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The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(11): 1995-1100

www.thepharmajournal.com
Received: 10-09-2021
Accepted: 28-10-2021

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Impact of INM practices on post-harvest life of cut flowers of hybrid gerbera (*Gerbera jamesonii* B.) cv. Shimmer

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Abstract
The present investigation on Impact of INM practices on post harvest life of cut flowers of hybrid gerbera (*Gerbera jamesonii* B.) cv. Shimmer in open field condition was conducted at Biotechnology cum Tissue Culture Centre, Odisha University of Agriculture and Technology, 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 and post harvest life of gerbera. There were eight treatment combinations consisting of 100% recommended dose of fertilizer (RDF), 75% RDF, Vermicompost, PSB, *Azospirillum*, *Azotobacter* and foliar spray of macro and micro elements. Treatment combination of 75% RDF + vermicompost + PSB + *Azotobacter/Azospirillum* + macro and micronutrient spray recorded maximum percent gain in weight of flower stalk, maximum percent gain in stalk length in vase, maximum percent gain in flower diameter, highest solution uptake in vase and longest vase life.

Keywords: RDF, vermicompost, PSB, *Azospirillum*, *Azotobacter*

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 (Chauhan, 2005) [3]. It also find a place in fresh and dry flower arrangement, exhibition, decoration, bouquet preparation (Patra *et al.*, 2015) [16]. 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 (Danaee *et al*., 2011) [6].
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 (Majumdar *et al*. 2014) [10]. 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 (Angadi, 2010) [1].
Organic manure regenerates natural resources lost from soil with each harvest (Bhalla *et al*. 2007) [2]. 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) [7]. 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 (Seetha and Gowda, 2002) [17]. 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 (Dalve *et al.* 2009) [5]. 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.(Shashavari *et al*., 2010) [18].

However very little information is available on INM practices in Gerbera for higher productivity and extending post harvest longevity of cut flowers. Farmer's are still using heavy dose of inorganic fertilizer to get higher productivity. The present investigation was carried out to standardize suitable combination of organic and inorganic source of nutrients during cut production and their effect in extending post harvest longevity of cut flowers of gerbera..

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. in 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 ºC to 40.8 ºC and minimum temperature was 14.1ºC to 15.2 ºC. 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.

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.

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 and 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 and micro elements (2 ml/l)

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 percent gain in weight of flower stalk, percent gain in stalk length in vase, percent gain in flower diameter, solution uptake in vase and vase life in winter, summer and rainy season 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 (1984) using one way ANOVA in CRD. A comparison of treatment means were done at 5% level of significance (P=0.05).

Results and Discussion

The results of the experiment obtained in the year 2015-16 and 2016-17 were pooled and presented in following tables and discussed under the following headings.

Percentage gain in flower weight in vase

The data from both the year revealed that in winter season maximum percentage gain in flower weight in vase (4.36% and 4.11%) was observed in T_7 and T_8 receiving 75% RDF + vermicompost + PSB + *Azotobacter/Azospirillum* + sprayable macro and micro elements while minimum percent gain in flower weight in vase was observed in T_2 receiving RDF in every month. Increase in percentage gain in weight of cut flowers may be due to accumulation of hormones, enzymes and nutrient in flower from organic sources like vermicompost and biofertilizer which improve qualitative parameters of cut flower. Similar findings of increase in fresh weight of flower was observed by Palagani *et al.* (2013) [13] in Chrysantherum with respect to application of 75% NPK + vermicompost + *Azotobacter* + PSB. Dalawai and Naik (2014) [4] found increase in fresh weight of carnation by application of *Azospirillum* + PSB + PSB + FYM + Vermicompost with 75% RDF. Palagani and Singh (2017) [14] reported increase in fresh weight of flower of gerbera by application of biofertifilizer and vermicompost. Lowest gain in fresh weight of flower in T_2 may be due to deterioration of qualitative parameters by application of 100% RDF in every month. Similar trends in increase in fresh weight of cut flowers in vase was also observed in summer and rainy season.

Percentage gain in stalk length

Pooled data from both the year revealed that in winter season maximum percent gain in stalk length (5.0% and 5.05%) of cut flower was observed in T_7 and T_8 receiving 75% RDF + vermicompost + PSB + *Azotobacter/ Azospirillum* + sprayable macro and micro elements while minimum percent gain in stalk length was recorded in T_2 (RDF in every month).

Increase in stalk length of cut flower might be due to accumulation of nutrients from organic source like vermicompost, biofertilizer and supplementation of hormones and enzyme from vermicompost. Similar trends in increase in percentage gain in stalk length of cut flowers in vase was also observed in summer and rainy season

Percentage gain in flower diameter

In winter season maximum percentage gain in flower diameter (4.36% and 4.11%) was observed in T_7 and T_8 receiving 75% RDF + vermicompost+ PSB + *Azospirillum/ Azotobacter* + sprayable macro and micro elements while minimum percentage gain in diameter of flower was recorded in T_2 (RDF in every month). Increase in diameter of flower in vase in T_7 and T_8 might be due to accumulation of dry matter in flower and more number of florets in flower because of balanced nutrition to plants along with vermicompost and biofertilizer.

Enzymes produced by bacteria like *Azospirillum/ Azotobacter* and hormones from vermicompost accumulated in cut flowers helped in increasing flower diameter due to opening of more disc florets. Minimum percentage gain in flower diameter in T_2 might be due to deterioration flower quality by application of 100% RDF in every month. Similar trends in increase in percentage gain in flower diameter in vase was also observed in summer and rainy season

Solution uptake in vase

Pooled data from both the years revealed that in winter season maximum solution uptake (42.5 ml) was observed in T_7 and T_8 receiving 75% RDF + vermicompost + PSB + *Azospirillum / Azotobacter* + sprayable macro and micro nutrients while minimum solution uptake was observed in T_2 (RDF in every month). Maximum water uptake in T_7 and T_8 might be due to absorption of water due to absorption of water by accumulated dry matter in flower. Besides, hormones from vermicompost and enzymes synthesized from biofertilizer which are accumulated in flower enhance qualitative parameters of cut flowers absorbing more water from vase solution.

Similar result of maximum water uptake by carnation flower was observed by Harshavardhan *et al.* (2016) [9] with respect to application of 75% RDF + *Azospirillum*+ vermicompost. Pandey *et al.* (2018) [15] found that use of 75% RDF, vermicompost, *Azotobacter* in Chrysanthemum increased water uptake by flower in vase.

Palagani and Singh (2017) [14] observed increased water uptake by gerbera cut flower in vase with respect to application of biofertilizer + vermicompost. Application of micronutrient in form of foliar spray trigger biochemical process, enzymatic activity in flower resulting more water uptake which is in conformity with Manjusha and Patil (2002) [11] in gerbera. Similar trend in increasing water uptake was observed in summer and rainy season.

Vase life

Pooled data from two years revealed that in winter season maximum vase life (12.67 days) was recorded in T_7 and T_8 receiving 75% RDF + vermicompost + PSB + *Azospirillum/ Azotobacter* + sprayable macro and microelements while minimum vase life was recorded in T_2 (RDF in every month). Increase in vase life in T_7 and T_8 might be due to accumulation of nutrients, hormones enzymes in flower from different organic sources like vermicompost and biofertilizer. As discussed earlier these treatment T_7 and T_8 recorded maximum percentage gain in flower weight and solution uptake in vase which helped in extending vase life in gerbera.

Similar results of increased vase life was observed by use of 75% RDF + vermicompost + *Azotobacter* + PSB in chrysanthemum as reported by Palagani *et al.* 2013 [13] and Pandey *et al.* (2018) [15]. Similar results of longest vase life was observed by use of *Azospirillum*, PSB, FYM and Vermicompost along with 75% RDF in carnation as reported by Dalawai and Naik (2014) [4] and Harshavardhan *et al.* (2016) [9]. Seetha and Gouda (2002) [17] observed longest vase life of gerbera cut flower by application of *Azospirillum* + VAM + NPK. Combined application of vermicompost and biofertilizer in soil maintain hormone and enzyme level in cut flowers increasing vase life of flower. Similarly application of nutrients in form of foliar spray helps in quick absorption by plants and maintain nutrients balance in flower prolonging vase life which was in conformity with findings of Muthumanickam *et al.* (1999) [12] with respect to application of $MnSO_4$, $ZnSO_4$ and $FeSO_4$ in gerbera.

The minimum vase life recorded in T_2 might be due to deterioration of flower quality by application 100% chemical fertilizer in every month. Similar trends in increase in vase life of gerbera was found in summer and rainy season.

Table 1: Impact of INM practices on flowering character i.e. Percentage gain in flower weight and Percentage gain in stalk length in vase (Pooled over years 2015-16 and 2016-17) in hybrid gerbera cv. Shimmer

Treatments number	Characters / Treatments	Percentage gain in weight			Percentage gain in length		
		Winter	Summer	Rainy	Winter	Summer	Rainy
T_1	RDF in alternate month	11.68 (20.00)	7.77 (16.22)	8.00 (16.43)	2.00 (8.13)	1.09 (6.02)	1.66 (7.27)
T_2	RDF in every month	8.06 (16.54)	4.33 (11.97)	4.41 (12.11)	0.95 (5.59)	0.57 (4.33)	0.76 (5.00)
T_3	75% RDF + Vermicompost	9.78 (18.24)	6.07 (14.30)	6.25 (14.54)	1.95 (7.92)	1.00 (5.74)	1.66 (7.27)
T_4	75% RDF + VC + *Azospirillum* + PSB	15.65 (23.34)	11.17 (19.55)	11.96 (20.18)	3.04 (9.98)	1.81 (7.71)	2.71 (9.46)
T_5	75% RDF + VC +*Azotobacter* + PSB	15.55 (23.19)	11.39 (19.73)	11.93 (20.18)	3.04 (9.98)	1.81 (7.71)	2.81 (9.63)
T_6	75% RDF + VC + macro and micro elements	11.77 (20.09)	7.57 (16.00)	8.07 (16.54)	2.24 (8.53)	1.23 (6.29)	1.90 (7.92)
T_7	75% RDF + VC + *Azospirillum* + PSB + macro and microelements	18.05 (25.18)	13.11 (21.22)	13.86 (21.89)	5.00 (12.92)	2.57 (9.28)	4.43 (12.11)
T_8	75% RDF + VC + *Azotobacter* + PSB + macro and micro elements	18.10 (25.18)	12.92 (21.05)	13.93 (21.89)	5.05 (13.05)	2.71 (9.46)	4.47 (12.25)

	SE (m) ±	0.262	0.190	0.415	0.113	0.076	0.095
	CD (0.05)	0.75	0.54	1.39	0.32	0.22	0.27

(Figures in parentheses indicate corresponding angular value)

Table 2: Impact of INM practices on flowering character i.e. Percentage gain in flower diameter in vase (Pooled over years 2015-16 and 2016-17) in hybrid gerbera cv. Shimmer

Treatments number	Characters / Treatments	Percentage gain in diameter		
		Winter	Summer	Rainy
T_1	RDF in alternate month	2.17 (8.53)	1.16 (6.29)	1.78 (7.71)
T_2	RDF in every month	1.38 (6.80)	1.09 (6.02)	1.13 (6.02)
T_3	75% RDF + Vermicompost	1.93 (7.92)	1.09 (6.02)	1.45 (7.04)
T_4	75% RDF + VC + *Azospirillum* + PSB	3.56 (10.94)	2.31 (8.72)	3.11 (10.14)
T_5	75% RDF + VC +*Azotobacter* + PSB	3.44 (10.63)	2.34 (8.72)	2.97 (9.81)
T_6	75% RDF + VC + macro and micro elements	2.47 (9.10)	1.46 (7.04)	2.10 (8.33)
T_7	75% RDF + VC + *Azospirillum* + PSB + macro and microelements	4.36 (12.11)	3.15 (10.31)	3.61 (10.94)
T_8	75% RDF + VC + *Azotobacter* + PSB + macro and micro elements	4.11 (11.68)	3.14 (10.14)	3.63 (10.94)
	SE (m) ±	0.123	0.119	0.109
	CD (0.05)	0.35	0.40	0.31

(Figures in parentheses indicate corresponding angular value)

Table 3: Impact of INM practices on flowering character i.e. solution uptake in vase and vase life (Pooled over years 2015-16 and 2016-17) in hybrid gerbera cv. Shimmer

Treatments number	Characters / Treatments	Solution uptake in vase(ml)			Vase life(days)		
		Winter	Summer	Rainy	Winter	Summer	Rainy
T_1	RDF in alternate month	30.17	20.50	23.33	10.00	7.17	8.67
T_2	RDF in every month	18.50	12.00	14.50	7.00	5.00	6.33
T_3	75% RDF + Vermicompost	29.17	19.67	23.17	9.83	7.00	8.17
T_4	75% RDF + VC + *Azospirillum* + PSB	34.17	24.00	25.33	11.00	7.67	10.00
T_5	75% RDF + VC +*Azotobacter* + PSB	34.83	24.17	25.67	11.17	7.83	10.00
T_6	75% RDF + VC + macro and micro elements	30.83	21.17	24.33	10.33	7.67	9.33
T_7	75% RDF + VC + *Azospirillum* + PSB + macro and microelements	42.50	30.17	34.33	12.67	9.17	11.33
T_8	75% RDF + VC + *Azotobacter* + PSB + macro and micro elements	42.50	30.83	34.33	12.67	9.17	11.33
	SE (m) ±	0.703	2.039	0.540	0.238	0.280	0.292
	CD (0.05)	2.01	6.82	1.54	0.68	0.80	0.83

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

Sl. No.	Month	Temperature ºC		Rainfall	Relative Humidity %		Rainy days
		Max	Min	Daily (mm)	7 hr	14 hr	
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 %		Rainy days
		Max	Min	Daily (mm)	7 hr	14 hr	
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

Plate 1: Impact of INM practices on vase life of hybrid gerbera cv. Shimmer (1st year)

Plate 2: Impact of INM practices on vase life of hybrid gerbera cv. Shimmer (2nd year)

Conclusion

From the above investigation it can be concluded that application of 75% RDF + vermicompost + PSB + *Azotobacter/ Azospirillum* + macro and micro elements spray increased percentage gain in flower weight, percentage gain in stalk length, percentage gain in flower diameter, solution uptake in vase and vase life. This result of this experiment will be useful for researcher and so also gerbera growers in post harvest management of the flower.

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