	25.00	23.42		21.00	24.00	30.00	26.67	25.42
PSB	19.67	28.67	32.33	26.00	26.67		23.33	26.67	32.00	30.33	28.08
Mean	17.67	23.89	29.12	24.78			20.78	23.89	30.22	27.11	

C.D. at 5%

Phosphorous	1.74	1.65
Biofertilizers	1.51	1.43
Phosphorous x Biofertilizers	3.02	2.96

Table 6. Response of biofertilizers in combination with phosphorous on days to first flowering in chrysanthemum

Year	2011-12						2012-13				
Treatments	Levels of phosphorus (g/m²)						Levels of phosphorus (g/m²)				
	0	**10**	**15**	**20**	**Mean**		**0**	**10**	**15**	**20**	**Mean**
Control	96.00	89.67	76.67	85.00	86.83		97.33	92.00	77.67	85.33	88.08
Mycorrhiza	98.67	90.00	86.33	93.33	92.08		100.33	92.33	87.67	91.00	92.83
PSB	82.67	79.33	75.00	79.33	79.08		89.00	83.00	75.67	79.00	81.67
Mean	92.45	86.33	79.33	85.89			95.56	89.11	80.33	85.11	

C.D. at 5%

Phosphorous	1.74	2.08
Mycorrhiza	1.51	1.80
Phosphorous x Biofertilizers	3.02	3.61

Table 7. Response of biofertilizers in combination with phosphorous on flower stalk length (cm) in chrysanthemum

Year	2011-12					2012-13				
Treatments	Levels of phosphorus (g/m^2)					Levels of phosphorus (g/m^2)				
	0	10	15	20	Mean	0	10	15	20	Mean
Control	5.19	5.32	5.45	5.25	5.30	5.13	5.34	6.17	5.67	5.58
Mycorrhiza	5.33	5.38	6.17	5.73	5.66	5.37	5.53	6.30	5.57	5.69
PSB	5.25	5.40	6.33	6.08	5.77	5.53	6.03	6.33	6.13	6.01
Mean	5.26	5.37	5.99	5.69		5.34	5.64	6.27	5.79	

C.D. at 5%

Phosphorous	0.44	0.23
Biofertilizers	0.38	0.20
Phosphorous x Biofertilizers	0.91	0.58

Table 8. Response of biofertilizers in combination with phosphorous on number of flowers per plant in chrysanthemum

Year	2011-12					2012-13				
Treatments	Levels of phosphorus (g/m^2)					Levels of phosphorus (g/m^2)				
	0	10	15	20	Mean	0	10	15	20	Mean
Control	13.00	17.33	22.33	19.00	17.92	14.33	16.33	22.33	18.00	17.75
Mycorrhiza	15.00	16.67	28.33	24.00	21.00	15.67	22.67	25.67	20.33	21.08
PSB	17.67	23.33	29.00	26.33	24.08	17.33	23.33	29.33	26.67	24.17
Mean	15.22	19.11	26.56	23.11		15.78	20.78	25.78	21.67	

C.D. at 5%

Phosphorous	1.24	1.04
Biofertilizers	1.08	0.91
Phosphorous x Biofertilizers	2.15	1.81

Table 9. Response of biofertilizers in combination with phosphorous on number of suckers per plant in chrysanthemum

Year	2011-12					2012-13				
Treatments	Levels of phosphorus (g/m^2)					Levels of phosphorus (g/m^2)				
	0	10	15	20	Mean	0	10	15	20	Mean
Control	3.67	4.33	6.67	6.00	5.17	4.00	5.33	7.00	6.00	5.58
Mycorrhiza	4.33	5.67	7.33	6.67	6.00	5.00	6.33	7.33	6.67	6.33
PSB	5.33	6.00	7.67	7.33	6.58	5.33	7.33	8.33	7.67	7.17
Mean	4.44	5.33	7.22	6.67		4.78	6.33	7.55	6.78	

C.D. at 5%

Phosphorous	0.63	0.74
Biofertilizers	0.73	0.60
Phosphorous x Biofertilizers	NS	NS

the application of phosphorus 15 g/m^2 in the year 2011-12 and 2012-13, respectively. However, in the year 2011-12, it remained at par with phosphorus 20 g/m^2 with the value of 28.30 cm. The shortest plant (24.91 and 25.03 cm) was recorded in control during the year 2011-12 and 2012-13, respectively. This might be due to the reason that phosphorus improved the plant root system, which led to higher uptake of plant nutrients and hence improved the plant growth (Nath *et al*., 2010). The present results are in conformity with the findings of Dorajeerao *et al.*, (2012) and Deshmukh *et al.*, (2006) in chrysanthemum and Sharma *et al.*, (2008) in tuberose.

The effect of biofertilizers on plant height was found to be significant. The maximum plant height (29.27 and 30.08 cm) was observed with the application of PSB, whereas, it was minimum (25.39 and 25.38 cm) in control during both the years of investigation, respectively. *Pseudomonas* sp. was found to be common effective bioinoculant, which increased the height of the plant with optimum dose of phosphorus. The reason may be due to the balanced absorption and solubilization of phosphorus by *P. fluorescens* (Prasad *et al*., 2012). The results are comparable to those of Kumar *et al.*, (2006) in marigold and Hemavathi (1997) in chrysanthemum. The conjunctive effect of phosphorous levels and biofertilizers on plant height was found to be significant for both the years. The tallest plant (31.77 and 33.33 cm) was observed with the application of PSB + phosphorus 15 g/m^2 in the year 2011-12 and 2012-13, respectively, which remained at par with the application of PSB + phosphorus 10 g/m^2 (29.73 cm) in first year. The shortest plant (22.70 and 22.33 cm) was found in control during both the years, respectively. Enhanced availability of phosphorus due to the presence of PSB in rhizosphere stimulated the root system through efficient translocation of certain growth stimulating compounds to roots from shoots, which further enhanced the absorption of nutrients, therefore, resulting in plant growth. Similar work was reported by Prasad *et al.*, (2012) in chrysanthemum.

Fresh weight of plant (g)

The fresh weight of plant increased with increasing levels of phosphorous up to 15 g/m^2, and thereafter, it decreased in the year 2011-12 and 2012-13 (Table 2). The maximum fresh weight of plant (89.96 and 90.89 g) was obtained with the application of phosphorus 15 g/m^2, whereas, it was minimum (63.06 and 69.29 g) in control during both the years, respectively. This might be due to the reason that phosphorus improved the root system of plant, which led to higher uptake of plant nutrients and hence improved the plant growth. Similar findings were reported by Kundu *et al*., (2010) in African marigold.

Biofertilizers application showed significant effect on fresh weight of plant. The maximum fresh weight of plant (80.33 and 82.40 g) was recorded with the application of PSB, while it was minimum (70.85 and 75.63 g) in control in the year 2011-12 and 2012-13, respectively. It might be due to that PSB releases the organic and inorganic acids, which reduce soil pH, leading to change of available phosphorus, other nutrients and their uptake by the plants. Among the interactions between phosphorous and biofertilizers, the maximum fresh weight of plant (100.90 and 96.77 g) was recorded with the application of PSB in combination of phosphorus 15 g/m^2, whereas, it was minimum (60.40 and 66.20 g) in control during both the years of investigation, respectively. This could be attributed to vigorous growth of the plants due to balanced nutrient levels with biofertilizers. Similar results have also been obtained by Prasad *et al.*, (2012) and Hashemabadi *et al*., (2012) in chrysanthemum.

Dry weight of plant (g)

The dry weight of plant was significantly influenced by the phosphorous levels and increased with increasing level of phosphorous up to 15 g/m^2, and thereafter, it declined in both the years (Table 3). The maximum dry weight of plant (9.35 and 9.13 g) was found with phosphorus 15 g/m^2, while it was minimum (6.44 and 6.35 g) in control during the year 2011-12 and 2012-13, respectively. Phosphorus had significant impact on uptake of N and P as well as N and P content of plant and ultimately increased the dry weight of plant. This is supported by several research workers (Dorajeerao *et al*., 2012; Deshmukh *et al.,* 2006) in chrysanthemum.

Interpretation of data further reveals that the dry weight of plant was recorded significantly maximum (8.37 and 8.03 g) with the application of PSB, whereas, it was recorded minimum (7.29 and 7.14 g) in control during the year 2011-12 and 2012-13, respectively. It might be due to that PSB inoculated plants were able to absorb nutrients from solution at faster rate than uninoculated plants, resulting in accumulation of more N, P and K in leaves. Prasad *et al.*, (2012) reported similar results in chrysanthemum. The interaction between levels of phosphorous and biofertilizers was found to be significant. The maximum dry weight of plant (10.85 and 10.15 g) was recorded with PSB + phosphorus 15 g/m^2, while it was minimum (6.20 and 6.05 g) in control during both the years, respectively.

Number of days taken for bud initiation

The number of days taken for bud initiation was significantly influenced by different phosphorous levels and decreased with increasing levels of phosphorous up to 15 g/m^2 over control (Table 4). The minimum number of days taken for bud initiation (64.89 and 67.11 days) was observed with phosphorus 15 g/m^2, whereas, the maximum number of days taken for bud initiation (73.77 and 76.44 days) was recorded in control during both the years, respectively. It might be due to the abundant availability of phosphorus in the rooting medium due to the application of phosphorus. The results are in line with the findings of Nath *et al*., (2011) in China aster.

The response of biofertilizers was found to be significant on number of days taken for bud initiation. The minimum number of days taken for bud initiation (63.66 and 66.75 days) was recorded with PSB inoculated plants, whereas, it was recorded maximum (74.58 and 76.42 days) in mycorrhiza inoculation during both the years, respectively. The earliness of bud initiation in PSB inoculated plants may be ascribed to easy uptake of nutrients and simultaneously the transport of growth promoting substances like cytokinins to the axillary buds, resulting in breakage of apical dominance ultimately this has resulted in a better sink for faster mobilization of photosynthates and early transformation of plant parts from vegetative to reproductive phase (Jayamma *et al*., 2008). Such a positive effect was in line with the findings of Meshram *et al*., (2008) in chrysanthemum. The interaction between phosphorous levels and biofertilizers was found to be significant during both the years. In first year, the minimum number of days taken for bud initiation (61.67 days) was recorded with the application of PSB in combination of phosphorus 15 g/m^2, which was at par with phosphorus 15 g/m^2 alone (62.33 days), PSB along with phosphorus 10 g/m^2 (63.00 days) and PSB along with phosphorus 20 g/m^2 (64.67 days), while in next year, it was observed minimum (63.33 days) in treatment combination of PSB with phosphorus 15 g/m^2, which remained at par with phosphorus 15 g/m^2 alone (64.33 days) and PSB with phosphorus 20 g/m^2 (66.00 days).

Number of buds per plant

It is inferred from the data (Table 5) that the maximum number of buds per plant (29.12 and 30.22) was observed in phosphorus 15 g/m^2 as compared to other treatments, whereas, it was found minimum (17.67 and 20.78) in control in the year 2011-12 and 2012-13, respectively. These finding are in agreement with the findings of Prakash *et al*., (2006) in lilium.

Biofertilizers application influenced the number of buds per plant significantly. The maximum number of buds per plant (26.67 and 28.08) was recorded in PSB application, while it was recorded minimum (21.50 and 23.00) in control during both the years, respectively. Inoculation of PSB along with phosphorus helped in mobilization of phosphate to higher extend than individual treatment, possibly due to enhanced rhizospheric activity. The interaction effect of phosphorous levels and biofertilizers on number of buds per plant was found to be significant in both the years. The maximum number of buds per plant (32.33 and 32.00) was recorded with PSB + phosphorus 15 g/m^2 which was at par with mycorrhiza + phosphorus 15 g/m^2 (29.36) in first year, whereas, in second year, it remained at par (30.00) with mycorrhiza + phosphorus 15 g/m^2 and PSB + phosphorus 20 g/m^2 (30.33). The minimum number of buds per plant (16.33 and 18.00) was found in control during both the years, respectively.

Days to first flowering

It is evident from the data (Table 6) that the minimum number of days taken to first flowering (79.33 and 80.33 days) was observed with phosphorus 15 g/m2, while it was recorded maximum (92.45 and 95.56 days) in control during the year 2011-12 and 2012-13, respectively irrespective to biofertilizers. The earlier flowering might be due to the abundant availability of phosphorus in the rooting medium due to the application of phosphorus. These findings corroborate with the findings of Nath *et al.,* (2011) in China aster.

Further, the interpretation of data reveals that the number of days taken to first flowering was observed minimum with PSB application (79.08 and 81.67 days), whereas, the maximum number of days taken to first flowering (92.08 and 92.83 days) was observed with mycorrhiza application. Delayed flowering due to the application of mycorrhiza has also been reported by Nowak (2009) in China aster. The interaction effect of phosphorous levels and biofertilizers was found to be significant in both the years. The minimum number of days to first flowering (75.00 and 75.67 days) was recorded with PSB + phosphorus 15 g/m2, which remained at par with phosphorus 15 g/m2 (76.67 and 77.67 days) in the year 2011-12 and 2012-13, respectively. The maximum number of days to first flowering (98.67 and 100.33 days) was recorded with mycorrhiza application alone in both the years, respectively. Phosphorus is an important element and essential for the initiation of flowering, PSB along with phosphorous known to increase the availability of phosphorus resulted in early flowering. This finding is in line with the findings of Haripriya and Sriramchandrasekharan (2002) in chrysanthemum.

Flower stalk length (cm)

It is inferred from the data presented in Table 7 that flower stalk length was significantly influenced by different levels of phosphorous. The significantly longest flower stalk (5.99 and 6.27 cm) was observed with phosphorus 15 g/m^2 in the year 2011-12 and 2012-13, respectively but in the year 2011-12, it was at par with phosphorus 20 g/m^2 (5.69 cm). The smallest flower stalk (5.26 and 5.34 cm) was recorded with control during both the years, respectively. Same results have also been reported by Satar *et al*., (2012) in annual chrysanthemum and Nath *et al*., (2010) and Singh and Sangama (2000) in China aster.

Among the biofertilizers treatments, the longest flower stalk (5.77 and 6.01 cm) was recorded with PSB application, but in first year, it was at par with mycorrhiza application with the value of 5.66 cm. The smallest flower stalk (5.30 and 5.58 cm) was found with control during both the years, respectively. The interaction effect of different levels of phosphorous and biofertilizers on flower stalk length was found to be significant during both the years. The longest flower stalk (6.33 and 6.33 cm) was recorded with PSB application in combination with phosphorus 15 g/m^2 in the year 2011-12 and 2012-13, respectively, which remained at par with mycorrhiza + phosphorus 15 g/m^2 (6.17 cm), PSB + phosphorus 20 g/m^2 (6.08 cm) and phosphorus 15 g/m^2 alone (5.45 cm) in first year, whereas, in second year, it was at par with PSB + phosphorus 10 g/m^2 (6.03 cm), PSB + phosphorus 20 g/m^2 (6.13 cm), mycorrhiza + phosphorus 15 g/m^2 (6.30 cm) and phosphorus 15 g/m^2 alone (6.17 cm). The smallest flower stalk (5.19 and 5.13 cm) was observed in control during both the years, respectively. All the treatments involving biofertilizers in combination with various levels of phosphorus were effective considerably as compared to control due to enhanced absorption in biofertilizers inoculated plants, leading to increased availability of assimilates that needed for the improvement in flower stalk length. Laishram *et al*., (2013) reported similar results in chrysanthemum.

Number of flowers per plant

The number of flowers per plant was significantly influenced by different levels of phosphorous and increased significantly with increasing levels of phosphorous up to 15 g/m^2, and thereafter, it declined at higher level of phosphorous, *i.e.*, 20 g/m^2 (Table 8). The maximum number of flowers per plant (26.56 and 25.78) was recorded with phosphorus 15 g/m^2, while it was recorded minimum (15.22 and 15.78) in control during the year 2011-12 and 2012-13, respectively irrespective to biofertilizers. Phosphorus is associated with phosphorylation and is a constituent of energy rich compounds like ATP, ADP, NADH and NADPH and these energy rich metabolites ultimately increased the number of flowers per plant. High soil phosphorus concentration resulted in the reduction of hyphal growth and spore production of arbuscular mycorrhizal fungi that ultimately reduced the phosphatase secretion, which is actually responsible for the conversion of bound P into available form, resulting in lesser P-uptake in high superphosphate concentration (Prasad *et al*., 2012). These results are in conformity with the findings of Dorajeerao *et al*., (2012) and Deshmukh *et al*., (2006) in chrysanthemum and Singh and Sangama (2000) in China aster.

The maximum number of flowers per plant (24.08 and 24.17) with respect to biofertilizers was observed with the application of PSB, whereas, the minimum number of flowers per plant (17.92 and 17.75) was found in control in the year 2011-12 and 2012-13, respectively irrespective to phosphorous. The interaction between levels of phosphorous and biofertilizers was found to be significant in both the years of investigation. The maximum number of flowers per plant was recorded with PSB in combination of phosphorous 15 g/m^2 (29.00 and 29.33) in the year 2011-12 and 2012-13, respectively, which remained at par with mycorrhiza along with phosphorus 15 g/m^2 (28.33) in first year. The minimum number of flowers per plant (13.00 and 14.33) was recorded in control in both the years, respectively. Similar results have also been reported by Pushkar and Rathore (2011) in marigold and Karishma *et al.,* (2013) in gerbera.

Number of suckers per plant

It is apparent from the data presented in Table 9 that the number of suckers per plant as influenced by the levels of phosphorous was found to be significant in both the years. The maximum number of suckers per plant (7.22 and 7.55) was recorded in phosphorus 15 g/m^2; however, it was at par with phosphorus 20 g/m^2 (6.67) in first year. The minimum number of suckers per plant (4.44 and 4.78) was observed in control during the year 2011-12 and 2012-13, respectively. Phosphorus is a component of complex nucleic acid structure of plants, which regulates protein synthesis. Phosphorus is, therefore, important in cell division and development of new tissue and increased the number of suckers per plant.

The interpretation of data has further reveals that PSB inoculated plants recorded the maximum number of suckers per plant (6.58 and 7.17) during both the years, respectively, which was at par with mycorrhiza (6.00) application in first year. The minimum number of suckers (5.17 and 5.58) was recorded with control in both the years, respectively. PSB helps in converting the unavailable phosphorus to its available form by releasing acid, which results in better sucker production. The effect of interaction between the levels of phosphorous and biofertilizers on number of suckers per plant was found to be non-significant during both the years of experimentation.

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