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RESEARCH ARTICLE :

Effect of organic manures and biofertilizers on vegetative and floral traits at different stages of Carnation (*Dianthus caryophyllus* L.) cv. Soto in hill zone of Karnataka under protected cultivation

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SUMMARY : Eleven treatments with different combinations of organic, biofertilizers and inorganic fertilizers were tested for growth, flowering, flower yield and vase life parameters to identify best combination of fertilizers for cultivation of Carnation (*Dianthus caryophyllus* L.) flower under naturally ventilated polyhouse in Mudigere condition. T_{11} (*Azospirillum* + PSB + FYM + VC + 75% RDF) and T_{10} (*Azospirillum* + PSB + VC + 75 % RDF) proved to have better results in vegetative growth at all the stages and flowering parameters. Maximum plant height (113.21 cm), Number of branches (8.13), number of leaves (202.30), leaf length (19.54 cm), Leaf width (1.04 cm), Internodal length (7.60 cm) and Number of nodes/ branch (30.37) were observed in T_{11} at all the stages of plant growth and recorded good height at 180 days after pinching. These combinations lead early to initiate full flower (133.78 DAP). Flower quality parameters like flower diameter (6.49 cm) recorded highest in $T_{11.}$ Longevity (12.52 days) and highest yield per m^2 per year (428.34) were recorded in T_{11} (*Azospirillum* + PSB + FYM + VC + 75% RDF) followed by T_{10} (12.01 days and 414.04, respectively). Thus, this combination of different fertilizers may effective for good plant growth and more production of Carnation cut flower.

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KEY WORDS :
Organic and inorganic fertilizers, Carnation, Biofertilizers, Yield

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BACKGROUND AND OBJECTIVES

Carnation (*Dianthus caryophyllus* L.), a member of family Caryophyllaceae is one of the leading cut flower crops in the global florist trade and ranks within the top ten cut flowers of the world. These are preferred to Rose and Chrysanthemum in several exporting countries, due to its long lasting keeping quality, attractive form, wide range of colours, ability to withstand long distance transportation and remarkable ability to rehydrate after continuous shipping (Bhatia *et al.*, 2007). In this modern era, with the increasing demand, development of Carnation cultivars with more

desirable floral characteristics and higher productivity are found to be very important.

In India, there is wide fluctuations exist with respect to temperature, light intensity and humidity which not only affect the yield and quality of flowers but also limit their availability for a particular period of a year. Hence it is necessary to grow Carnation under polyhouse condition for obtaining good quality flowers. In Karnataka Carnation is being cultivated over an area of 36 ha with annual production of 74.0 t. with productivity of 2.04 t/ha which is valued for Rs.162 lakhs per annum. Carnation is mainly cultivated in four districts of Karnataka *viz*., Belgagavi, Bengaluru and Chikkaballapura Among these Bengaluru occupies first place with respect to area, production, and value of the product (25 ha, 49 lakh cut flowers, Rs.122.00 lakhs/annum, respectively) and Belagavi with respect to climate and market (Anonymous, 2008).

Increased flower production, quality of flowers and perfection in the form of plants are the important objectives to be reckoned in commercial flower production. By using inorganic fertilizers, one can get higher yield but indiscriminate use of chemical fertilizers has adverse and ill effects on the soil structure, environment, flora and fauna. Recently, there is fall in mineral fertilizers consumption due to unprecedented hike in price of fertilizers and also soil and water pollution has aggravated the problem of soil health (Bhatia and Gupta, 2007) and the increasing costs of fertilizers prevent their use by poor farmers. Therefore, nowadays attention is shifted towards the alternate sources *i.e.*, organic manures and bioinoculants. The role of organic manures and biofertilizers to make the soil healthy as well as make unavailable form of soil nutrients to available form by enhancing mineralization and solubilization process. In soil by adding organic manures and microbial agents make easy uptake of nutrients when crop required comparing to chemical fertilizers. Keeping in view the importance of organic manures and biofertilizers, the present investigation was undertaken to find out the effect of these sources of fertilizers on vegetative and flowering traits of Carnation cv. Soto under protected conditions.

RESOURCES AND METHODS

The present investigation was carried out at Department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere (hill zone of Karnataka) to find out the effect of eleven different combinations of organic, inorganic and biofertilizers with three replications on vegetative and flowering traits at different stages of Carnation (*Dianthus caryophyllus* L.) cv. Soto under protected cultivation. Raised beds of 30 cm height were prepared having one meter width with a row spacing of 20 cm and 15 cm between plants. Rooted cuttings of Carnation plants were planted and grown by following standard cultivation practices like soil sterilization, irrigation, pinching, netting, disbudding and harvesting. Collected the data from five randomly selected tagged plants after 30 days of pinching from each replication and analyzed as described by Panse and Sukhatme (1967).

Treatment combination consisted of the recommended dose of fertilizers applied was 250:80:200g NPK + 2 kg FYM /m^2/year (were applied at bimonthly interval after the first pinch). *Azospirillum* (60 g/m^2), Phosphorus Solubilizing Bacterium (60 g/m^2) and vermicompost (500 g/m^2) were applied to prepared beds before a day to planting. The flowers were harvested at paint brush stage by cutting with secateurs at the base of stalk, leaving 5-6 nodes on the main stem, to encourage side shoots to grow and immediately kept in water.

OBSERVATIONS AND ANALYSIS

Data pertaining to application of organic manures and Biofertilizers on floral attributes of Carnation (*Dianthus caryophyllus* L.) cv. Soto are presented in table 4. Flower yield is an important parameter. Minimum days to opening (133.78 days) maximum vase life (12.52 days), number of flowers per square meter (428.34), flower length (6.49 cm) and diameter of flower (6.95 cm) were recorded in T_{11} (*Azospirillum* + PSB + FYM + VC + 75% RDF). Whereas, minimum results recreded in control [(100% RDF (250:80:200 g NPK + 2 kg FYM /m^2)]. The above results are in corroboration with the findings of Bhatia and Gupta, 2007 and Renukaradya *et al.*, 2011 in Carnation.

Number of flowers per plant is one of the cumulative expression of crop yield components and it is the ultimate output and flower production. Significantly higher number per meter square (428.34 and 414.04) was significantly higher in the treatment T_{11} and followed by T_{10} which received *Azospirillum* (60 g/m^2), PSB (60 g/m^2). Vermicompost (500 g/m^2) and 75 per cent RDF as compared to other treatments. It might be attributed to better supply of nutrients and their uptake by the crop

have increased the number of flowers per plant and per metre square and which inturn improved the flower yield. The increased in flower yield might be attributed to the greater leaf area and more number of leaves per plant as well as plant spread would have resulted in production and accumulation of maximum photosynthates, resulting the production of more number of flowers with bigger size. Potassium availability to the plant by inorganic K, *Azospirillum*, PSB and vermicompost being rich in micronutrients like Fe and Zn, enzymes, growth hormones and beneficial effect of micro flora might have played a secondary role in increasing the flower yield. These results are in accordance with the similar findings of Bhalla *et al.* (2006 and 2007), Bhatia, *et al.* (2007) and Renukaradya *et al.* (2011) in Carnation.

Individual flower length Diameter of flower bud, flower and vase life of flower differed significantly among the treatments. PSB and *Azospirillum* stimulated the formation of auxillary buds leading to increase in number of branches and flower length. Similar results were obtained by Krishna *et al.* (1999) and Bhalla *et al.* (2007) in Carnation. Biofertilizers with water soluble commercial straight fertilizers resulted in the production of more length and width of flowers with increased vase life in Carnation by Bhatia *et al.* (2007) in Carnation. Days for 50 per cent flowering was significantly increased in T_{11} and $T_{10.}$ These results might be attributed to the sufficient quantity of nutrient flow into plants treated with vermicompost, PSB and *Azospirillum.* PSB mobilizes the phosphorus at flowering period and *Azospirillum* lead to the enhanced level of auxins which divert the photo assimilates to the developing flower buds, resulting in increased petal number and flower weight thereby, increasing the flower diameter. Similar results were observed by Bhatia *et al.* (2007) and Bhalla *et al.* (2007) in Carnation.

Perusal of data in table 1 to 3 clearly showed that, various plant growth parameters at different stages were significantly influenced greatly by the treatments. Application of *Azospirillum* + PSB + FYM + VC + 75% RDF resulted in maximum plant height 24.26, 37.21, 65.37, 85.20, 96.55 and 113.21cm at 30, 60, 90, 120, 150 and

Table1 : Effect of organic manures and biofertilizers on vegetative characters at 30 and 60 days after planting in carnation

Treatments	At 30 days							At 60 days						
	Plant height (cm)	Number of shoots	Number of leaves	Leaf length (cm)	Leaf width (cm)	Internodal length (cm)	Number of nodes/ shoot	Plant height (cm)	Number of shoots	Number of leaves	Leaf length (cm)	Leaf width (cm)	Internodal length (cm)	Number of nodes/ shoot
T_1	16.68	4.37	23.73	6.31	0.26	1.07	6.51	28.40	4.81	42.85	9.02	0.34	2.09	10.38
T_2	19.10	4.55	29.08	7.50	0.34	1.06	6.91	32.40	4.96	37.63	12.52	0.40	2.10	11.92
T_3	19.12	4.98	38.13	9.46	0.52	2.03	8.51	32.71	5.40	45.32	11.12	0.62	2.17	12.38
T_4	21.67	5.28	31.33	9.38	0.42	1.48	7.12	33.26	5.60	44.80	10.06	0.50	2.44	9.12
T_5	22.58	4.90	45.33	7.31	0.33	2.23	7.67	31.07	5.45	55.94	11.96	0.43	3.24	10.75
T_6	19.18	5.20	32.15	6.35	0.30	2.02	7.11	36.79	5.88	47.26	9.09	0.46	3.01	12.26
T_7	20.13	4.60	41.51	6.55	0.28	1.46	7.54	33.39	5.85	55.48	11.56	0.38	2.45	11.98
T_8	20.88	4.96	49.56	9.54	0.57	2.45	9.57	36.93	5.62	60.59	13.48	0.65	3.32	14.93
T_9	22.25	5.25	44.31	8.48	0.43	2.18	7.86	30.26	5.82	53.79	10.35	0.53	3.15	12.70
T_{10}	22.70	5.60	50.63	10.56	0.59	2.65	9.45	36.99	6.16	60.66	13.55	0.68	3.92	14.38
T_{11}	24.26	5.94	60.59	11.52	0.64	2.63	9.66	37.21	6.37	64.39	14.94	0.74	3.62	16.33
S.E. ±	0.80	0.09	0.71	0.19	0.005	0.03	0.10	0.80	0.12	0.97	0.28	0.007	0.02	0.41
C.D. (P=0.05)	2.37	0.28	2.09	0.56	0.02	0.10	0.29	2.37	0.38	2.88	0.84	0.02	0.08	1.22

*T_1 (100% RDF (250:80:200 g NPK + 2 kg FYM/m^2),
T_2 (*Azospirillum* + 75% RDN + 100% RDP and K),
T_3 (PSB + 75% RDP + 100% RDN and K),
T_4 (*Azospirillum* + FYM + 75% RDF),
T_5 (*Azospirillum* + VC + + 75% RDF),
T_6 (PSB + FYM + 75% RDF),
T_7 (PSB + VC + 75% RDF),
T_8 (*Azospirillum* + PSB + 75% RDN and P + 100% RDK),
T_9 (*Azospirillum* + PSB + FYM + 75% RDF),
T_{10} (*Azospirillum* + PSB + VC + 75 % RDF),
T_{11} (*Azospirillum* + PSB + FYM + VC + 75% RDF)

RDF- Recommended Dose of Fertilizers
RDN - Recommended Dose of Nitrogen
RDP - Recommended Dose of Phosphorus
RDK - Recommended Dose of Potassium
FYM – Farm Yard Manure
PSB –Phosporus Solubilising Bacteria
VC – Vermicompost

180 days after pinching, respectively and also it was registered maximum Number of shoots (5.94, 6.37, 5.94, 6.37, 6.86 and 8.13), number of leaves (60.59, 64.39, 108.37, 119.08, 173.32 and 202.30), leaf length (11.52, 14.94, 16.61, 17.80, 18.61 and 19.54 cm), leaf width (0.64, 0.74, 0.79, 0.85, 0.96 and 1.04 cm), Internodal length (2.63, 3.62, 4.94, 5.56, 6.61 and 7.60 cm) and number of nodes/shoot (9.66, 16.33, 18.43, 22.32, 28.68 and 30.37) at 30, 60, 90, 120, 150 and 180 days after pinching followed by T_{10} (*Azospirillum* + PSB + VC + 75 % RDF). Whereas, all these parameters were recorded minimum in control (T_1 (100% RDF (250:80:200 g NPK + 2 kg FYM/m^2). This was in accordance with the reports of Bhalla *et al*. (2006), Bhatia *et al*. (2007) and Renukaradya *et al.* (2011) in Carnation.

Increased growth of vegetative traits may be due to better flow of various macro- and micro-nutrients along with plant growth substances into the plant system in the plots applied with vermicompost and farm yard manure and due to the supplementation of balanced nutrition for crop growth due to quick and greater availability of plant nutrients providing a better environment for root growth and proliferation. It also creates more adsorptive surface for uptake of nutrients. Higher availability of nitrogen favours apical dominance and maintains proper rate of cell division, which inturn leads to increased rate of meristematic activity resulting in better plant height. Enhanced plant height may also be attributed to the presence and synthesis of gibberellin in vermicompost and by *Azospirillum.* Gibberellin causes both cell division and cell elongation resulted in increased plant height on the contrary, decreased plant height may be due to unavailability of sufficient nutrients at critical stages for its luxuriant growth, which will be combined into amino acids, the building blocks of proteins, which in turn leads to increase in the rate of maristematic activity resulted in better plant height in all the stages. This is confirmation with earlier reports of Mukhopadhyay (1981) and Biswas *et al*. (1982) in Carnation.

The shoots are the skeletal structure of the plant

Table 2 : Effect of organic manures and biofertilizers on vegetative characters at 90 and 120 days after planting in Carnation

Treatments	At 90 days							At 120 days						
	Plant height (cm)	Number of shoots	Number of leaves	Leaf length (cm)	Leaf width (cm)	Internodal length (cm)	Number of nodes/ shoot	Plant height (cm)	Number of shoots	Number of leaves	Leaf length (cm)	Leaf width (cm)	Internodal length (cm)	Number of nodes/ shoot
T_1	47.21	4.37	70.27	9.36	0.37	2.46	12.13	60.31	4.81	85.70	10.50	0.45	3.25	16.15
T_2	56.09	4.55	87.02	12.79	0.42	2.78	15.20	74.89	4.96	95.93	14.66	0.43	3.10	19.65
T_3	62.21	4.98	66.47	14.21	0.62	3.26	15.51	79.11	5.40	88.80	15.23	0.70	4.61	19.54
T_4	52.01	5.28	61.17	11.21	0.52	3.45	12.27	72.78	5.60	91.53	12.13	0.62	4.53	16.53
T_5	54.30	4.90	66.41	14.29	0.44	3.93	12.34	74.40	5.45	91.18	15.28	0.54	4.94	16.35
T_6	54.55	5.20	77.75	9.84	0.47	3.43	14.74	78.36	5.88	96.16	10.53	0.57	4.64	17.56
T_7	52.39	4.60	74.78	12.64	0.40	2.91	14.82	73.10	5.85	93.23	13.63	0.51	3.53	18.87
T_8	63.58	4.96	77.39	14.52	0.68	4.53	17.90	75.36	5.62	107.67	15.51	0.77	5.51	21.35
T_9	47.93	5.25	82.92	11.41	0.55	4.12	14.23	78.94	5.82	109.30	12.62	0.65	5.14	18.06
T_{10}	64.65	5.60	96.41	15.48	0.72	4.71	17.21	83.98	6.16	113.24	16.45	0.81	5.65	21.20
T_{11}	65.37	5.94	108.37	16.61	0.79	4.94	18.43	85.20	6.37	119.08	17.80	0.85	5.56	22.32
S.E.±	0.77	0.09	1.34	0.21	0.004	0.04	0.19	0.68	0.12	1.64	0.16	0.005	0.05	0.33
C.D. (P=0.05)	2.27	0.28	3.97	0.62	0.01	0.13	0.57	2.02	0.38	4.84	0.47	0.01	0.16	0.99

*T_1 (100% RDF (250:80:200 g NPK + 2 kg FYM/m^2),
T_2 (*Azospirillum* + 75% RDN + 100% RDP and K),
T_3 (PSB + 75% RDP + 100% RDN and K),
T_4 (*Azospirillum* + FYM + 75% RDF),
T_5 (*Azospirillum* + VC + + 75% RDF),
T_6 (PSB + FYM + 75% RDF),
T_7 (PSB + VC + 75% RDF),
T_8 (*Azospirillum* + PSB + 75% RDN and P + 100% RDK),
T_9 (*Azospirillum* + PSB + FYM + 75% RDF),
T_{10} (*Azospirillum* + PSB + VC + 75 % RDF),
T_{11} (*Azospirillum* + PSB + FYM + VC + 75% RDF)

RDF- Recommended Dose of Fertilizers
RDN - Recommended Dose of Nitrogen
RDP - Recommended Dose of Phosphorus
RDK - Recommended Dose of Potassium
FYM – Farm Yard Manure
PSB –Phosporus Solubilising Bacteria
VC – Vermicompost

and these were significantly influenced by the varying sources of the nutrients. This could be attributed to better flow of various micro and macro nutrients along with plant growth substances into plant system in the plots applied with vermicompost, *Azospirillum*, PSB, FYM and 75 per cent RDF. There by it might have favored for

Table 3 : Effect of organic manures and biofertilizers on vegetative characters at 150 and 180 days after planting in Carnation

Treatments	At 150 days							At 180 days						
	Plant height (cm)	Number of shoots	Number of leaves	Leaf length (cm)	Leaf width (cm)	Internodal length (cm)	Number of nodes/ shoot	Plant height (cm)	Number of shoots	Number of leaves	Leaf length (cm)	Leaf width (cm)	Internodal length (cm)	Number of nodes/ shoot
T_1	75.82	5.46	106.83	11.17	0.48	4.26	17.77	90.50	6.01	151.82	13.35	0.51	5.17	21.52
T_2	90.49	5.89	117.18	15.73	0.53	4.46	22.39	98.83	5.91	165.36	16.37	0.56	5.42	24.16
T_3	89.90	5.96	117.11	16.32	0.75	5.60	22.52	102.66	6.53	170.34	16.97	0.78	6.63	25.99
T_4	88.69	6.07	123.56	12.47	0.72	5.56	19.76	101.24	6.56	160.34	13.38	0.77	6.52	22.39
T_5	91.65	5.34	115.63	15.55	0.64	5.93	20.26	104.46	6.23	165.11	16.38	0.68	6.87	22.50
T_6	93.57	6.46	111.91	12.62	0.67	5.61	21.46	107.92	7.01	139.71	15.30	0.70	6.33	23.19
T_7	95.98	6.37	121.70	14.61	0.63	4.54	21.54	103.22	6.92	157.88	14.65	0.64	5.26	22.39
T_8	92.31	6.21	155.30	16.66	0.90	6.20	28.34	108.55	6.74	188.45	17.59	0.96	7.55	29.65
T_9	91.26	6.37	136.65	13.41	0.90	6.17	20.21	105.95	7.39	171.14	14.31	0.94	7.14	23.19
T_{10}	94.61	6.62	165.27	17.45	0.92	6.63	22.23	110.32	7.94	186.60	18.48	0.99	7.64	28.81
T_{11}	96.55	6.86	173.32	18.61	0.96	6.61	28.68	113.21	8.13	202.30	19.54	1.04	7.60	30.37
S.E. ±	0.49	0.07	1.24	0.16	.005	0.10	0.22	0.43	0.06	1.55	0.16	0.008	0.11	0.29
C.D. (P=0.05)	1.47	0.23	3.66	0.49	0.01	0.29	0.66	1.28	0.20	4.58	0.50	0.02	0.32	0.86

*T_1 (100% RDF (250:80:200 g NPK + 2 kg FYM/m^2),
T_2 (*Azospirillum* + 75% RDN + 100% RDP and K),
T_3 (PSB + 75% RDP + 100% RDN and K),
T_4 (*Azospirillum* + FYM + 75% RDF),
T_5 (*Azospirillum* + VC + + 75% RDF),
T_6 (PSB + FYM + 75% RDF),
T_7 (PSB + VC + 75% RDF),
T_8 (*Azospirillum* + PSB + 75% RDN and P + 100% RDK),
T_9 (*Azospirillum* + PSB + FYM + 75% RDF),
T_{10} (*Azospirillum* + PSB + VC + 75 % RDF),
T_{11} (*Azospirillum* + PSB + FYM + VC + 75% RDF)

RDF- Recommended Dose of Fertilizers
RDN - Recommended Dose of Nitrogen
RDP - Recommended Dose of Phosphorus
RDK - Recommended Dose of Potassium
FYM – Farm Yard Manure
PSB –Phosporus Solubilising Bacteria
VC – Vermicompost

Table 4 : Effect of organic manures and biofertilizers on floral characters in Carnation (*Dianthus caryophyllus* L.) cv. Soto under protected cultivation

Treatments		Days to flower opening	Diameter (cm) flower	Flower length (cm)	Flower yield Per m^2 per year	Longevity (days)
T_1	100% RDF (250:80:200 g NPK + 2 kg FYM /m^2)	158.61	6.14	4.56	305.25	9.12
T_2	*Azospirillum* + 75% RDN + 100% RDP and K	155.60	6.58	4.76	323.84	10.55
T_3	PSB + 75% RDP + 100% RDN and K	144.13	6.73	4.93	317.90	11.51
T_4	*Azospirillum* + FYM + 75% RDF	147.44	6.21	5.26	315.59	10.87
T_5	*Azospirillum* + VC + + 75% RDF	155.06	6.33	5.16	360.03	10.96
T_6	PSB + FYM + 75% RDF	145.54	6.71	4.96	357.94	10.74
T_7	PSB + VC + 75% RDF	146.38	6.30	5.35	375.32	10.45
T_8	*Azospirillum* + PSB + 75% RDN and P + 100% RDK	137.17	6.86	6.10	398.20	11.98
T_9	*Azospirillum* + PSB + FYM + 75% RDF	153.46	6.53	5.53	327.03	10.48
T_{10}	*Azospirillum* + PSB + VC + 75 % RDF	142.44	6.74	6.30	414.04	12.01
T_{11}	*Azospirillum* + PSB + FYM + VC + 75% RDF	133.78	6.95	6.49	428.34	12.52
S.E.±		1.15	0.04	0.65	1.61	0.14
C.D. (P=0.05)		3.40	0.11	2.10	4.76	0.43

stimulation and production of auxiliary buds resulting in the formation of more number of branches. Similar results are in line with the findings of Krishna *et al.* (1999) and Renukaradya *et al.* (2011) in Carnation. Number of nodes per branch, number of leaves, leaf length, leaf width and intermodal length were significantly increased in T11 followed by T10. It may be due to the use of *Azospirillum*, PSB, and potassium. *Azospirillum* and PSB might have resulted in breaking of apical dominance and increased the number of node per branch and per plant. These results are supported by Bhatia *et al.* (2007) and Renukaradya *et al.* (2011) in Carnation.

Apart from the reasons mentioned earlier, enhanced growth parameters like plant height, number of leaves, leaf area, stem girth etc., due to *Azospirillum* may also be attributed to the influence of nitrogen, the chief constituent of protein essential for formation of protoplasm, which enhances cell division and cell enlargement. PSB solubilises the phosphorus, vermicompost is a component of micro and macronutrients, growth regulators which provides the nitrogen to the plants leads to healthy plant growth in their vegetative period.

Conclusion :

It is concluded that, the use of *Azospirillum* (60 g/ m2), PSB (60 g/m^2), vermicompost (500 g/m^2), FYM (2 kg/m^2) along with 75 per cent recommended dose of fertilizer influenced in realizing better plant growth, higher quality flower yield and above mentioned all the parameters in the economic production of Carnation.

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