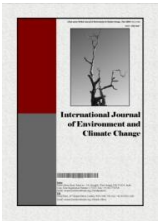

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Effect of Organic and Inorganic Sources of Nutrients on Flowering of Hybrid Gerbera (*Gerbera jamesonii* B.) cv. Shimmer in Open Field Condition

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The present investigation on Effect of organic and inorganic sources of nutrients on flowering of hybrid gerbera (*Gerbera jamesonii* B.) cv. Shimmer in open field condition was conducted at Biotechnology cum Tissue Culture Centre, OUAT Bhubaneswar during 2015-16 and 2016-17. The aim of the study was to find out suitable organic and inorganic sources of nutrients for cut flower production of gerbera in open field condition. There were eight treatment combinations consisting of 100% recommended dose of fertilizer (RDF), Vermicompost, 75% RDF, PSB, *Azospirillum, Azotobacter* and foliar spray of macro and micro elements. Application of 75% RDF (15:10:30 g NPK/10 plants) + Vermicompost (25 g/10 plants) + *Azospirillum/ Azotobacter* (20 g/10 plants) + PSB (20 g/10 plants) + macro and micro element spray recorded earlier flower bud initiation and flowering. The same treatments conducted to maximum length of flower stalk, thickness of flower stalk, flower diameter, number of flowers/plant and bloom life. It can be concluded that reduced dose of chemical fertilizer (75% RDF) along with application of vermicompost and biofertiizer can improve flower yield of gerbera in open field condition.

Keywords: Azospirillum; azotobacter; PSB; RDF; vermicompost.

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1. INTRODUCTION

Gerbera (*Gerbera jamesonii*) belongs to family Asteraceae occupying 5th place as cut flower in international flower trade. It has attractive colour, long vase life (12 days) and is suitable for long distance transport [1]. It also find a place in fresh and dry flower arrangement, exhibition, decoration, bouquet preparation [2]. These are grown in garden, flower bed, pots, borders, dish garden and rock garden. Different colour of flower like white cream, yellow, pink, orange, brick red, scarlet, salmon, maroon, bicolor are available in single, semidouble or double form [3].

Soil health and fertility is gradually decreasing by indiscriminate use of chemical fertilizer. Under ground water is contaminated due to fertilizer leachates creating environmental hazards. In this context, standardization of suitable organic source of nutrients is required along with chemical fertilizer. Integrated nutrient management reduce fertilizer use and increases productivity and quality of gerbera [4]. Integrated nutrient management (INM) involves use of all possible sources of nutrients in an integrated manner to increase production without deterioration of soil health and environment for long term sustainability. Improvement of physical properties, chemical properties and biological properties of soil can be achieved through INM practices. INM practices involve use of FYM and other bulky organic manure, oil cakes, organic waste product, vermicompost, biofertilizer and lastly inorganic fertilizer as different source of nutrients to plants [5].

Organic manure regenerates natural resources lost from soil with each harvest [6]. Further, it has been established by several investigation that integration of both organic and inorganic source of nutrient increases growth and yield of crop than using inorganic fertilizer alone (Gangadharan and Gopinath, 2002). Organic manure has vital role in maintaining sustained production and soil fertility as well. Vermicompost maintain humic substance in soil, increases efficiency of bio fertilizer and chemical fertilizer added to soil [7]. It make availability of micronutrient through chelating process. It also help in organic matter decomposition, biological nitrogen fixation, solubilisation of insoluble phosphates and helps in availability of several essential plant nutrients through increasing microbial activity and biological properties of soil.

Bio fertilizer maintain soil health, improve efficiency of chemical fertilizer and help in sustainable production in long run [8]. They are also economically and ecologically sound without any adverse effect on environment. *Azospirillum* and *Azotobacter* help in asymbiotic N fixation while PSB solublises insoluble P to available form in soil solution. They also suppress the activity of harmful microorganism and pathogen of plant. These are naturally gifted to us and do not require any non renewable energy for their production. Apart from fixing N, *Azospirillum* secrete hormone like auxin gibberlin and cytokinin in plant rhizosphere. It also produce antifungal and antibacterial substances preventing plant from bacterial and fungal infection. These bacteria also synthesize vitamins like thiamine, riboflavin, pyridoxine, cyanocobalamine, nicotinic acid, pantothenic acid improving plant growth and yield [9].

However very little information is available on INM practices in Gerbera for higher productivity. Farmer's are still using heavy dose of inorganic fertilizer to get higher productivity. The present investigation was carried out taking account of above situation.

2. MATERIALS AND METHODS

The experiment was carried out in premises of Bio technology cum Tissue Culture Centre, Odisha University of Agriculture Technology, Bhubaneswar, Odisha State, India from Nov. to Oct. 2015-16 and 2016-17 in open field condition.

The investigation site is located 63 km away from Bay of Bengal at an altitude of 25 m above MSL (Mean Sea Level). The site extends between 20^{O} 15' North latitude and 85^{O} 50' East longitude. The average rainfall of the site is 1646 mm. The maximum temperature during the experimental period was 38.8^{o}C to 40.8^{o}C and minimum temperature was 14.1^{o}C to 15.2^{o}C. The relative humidity during the experimental period was 37% to 94%. The soil was sandy loam with pH 5.83, electrical conductivity (EC) 0.64 ds/m, organic carbon (OC) 0.47%; Nitrogen(N) 125 kg/ha, phosphate (P_2O_5) 67.1 kg/ha and potash (K_2O) 166.6 kg/ha. The soil mixture is prepared of sandy loam soil, Farm Yard Manure and coco peat in 1: 1: 1 proportion.

Table 1. Treatment Details

Code	Different combination of nutrient source
T_1	RDF (15:10:30 g NPK/10 plants) in alternate month
T_2	RDF (15:10:30 g NPK/10 plants) in every month
T_3	75% RDF + Vermicompost (25 g/10 plants)
T_4	75% RDF + Vemicompost (25 g/10 plants) + Azospirillum (20 gm/10 plants) + PSB (20 g/10 plants)
T_5	75% RDF + Vermicompost (25 g/10 plants) + Azotobacter (20 g/10 plants) + PSB (20 g/10 plants)
T_6	75% RDF + vermicompost (25 g/10 plants) + sprayable macro & micro elements (2 ml/l)
T_7	75% RDF + vermicompost (25 g/10 plants) + Azospirillum (20 g/10 plants) + PSB (20 g/10 plants) + sprayable macro & microelements (2 ml/l)
T_8	75% RDF + vermicompost (25 g/10 plants) + Azotobacter (20 g/10 plants) + PSB (20 g/10 plants + sprayable macro & micro elements (2 ml/l)

Earthen pots with a hole at the bottom were filled with soil mixture and four leaved tissue culture plantlets of gerbera cv. Shimmer a variety suitable for protected cultivation were planted in these pots. Experiment was laid down in Completely Randomized Design (CRD) with eight treatments combination and three replications per treatment. There were 30 plants per treatment making a total population of 240 plants.

The bio fertilizer were incubated with vermicompost for 7 days and then applied in pot. Recommended dose of fertilizer were applied 3 month after planting as top dressing and subsequently as per treatment. The observations were recorded from 5 randomly selected plants within each replication of a treatment for different parameters like days taken to flower bud initiation, days taken to flowering, flower stalk length, stalk thickness, number of flowers per plant, flower diameter and bloom life in each month of two consecutive years and the pooled mean data of both the years were given in following tables.

The data collected were analyzed statistically following the method of Gomez and Gomez [10] using one way ANOVA in CRD. A comparison of treatment means were done at 5% level of significance (P=0.05).

3. RESULTS AND DISCUSSION

The results of the study obtained in the year 2015-16 and 2016-17 were pooled and the pooled mean data of both the years were presented in Table 1, Table 2 and Table 3 and discussed under the following headings.

3.1 Days to Flower Bud Initiation

It was observed from Table 1 that earliest flower bud initiation (8.67 days) after disbudding was found in T_7 and T_8 (75% RDF + VC + PSB + *Azotobacter/ Azospirillum* + sprayable macro and microelements) which was at par with T_4 and T_5 (75% RDF + VC + PSB + *Azospirillum* / *Azotobacter*). The maximum days to flower bud initiation (15.75 days) after disbudding was found in T_2 (RDF in every month).

Early flower bud initiation in T_7, T_8 , T_4 and T_5 may be due to integration of organic and inorganic source of nutrients in plant nutrition resulting optimum growth of plant. Dalve *et al*. [8] observed that application of *Azotobacter* + 75% N + full P and K in gladiolus resulted early spike emergence. Similarly, Angadi [5] reported that application of *Azospirillum* + PSB + 50% vermicompost + 50% NPK in chrysanthemum resulted early flower bud development. Application of RDF in every month build up fertilizer residues in soil leading to poor and sick growth of plant delaying flower bud initiation.

3.2 Days to Flowering

The minimum days taken to flowering (14.08 days) was observed in T_8 (75% RDF + VC + *Azotobacter* + PSB + sprayable macro and micro elements) which was at par with T_7 (75% RDF + VC + PSB + *Azospirillum* + sprayable macro and micro elements) and followed by T_4 (75% RDF + VC + PSB + *Azospirillum*) while maximum days to flowering (19.75 days) was observed in T_2 (RDF is every month).

The minimum days taken to flowering in T_8, T_7 and T_4 might be due to proper nutrition to plant from organic and inorganic sources.

Gangadharan and Gopinath (2002) observed early flowering by application of vermicomost + 80% RDF in gladiolus. Dalve *et al*. [8] observed that application of *Azotobacter* + *Azospirillum* + 75% N and full P, K in gladiolus resulted early flowering. Bhalla [6] observed that application of VC + RDF + *Azospirillum* + PSM in carnation resulted early flowering. The delay in flowering in T_2 might be due to application of RDF in every month increasing fertilizer residue in soil which hampers growth of plant thereby delaying flowering.

3.3 Length of Flower Stalk

Pooled data from both the consecutive years (Table 1) revealed that in winter season the longest stalk (53.65 cm) was observed in T_8 (75% RDF + VC + PSB + *Azotobacter* + sprayable macro and micro elements) which was at par with T_7 (75% RDF + VC +PSB + *Azospirillum* + sprayable macro and micro elements) which was closely followed by T_5 (75% RDF + VC + PSB + *Azotobacter*) and T_4 (75% RDF + VC + PSB + *Azospirillum*) while the shortest stalk (35.32 cm) was found in T_2 (RDF in every month). Similar trend in increase in stalk length was also observed in summer and rainy season.

Increase in stalk length in T_8, T_7, T_4 and T_5 might be due to beneficial effect of *Azotobacter*, *Azospirillum and PSB* incubated in vermicompost. Vermicompost is rich in hormones, nutrients, enzyme. This resulted profuse vegetative growth and increased stalk length. Similar finding have been obtained by Seetha and Gouda [7] with respect to application of vermicompost + 75% NPK in gerbera. Bhalla *et al.* [6] observed that application of VC + RDF + *Azospirillum* + PSB @ 2 g /plant in carnation resulted longest stalk length. Decrease in stalk length in T_2 might be due to poor and sick growth of plant due to fertilizer residue in soil.

3.4 Thickness of Flower Stalk

Pooled data of both the consecutive years (Table 2) revealed that in winter season the maximum stalk thickness (6.92 mm) was observed in T_7 (75% RDF + VC + PSB + *Azospirillum* + sprayable macro and micro elements) which was at par with T_8 (75% RDF + VC + PSB + *Azotobacter* + sprayable macro and micro elements) and followed by T_4 and T_5 (75% RDF + VC + PSB + *Azospirillum/ Azotobacter*) while the minimum stalk thickness (5.47 mm) was observed in T_2 (RDF in every month). Similar trends in increase in thickness of stalk was observed in summer and rainy season.

Increase in stalk thickness observed in T_7, T_8, T_5 and T_4 might be due to luxuriant growth of plants due to supply of nutrients from organic and inorganic sources. Bio fertilizer like PSB solublizes insoluble nutrient in soil to available form for absorption by plants. Similar finding have been obtained by Harshavardhan [11] by application of 75% RD N, P + 100 % K + *Azospirillum* + vermicompost + VAM in carnation. Thinnest stalk observed in T_2 was due to sick and poor growth of plant due to residual toxicity of fertilizer.

3.5 Number of Flower/Plant

The pooled data from both the years (Table 2) revealed that in winter season there were maximum number of flowers (13.10) per plant in T_8 (75% RDF + vermicompost + PSB + *Azotobacter* + sprayable macro and micro elements) which was at par with T_7 (75% RDF + vermicompost + PSB + *Azospirillum* + sprayable macro and micro elements) and closely followed by T_4 and T_5 (75% RDF + Vermicompost + PSB + *Azospirillum/ Azotobacter*) while the lowest flower yield (5.26) per plant was observed in T_2 (RDF in every month) in open field condition. Similar trends in increase in number of flowers/plant was observed in summer and rainy season.

Treatments with organic source of nutrients have higher capability of carbon assimilation than other treatments. Insoluble and fixed form of P_2O_5 in soil becomes available to plant by organic acid secreted by PSB. Asymbiotic nitrogen fixing bacteria like *Azospirillum*/ *Azotobacter* fix atmospheric N and supply to the plants. Vermicompost is rich source of hormones and nutrient like Zn, Fe etc. which accelerates enzymatic activity in the plant. Integration of all source of nutrients might have resulted maximum dry matter accumulation in plant which resulted higher number of flower yield per plant than others. Similar results have been obtained by Seetha and Gouda [7] by application of vermicompost and biofertilizer in gerbera. Subramaniam (2002) observed increased number of flowers by INM practices in crossandra. The lowest flower yield in T_2 (RDF in every month) may be due to nutrient toxicity in soil with sick and poor growth of plant resulting low carbon assimilation and so lowest number of flower/plant.

Table 2. Impact of INM practices on flowering character on days to flower bud initiation after disbudding, days taken to flowering and flower stalk length (pooled mean data of the years 2015-16 and 2016-17) in hybrid gerbera cv. Shimmer

Treatments number	Characters / Treatments	Days to flower bud initiation after disbudding	Days taken to flowering	Flower stalk length(cm)		
				Winter	Summer	Rainy
T_1	RDF in alternate month	12.42	17.33	43.54	39.99	42.87
T_2	RDF in every month	15.75	19.75	35.32	33.96	35.02
T_3	75% RDF + Vermicompost	11.75	17.5	40.28	37.79	39.94
T_4	75% RDF + VC + *Azospirillum*+ PSB	9.5	15.58	48.48	42.80	45.93
T_5	75% RDF + VC +*Azotobacter* + PSB	9.5	15.75	48.80	42.63	46.09
T_6	75% RDF + VC + macro & micro elements	11.08	16.92	43.80	40.21	43.22
T_7	75% RDF + VC + *Azospirillum*+ PSB + macro & microelements	8.67	14.17	53.62	46.09	49.50
T_8	75% RDF + VC + *Azotobacter* + PSB + macro & micro elements	8.67	14.08	53.65	46.21	49.50
	SE (m) ±	0.652	0.325	0.587	1.092	1.468
	CD (0.05)	2.18	0.93	1.68	3.65	4.91

Table 3. Impact of INM practices on flowering character i.e. thickness of flower stalk and number of flowers/plant (pooled mean data of the years 2015-16 and 2016-17) in hybrid gerbera cv. Shimmer

Treatments number	Characters / Treatments	Thickness of flower stalk (mm)			Total number of flowers/plant		
		Winter	Summer	Rainy	Winter	Summer	Rainy
T_1	RDF in alternate month	6.18	5.45	6.04	9.35	7.93	8.83
T_2	RDF in every month	5.47	5.07	5.07	5.26	4.87	5.16
T_3	75% RDF + Vermicompost	5.81	5.19	5.51	7.35	6.63	6.91
T_4	75% RDF + VC + *Azospirillum*+ PSB	6.50	5.92	6.33	10.69	9.42	10.25
T_5	75% RDF + VC +*Azotobacter* + PSB	6.50	5.93	6.33	10.68	9.76	10.24
T_6	75% RDF + VC + macro & micro elements	6.21	5.54	6.11	10.01	8.25	9.08
T_7	75% RDF + VC + *Azospirillum*+ PSB + macro & microelements	6.92	6.40	6.83	13.01	11.17	11.75
T_8	75% RDF + VC + *Azotobacter* + PSB + macro & micro elements	6.83	6.51	6.78	13.10	11.35	11.74
	SE (m) ±	0.073	0.260	0.167	0.324	0.19	0.419
	CD (0.05)	0.21	0.87	0.56	1.08	0.54	1.40

Table 4. Impact of INM practices on flowering character on flower diameter and bloom life (pooled mean data of the years 2015-16 and 2016-17) of hybrid gerbera cv. Shimmer

Treatments number	Characters / Treatments	Flower diameter (cm)			Bloom life (days)		
		Winter	Summer	Rainy	Winter	Summer	Rainy
T_1	RDF in alternate month	9.89	9.17	9.45	11.48	7.75	9.90
T_2	RDF in every month	9.15	8.09	8.33	9.86	6.15	8.52
T_3	75% RDF + Vermicompost	9.49	8.66	8.79	12.15	7.84	10.71
T_4	75% RDF + VC + *Azospirillum*+ PSB	10.30	9.53	9.89	14.09	8.69	12.84
T_5	75% RDF + VC +*Azotobacter* + PSB	10.31	9.53	9.91	14.17	8.67	12.75
T_6	75% RDF + VC + macro & micro elements	9.95	9.21	9.49	13.21	8.21	11.23
T_7	75% RDF + VC + *Azospirillum*+ PSB + macro & microelements	10.75	9.94	10.55	16.17	9.69	14.25
T_8	75% RDF + VC + *Azotobacter* + PSB + macro & micro elements	10.75	9.94	10.57	16.07	9.73	14.27
	SE (m) ±	0.091	0.098	0.222	0.445	0.100	0.770
	CD (0.05)	0.26	0.28	0.74	1.49	0.28	2.57

Table 5. Monthly mean weather data from November 2015 to October 2016

Sl. No.	Month	Temperature ^{o} C		Rainfall	Relative Humidity %		
		Max	Min	Daily (mm)	7 hr	14 hr	Rainy days
1	November 15	31.3	20.1	3.0	91	55	2
2	December 15	29.3	17.6	14.8	87	53	3
3	January 16	29.9	15.7	0.6	92	39	1
4	February 16	34.5	21.3	3.0	89	41	1
5	March 16	37.1	23.4	1.5	86	40	2
6	April 16	40.8	26.8	7.6	86	37	1
7	May 16	38.8	26.4	114.9	81	47	9
8	June16	34.8	26.4	264.8	89	68	19
9	July 16	32.2	25.8	222.2	92	79	15
10	August 16	31.8	25.5	247.8	94	79	22
11	September16	31.4	25.4	238.2	93	80	23
12	October 16	32.2	22.6	132.8	89	68	11

Table 6. Monthly mean weather data from November 2016 to October 2017

Sl. No.	Month	Temperature deg C		Rainfall	Relative Humidity %		
		Max	Min	Daily (mm)	7 hr	14 hr	Rainy days
1	November 16	31.0	17.4	20.3	92	46	2
2	December 16	30.1	15.2	0.0	87	39	0
3	January 17	29.7	15.0	0.0	90	39	0
4	February 17	33.8	19.3	0.0	94	38	0
5	March 17	34.7	22.8	45.4	91	42	5
6	April 17	36.9	26.1	29.2	88	49	1
7	May 17	38.8	27.2	43.1	82	46	3
8	June17	35.2	26.5	122.0	87	59	15
9	July 17	31.9	25.9	445.9	92	78	24
10	August 17	32.9	25.8	377.0	91	76	24
11	Septeber17	33.6	25.7	245.2	92	70	14
12	October 17	32.2	24.3	204.5	93	69	9

T_1 :- RDF in alternate month (flower diameter = 9.1 cm)

T_2 :- RDF in alternate month (flower diameter = 8.5 cm)

Plate 1. Impact of INM practices on flower diameter of hybrid gerbera cv. Shimmer

T_3 :- RDF in alternate month (flower diameter = 9.4 cm)

T_4 :- RDF in alternate month (flower diameter = 10.0)

Plate 2:- Impact of INM practices on flower diameter in hybrid gerbera cv. Shimmer

T_5 :- RDF in alternate month (flower diameter = 10.1cm)

T_6 :- RDF in alternate month (flower diameter = 9.8 cm)

Plate 3:- Impact of INM practices on flower diameter in hybrid gerbera cv. Shimmer

T_7 :- RDF in alternate month (flower diameter = 10.3cm)

T_8 :- RDF in alternate month (flower diameter = 10.4 cm)

Plate 4:- Impact of INM practices on flower diameter in hybrid gerbera cv. Shimmer

3.6 Flower Diameter

The pooled data from both the years (Table 3) revealed that in winter season maximum flower diameter (10.75 cm) was recorded in T_8 (75 % RDF + VC + PSB + *Azotobacter* + sprayable macro and microelements) and T_7 (75 % RDF + VC + PSB + *Azospirillum*+ sprayable macro and microelements) followed by T_5 (75 % RDF + VC +PSB + *Azotobacter*) and T_4 (75 % RDF + VC + PSB + Azospirillum) while lowest flower diameter (9.15 cm) was observed in T_2 (RDF in every month). Similar trends in increase in flower diameter was observed in summer and rainy season.

Increase in diameter of flower in T_8 and T_7 might be due to application of nutrients from both organic and inorganic source. Vermicompost is rich in nutrients, hormones which promote growth and accumulate photosynthates in flowers resulting larger flower diameter. Bio fertilizer like PSB solublize nutrients in soil and supply to the plant resulting larger flower. Similar finding have been obtained by Seetha and Gowda [7] with respect to application of vermicompost + 75 % NPK in gerbera. Smallest flower diameter observed in T_2 might be due to sick and poor growth of plant because of fertilizer residue in soil.

3.7 Bloom Life

The pooled data from both the years (Table 3) revealed that in winter season maximum bloom life (16.17 days) was observed in T_7 (75% RDF + VC + PSB + *Azospirillum* + sprayable macro and microelements) which was at par with T_8 (75% RDF + VC + PSB + *Azotobacter* + sprayable macro and microelements) and followed by T_4 (75% RDF + VC + PSB + *Azospirillum*) and T_5 (75% RDF + VC + PSB + *Azotobacter*) while minimum bloom life (9.86 days) was found in T_2 (RDF in alternate month). Similar trends in increase in bloom life was observed in summer and rainy season.

Increase in bloom life in T_7 and T_8 might be due to application of nutrients from organic sources. Organic source of nutrients like vermicompost and biofertilizers contain several hormones and enzymes which delay the process of senescence prolonging bloom life of flower. Similar finding have been reported by Patil and Chaitra [12] by application of *Azospirillum* + PSB + VC + NPK in china aster and chrysanthemum. Singh *et al*. [13] observed enhanced bloom life by application of $ZnSO_4$, $FeSO_4$ in lilium. Lowest bloom life in T_2 might be due to deficiency of nutrients and hormone in plant because of sick and poor growth of plant by application of fertilizer in every month.

4. CONCLUSION

This experiment reveals that application of 75% RDF (15:10:30 g NPK/10 plants) + Vermicompost + (25 g/10 plants) + PSB (20 g/10 plants) + *Azospirillum*/ *Azotobacter* (20 g/10 plants) + macro and micro element spray recorded early flower bud initiation and flowering and increased all flowering parameters of gerbera with maximum number of flowers/plant. The result will be helpful in future for the farming community of our state as well as country for increasing flower production of gerbera under open field condition.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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