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Response of Biostimulants and Biofertilizers on Yield and Quality of *Chrysanthemum* cv. Ratlam Selection

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A B S T R A C T

The present experiment entitled “Response of biostimulants and biofertilizers on growth yield and quality of chrysanthemum cv. Ratlam Selection” was carried out at Jamuvadi Farm, Department of Horticulture, College of Agriculture, Junagadh Agricultural University, Junagadh, during October 2017 to February 2019. The experiment was laid out in Randomized Block Design with Factorial concept (FRBD) consisting two factors with three replications. The treatment comprised with five biostimulants and three treatments of biofertilizers. The results indicated that the foliar application of humic acid @ 0.2 % at 60, 90 & 120 DAT with soil drenching of *Azotobacter* @ 3 l/ha + PSB @ 3 l/ha + KSB @ 3 l/ha after transplanting in addition to recommended dose of fertilizers (120:60:60 kg/ha NPK) produced better yield characters viz., number of flowers per plant, plot, flower yield per plant, per plot, per hectare as well as quality characters viz., vase life of cut flowers, shelf life of loose flowers, *in situ* longevity of flowers, flower diameter, number of ray florets per flower in chrysanthemum cv. Ratlam Selection.

Introduction

Chrysanthemum (*Chrysanthemum morifolium* Ramat.), which occupies a prominent place in ornamental horticulture, is one of the commercially exploited flower crops belongs to the family 'Asteraceae' and referred as “Queen of the East” having diploid chromosome number 2n = 18. The word “Chrysanthemum” comes from two Greek words, *Chrysos* – golden and *anthos* - flower which means golden flower. Chrysanthemum is native to the northern hemisphere and is widely distributed in Europe and Asia. However, it is believed that, its origin is China (Carter, 1990).

At present, for the increasing flower production, nutrients are supplied through chemical fertilizers. Heavy use of chemicals in agriculture has weakened the ecological base in addition to degradation of soil, water resources and quality. At this juncture, a keen awareness has sprung on the adoption of “organic farming” as a remedy to cure the ills of modern chemical agriculture (Kannaiyan, 2000). Biostimulants are defined as materials, other than fertilizers, that promote plant growth when applied in small quantities and are also referred to as metabolic enhancers (Zhang and Schmidt, 1997).

While separating fibers from the banana pseudostem, the liquid available is known as sap which contains contained macro elements like, 119 ppm N, 50.4 ppm P, 1289 ppm K and micronutrients like Fe-124 ppm, Mn-6.73 ppm, Cu-4.61 ppm and Zn-0.97 ppm (Gundrashiya, 2013) and also growth promoting substance like, cytokinin- 137.8 mg/l and gibberellic acid- 110.2 mg/l present (Desai, 2018). Seaweed components such as macro and micro element, amino acids, vitamins, cytokinins, auxins, and abscisic acid (ABA)-like growth substances affect cellular metabolism in treated plants leading to enhanced growth and crop yield (Durand *et al.,* 2003; Stirk *et al.,* 2003).

The liquid contained macronutrients like P-120 mg/100 g, K- 4170 mg/100 g, Ca- 66.98 mg/100 g and micronutrients like Fe- 147 mg/100 g, Mn- 5.84 mg/100 g, Zn- 9.08 mg/100 g and Cu- 0.36 mg/100 g (Yan *et al.,* 2013).

Panchagavya is a fermented product made from five ingredients obtained from cow, such as milk, urine, dung, curd and clarified butter (Amalraj *et al.,* 2013). Panchgavya contained macro elements like total nitrogen (229 ppm), total phosphorus (209 ppm), total potassium (232 ppm), calcium (25 ppm), IAA (8.5 ppm) and GA (3.5 ppm) (Anon., 2017). Humic acids promote antioxidant production in plants which, in turn, reduces “free radicals”. Free radical molecules result from stress such as drought, heat, ultraviolet light and herbicide use. It suppresses diseases, heat stress and frost damage by promoting antioxidant activity (El-Bassiouny *et al.,* 2014; Syedabadi and Armin 2014).

Biofertilizer usually consists of live or latent cells of micro-organisms which include biological nitrogen fixers, P-solubilizing, mineralization of nitrogen and transformation of several elements into available forms.

Azotobacter has beneficial effects on crop growth and yield through, biosynthesis of biologically active substances, stimulation of rhizospheric microbes, producing phyopathogenic inhibitors (Chen, 2006; *Lenart, 2012*).

Phosphates solubilizing activity is determined by the action of several phosphorus solubilizing microorganisms (PSMs) like phosphorus solubilizing bacteria (PSB) and phosphorus solubilizing fungi (PSF) which convert these insoluble phosphates into soluble forms through the process of acidification, chelation, exchange reactions and production of gluconic acid (Rodriguez *et al.,* 2006; Chung *et al.,* 2005). Potash is present in several forms in the soil, including mineral K, non-exchangeable K, exchangeable K, and solution K.

The KSB are effective in releasing K from inorganic and insoluble pools of total soil K through solubilization (Archana *et al.,* 2013; Gundala *et al.,* 2013; Meena *et al.,* 2014). To maintain long term soil health and productivity there is a need for integrated nutrient management through manures and biofertilizers apart from costly chemical fertilizers for better yield of the crop (Mondel *et al.,* 2003). Considering the above facts, the present study was planned and undertaken with the objective to assess the response of biostimulants and biofertilizers on yield and quality of chrysanthemum cv. Ratlam Selection.

Materials and Methods

The field experiment was carried out twice during October 2017 to February 2019 at the Jamuvadi Farm, Department of Horticulture, Junagadh Agricultural University, Junagadh (Gujarat). The experiment was laid out in Randomized Block Design with Factorial concept (FRBD) consisting two factors with three replications.

The treatment comprised of five treatments of biostimulants *viz*., Without spray of biostimulants (B_0), Banana pseudostem Sap @ 1 % (B_1), Seaweed extract @ 0.5 % (B_2), Panchgavya @ 4 % (B_3), Humic acid @ 0.2 % (B_4) and three treatments of biofertilizers *i.e.* Without biofertilizers (F_0), *Azotobacter* @ 2 l/ha + PSB @ 2 l/ha + KSB @ 2 l/ha (F_1) and *Azotobacter* @ 3 l/ha + PSB @ 3 l/ha + KSB @ 3 l/ha (F_2). Five plants from each treatment plot were randomly selected, labeled and used for recording observations.

For the yield characters, viz., number of flowers per plant, plot, flower yield per plant, per plot, per hectare as well as quality characters viz., vase life of cut flowers, shelf life of loose flowers, *in situ* longevity of flowers, flower diameter, number of ray florets per flower in chrysanthemum cv. Ratlam Selection.

Time of application of Biostimulants (Both seasons)	Time of application of Biofertilizers (Both seasons)
1st 60 days after transplanting	At the time of transplanting
2nd 90 days after transplanting	
3rd 120 days after transplanting	

Results and Discussion

Effect of biostimulants

Significantly maximum number of flowers per plant (69.78), per plot (805.95), flower yield per plant (169.70 g), per plot (1.91 kg), per hectare (7.86 t), vase life of cut flowers (6.09 days) were recorded with foliar application banana pseudostem sap 1 % (B1) during the year 2017-18. Increase in number of flowers per plant may be due to increase in cell division and cell elongation with GA_3 and lower concentration of BA and NAA, (Kumar *et al.*, 2011). Chlorophyll content of leaves plays a vital role in photosynthesis process for making the food. Greater amount of carbohydrate accumulation and increase metabolic activities is due to gibberellic acid which is provided by banana pseudostem sap. Flower yield results might be due to the superiority of vegetative growth might have led to the higher productivity and good quality of flowers in chrysanthemum cv Ratlam Selection also due to effect of gibberellic acid and cytokinin singly or combine effect of both. The results of present study are in close conformity with findings of Jadhav *et al.*, (2014) and Patel *et al.*, (2018) in marigold; Desai (2018) in tuberose and Gundrashiya (2013) in okra, cluster bean and cow pea.

Significantly maximum number of flowers per plant (83.29 & 74.87), per plot (933.07 & 841.53), flower yield per plant (201.45 & 181.06 g), per plot (2.27 & 2.04 kg), per hectare (9.35 & 8.39 t), shelf life of loose flowers (4.11 & 4.00 days) were recorded with foliar application humic acid 0.2 % (B4) during the year 2018-19 and in pooled, respectively. Also vase life of cut flowers (6.19 days) in pooled and *in situ* longevity of flowers (12.67, 12.51 & 12.59 days) during both the years and in pooled, respectively were recorded with foliar application humic acid 0.2 % (B_4).

The number of flowers per plant is the genetically control attributes but the improvement in this trait is also common observation due to better nutrient management.

The partitioning of photosynthate is an important component of economic yield and it operates in conjunction with other physiological processes and is influenced by the environment. Humic acid play a beneficial role in Fe acquisition which increases the availability of micro nutrients from sparingly soluble hydroxides (Chen and Aviad 1990a).

The effect of humic acid appear to be mainly exerted an cell membrane, function promoting nutrient uptake or plant growth and development by acting as hormone like substance which collectively affected assimilate production and its maximum real function to the developing economic sink. Harvest index is the promoting of biological yield represented by the economic yield, which is the weight of plant part that constitutes the product of economics agricultural value.

Application of humic acid caused a significant influence of partitioning efficiency of crop plant. Furthermore, these findings are well supported by Fan *et al.,* (2014) in chrysanthemum; Bhagawat (2018) in marigold; Khenizy *et al.,* (2013) in gerbera; Aghera (2018) in tuberose; Pansuriya (2018) in gladiolus; Yasser *et al.,* (2011) in roselle plants.

Foliar spray of humic acid improved the *in situ* longevity in chrysanthemum. This might be attributed due to the entry of humic acid into the plant, which might have mediated the respiration by acting as a hydrogen acceptor, and thus, altering the carbohydrate metabolism of plants promoting the accumulation of sugar. Humic acid contain cytokinins and auxin that might have increased the antioxidant levels and resistance to senescence.

The increased storage life might be due to by triggering of such metabolic activity and narrowing of the C:N ratio by the significant accumulation of carbohydrates. The present findings are in agreement with Fan *et al.,* (2014) in chrysanthemum; Bhagawat (2018) in marigold; Aghera (2018) in tuberose; Khenizy *et al.,* (2013) in gerbera.

Effect of biofertilizers

Significantly maximum number of flowers per plant (70.09, 85.32 & 77.71), per plot (774.67, 962.15 & 868.41), flower yield per plant (167.92, 204.24 & 186.08 g), per plot (1.93, 2.33 & 2.13 kg), per hectare (7.95, 9.58 & 8.76 t/ha), shelf life of loose flowers (3.94, 4.13 & 4.04 days) & *in situ* longevity of flowers (12.47, 12.39 & 12.43 days) were registered with an application of *Azotobacter* @ 3 l/ha + PSB @ 3 l/ha + KSB @ 3 l/ha (F_2) during both the years and in pooled, respectively.

Also vase life of cut flowers (6.55 & 6.33 days) during the year 2018-19 & in pooled, respectively and number of ray florets per flower (204.44 & 203.58) during the year 2017-18 and in pooled, respectively were recorded with treatment F_2. The result might be due to positive effect of biofertilizer on soil which resulted to better yield. Bio inoculants improve the nutrient availability of the plant by addition of atmospheric nitrogen to the soil and promote vegetative growth and yield of the plant. The conversion of photosynthates into proteins results in more flower primordia and development of flower bud attributing to higher flower yield.

The increase in number of flowers might be due to possible role of *Azotobacter* through atmospheric nitrogen fixation, better root proliferation, uptake of nutrients and water and also attribute of PSB to the increase availability of phosphorus and KSB to the increase availability of potash. In addition, KSB are also known to produce amino acids, vitamins and growth promoting substance like indol-3-acetic acid (IAA) and gibberellic acid (GA_3) which helps in better growth of the plants which ultimately increase in the yield. Similar improvement in yield attributes was reported by Palagani *et al.,* (2013) in chrysanthemum; Bhaskaran *et al.,* (2007) and Thumar *et al.,* (2013) in marigold; Aghera (2007) and Hadwani *et al.,* (2013) in tuberose; Dongardive *et al.,* (2007), Srivastava and Govil (2007) and Kaushik *et al.,* (2016) in gladiolus; Singh *et al.,* (2008) in calendula and Bhavanisankar & Vanangamudi (2000) in crossandra;

Biofertilizers increased storage life of chrysanthemum. Longer shelf life may be due to higher retention of water in the cells of flowers and flower desiccation as caused due to the beneficial effect of biofertilizer. Biofertilizers contain cytokinins and auxin that might have increased the antioxidant levels and resistance to senescence. The increased vase life and shelf life might be due to by triggering of such metabolic activity and narrowing of the C:N ratio by the significant accumulation of carbohydrates. Furthermore, these findings are well supported by Meshram *et al.,* (2008), Palagani *et al.,* (2013) and Pandey *et al.,* (2018) in chrysanthemum; Patel *et al.,* (2018) and Rolaniya *et al.,* (2017) in marigold; Bhor (2010) in rose; Hadwani *et al.,* (2013) and Aghera (2018) in tuberose; Pansuriya (2018) in gladiolus; Khan *et al.,* (2009) in tulip; Bhalla *et al.,* (2007) in carnation.

Interaction effect

Significantly maximum number of flowers per plant (82.73 & 88.17), per plot (978.81 & 955.77), flower yield per plant (198.93 & 211.95 g), per plot (2.35 & 2.38 kg) and per hectare (9.69 & 9.78 t/ha) was registered in combined application of humic acid @ 0.2 % with *Azotobacter* @ 3 l/ha + PSB @ 3 l/ha + KSB @ 3 l/ha (B_4F_2) during the year 2017-18 in pooled, respectively. It is true that humic acid increased the efficiency of biofertilizers resulted to more availability of various nutrients resulted to higher yield. This could be associated with higher uptake of N, P and K nutrient from soil due to chelating action of humic acid, which resulted in development of more number of flowers. The application of humic with biofertilizers reduces the requirement of other fertilizers. It also increases crop yield, soil aeration, and drainage. Humic acid increased availability of biofertilizers and increase in number of flowers per plant may be due to ability of *Azotobacter* to increase the available nitrogen in soil through atmospheric nitrogen fixation, better root proliferation, uptake in nutrients and water, higher photosynthetic activity and enhanced food accumulation which might have resulted in better plant growth and subsequently higher yield.

While, PSB improved these parameters which might be due to enhanced availability of phosphorus due to presence of PSB in rhizosphere which stimulates the root system through efficient translocation to roots of certain growth stimulating compounds formed in the plants, which further enhances the absorption of nutrients thus, resulting in a vigorous growth and yield of chrysanthemum. In addition, KSB are also known to produce amino acids, vitamins and growth promoting substance like indol-3-acetic acid (IAA) and gibberellic acid (GA_3) which help in better growth of the plants. The results of present study are in close conformity with findings of Bhagawat (2018), in marigold Aghera (2018) in tuberose and Bhalla *et al.,* (2007) and Pansuriya (2018) in gladiolus.

Table.1 Effect of biostimulants and biofertilizers on yield parameters in chrysanthemum cv. Ratlam Selection

Treatments	Number of flowers per plant			Number of flowers per plot			Flower yield per plant (g)			Flower yield per plot (kg)			Flower yield per hectare (tonne)		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Level of Biostimulants (B)															
B_0	52.96	68.36	60.66	632.10	748.64	690.37	114.28	148.14	131.21	1.28	1.72	1.50	5.27	7.09	6.18
B_1	69.78	78.56	74.17	805.95	812.16	809.05	169.70	190.98	180.34	1.91	2.10	2.01	7.86	8.65	8.26
B_2	64.29	72.11	68.20	744.67	800.94	772.81	154.46	173.21	163.84	1.80	1.90	1.85	7.43	7.82	7.62
B_3	62.96	80.73	71.84	699.36	888.69	794.02	150.73	193.59	172.16	1.71	2.17	1.94	7.03	8.92	7.98
B_4	66.44	83.29	74.87	750.00	933.07	841.53	160.68	201.45	181.06	1.81	2.27	2.04	7.43	9.35	8.39
S.Em.±	1.760	2.148	1.388	36.841	44.358	28.831	4.712	4.864	3.386	0.039	0.078	0.044	0.161	0.323	0.180
C.D. at 5 %	5.10	6.22	3.93	106.72	128.50	81.68	13.65	14.09	9.59	0.11	0.23	0.12	0.47	0.93	0.51
Level of Biofertilizers (F)															
F_0	58.12	65.36	61.74	649.92	719.85	684.88	136.10	152.95	144.53	1.52	1.71	1.62	6.27	7.03	6.65
F_1	61.64	79.15	70.39	754.65	828.09	791.37	145.89	187.23	166.56	1.65	2.06	1.86	6.79	8.50	7.64
F_2	70.09	85.32	77.71	774.67	962.15	868.41	167.92	204.24	186.08	1.93	2.33	2.13	7.95	9.58	8.76
S.Em.±	1.363	1.664	1.075	28.537	34.360	22.332	3.650	3.767	2.623	0.030	0.061	0.034	0.125	0.250	0.140
C.D. at 5 %	3.95	4.82	3.05	82.67	99.54	63.27	10.57	10.91	7.43	0.09	0.18	0.10	0.36	0.72	0.40
Interaction (B X F)															
S.Em.±	3.048	3.720	2.405	63.810	76.831	49.937	8.162	8.424	5.865	0.068	0.136	0.076	0.279	0.559	0.312
C.D. at 5 %	8.83	NS	6.81	184.85	NS	141.47	23.64	NS	16.61	0.20	NS	0.21	0.81	NS	0.88
CV %	8.34	8.41	8.42	15.21	15.90	15.65	9.43	8.04	8.67	6.89	11.56	9.95	6.89	11.56	9.95

Table.2 Interaction effect of biostimulants and biofertilizers on yield parameters in chrysanthemum cv. Ratlam Selection

Treatment combinations	Number of flowers per plant			Number of flowers per plot			Flower yield per plant (g)			Flower yield per plot (kg)			Flower yield per hectare (tonne)		
B_0F_0	58.33	62.20	60.27	532.74	645.59	589.17	119.50	126.12	122.81	1.19	1.47	1.33	4.92	6.05	5.48
B_0F_1	50.40	69.27	59.83	761.94	617.58	689.76	105.12	144.79	124.95	1.23	1.61	1.42	5.08	6.64	5.86
B_0F_2	50.13	73.60	61.87	601.60	982.74	792.17	118.23	173.52	145.87	1.41	2.08	1.75	5.81	8.57	7.19
B_1F_0	68.33	65.33	66.83	575.88	674.48	625.18	167.67	160.28	163.97	1.65	1.89	1.77	6.77	7.78	7.27
B_1F_1	67.60	82.73	75.17	899.10	881.60	890.35	163.70	200.58	182.14	1.95	2.17	2.06	8.04	8.94	8.49
B_1F_2	73.40	87.60	80.50	942.87	880.39	911.63	177.73	212.09	194.91	2.13	2.25	2.19	8.78	9.24	9.01
B_2F_0	52.13	62.33	57.23	886.65	748.00	817.33	124.59	148.83	136.71	1.79	1.65	1.72	7.36	6.80	7.08
B_2F_1	70.33	74.47	72.40	844.00	675.72	759.86	169.21	179.22	174.22	1.80	1.75	1.77	7.40	7.20	7.30
B_2F_2	70.40	79.53	74.97	707.35	979.11	843.23	169.59	191.58	180.59	1.83	2.30	2.06	7.53	9.46	8.49
B_3F_0	55.87	66.47	61.17	670.40	647.48	658.94	132.67	158.15	145.41	1.53	1.50	1.51	6.28	6.16	6.22
B_3F_1	59.20	83.47	71.33	580.94	982.79	781.86	144.39	203.60	174.00	1.67	2.40	2.03	6.86	9.86	8.36
B_3F_2	73.80	92.27	83.03	846.74	1035.79	941.26	175.12	219.03	197.08	1.93	2.61	2.27	7.96	10.74	9.35
B_4F_0	55.93	70.47	63.20	583.91	883.69	733.80	136.06	171.39	153.72	1.47	2.03	1.75	6.03	8.35	7.19
B_4F_1	60.67	85.80	73.23	687.27	982.78	835.03	147.05	207.98	177.52	1.60	2.39	1.99	6.58	9.83	8.21
B_4F_2	82.73	93.60	88.17	978.81	932.74	955.77	198.93	224.98	211.95	2.35	2.40	2.38	9.69	9.87	9.78
S.Em. ±	3.048	3.720	2.405	63.810	76.831	49.937	8.162	8.424	5.865	0.068	0.136	0.076	0.279	0.559	0.312
C.D. at 5%	8.83	NS	6.81	184.85	NS	141.47	23.64	NS	16.61	0.20	NS	0.21	0.81	NS	0.88
CV%	8.34	8.41	8.42	15.21	15.90	15.65	9.43	8.04	8.67	6.89	11.56	9.95	6.89	11.56	9.95

Table.3 Effect of biostimulants and biofertilizers on quality parameters in chrysanthemum cv. Ratlam Selection

Treatments	Vase life of cut flowers (days)			Shelf life of loose flowers (days)			*In situ* longevity of flowers (days)			Flower diameter (cm)			Number of ray florets per flower		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Level of Biostimulants (B)															
B_0	5.46	6.02	5.74	3.49	3.56	3.53	10.47	10.53	10.50	5.62	5.48	5.55	182.71	194.07	188.39
B_1	6.09	6.17	6.13	3.90	3.79	3.85	11.00	11.00	11.00	5.67	5.74	5.71	204.04	197.56	200.80
B_2	5.84	6.04	5.94	3.77	3.64	3.71	11.60	11.78	11.69	5.57	5.58	5.57	201.16	192.18	196.67
B_3	6.01	6.16	6.08	3.92	3.88	3.90	11.93	11.96	11.94	5.56	5.77	5.66	199.33	200.29	199.81
B_4	6.03	6.34	6.19	3.89	4.11	4.00	12.67	12.51	12.59	5.51	5.86	5.68	199.18	201.33	200.26
S.Em.±	0.147	0.146	0.104	0.099	0.126	0.080	0.383	0.446	0.294	0.154	0.166	0.113	4.980	4.619	3.396
C.D. at 5 %	0.43	NS	0.29	0.29	0.37	0.23	1.11	1.29	0.83	NS	NS	NS	14.43	NS	NS
Level of Biofertilizers (F)															
F_0	5.75	5.71	5.73	3.66	3.39	3.52	10.59	10.68	10.63	5.34	5.59	5.47	188.17	192.67	190.42
F_1	5.80	6.18	5.99	3.80	3.87	3.83	11.55	11.60	11.57	5.65	5.78	5.72	199.24	195.87	197.55
F_2	6.10	6.55	6.33	3.94	4.13	4.04	12.47	12.39	12.43	5.76	5.69	5.72	204.44	202.72	203.58
S.Em.±	0.114	0.113	0.080	0.077	0.098	0.062	0.296	0.345	0.227	0.119	0.129	0.088	3.857	3.578	2.631
C.D. at 5 %	NS	0.33	0.23	0.22	0.28	0.18	0.86	1.00	0.64	NS	NS	NS	11.17	NS	7.45
Interaction (B X F)															
S.Em.±	0.255	0.253	0.180	0.171	0.219	0.139	0.663	0.772	0.509	0.266	0.288	0.196	8.625	8.001	5.882
C.D. at 5 %	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV %	7.52	7.14	7.32	7.81	9.99	8.96	9.95	11.57	10.79	8.25	8.78	8.53	7.57	7.03	7.31

From the foregoing discussion it can be concluded that the foliar application of humic acid @ 0.2 % at 60, 90 & 120 DAT with soil drenching of *Azotobacter* @ 3 l/ha + PSB @ 3 l/ha + KSB @ 3 l/ha after transplanting in addition to recommended dose of fertilizers (120:60:60 kg/ha NPK) proved to be economically best treatment for obtaining higher yield and quality flower of chrysanthemum cv. Ratlam Selection.

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