Original Research Article

Effect of mycorhizal and vermicompost application on growth and quality flower production of annual chrysanthemum (*Chrysanthemum coronium* L.)

ABSTRACT

Annual Chrysanthemum (*Chrysanthemum coronarium* L.) is one of the most widely cultivated garden flowers and is highly suitable for loose flower, pot culture and bedding purposes. The objective of this research was to evaluate the effect of different mycorrhizal strains and vermicompost on growth and flowering of *Chrysanthemum coronarium.* The treatments comprise of 4 mycorrhiza treatments (No application, *Glomus mosseae*, *Acaulospora laevis*, *Gigaspora margarita*) and 4 vermicompost doses (0 g/ m^2, 500 g/ m^2, 750 g/ m^2, 1 kg/ m^2). After one year experiment, results revealed that chrysanthemum plants showed improved growth and flowering with the application of vermicompost and mycorrhiza. The highest plant height (107.00 cm), maximum number of side shoots per plant (18.22), maximum number of flowers per plant (107.88), flower diameter and flowering duration (57.00 days) was recorded with the application of *Glomus mosseae* + vermicompost @ 1 kg/m^2 while maximum flower weight (8.64 g), maximum flower yield (902.36 g) and shelf life (8.40 days) was recorded with *Gigaspora margarita* + vermicompost @ 1 kg/m^2). Thus, integration of mycorrhiza and vermi-compost serve as a way for sustainable chrysanthemum flower production.

Keywords: *Chrysanthemum*, flowering, mycorrhiza, vermicompost and growth

1. Introduction

Annual Chrysanthemum(*Chrysanthemum coronarium* L.) belongs to the family Asteraceae is one of the most widely cultivated garden flowers. The flower comes in yellow and white colour and is highly suitable for garland making, pot culture and bedding purposes. The utility of this flower can be used to enhance its value and profitability in garland making. Despite high demand of this flower, their production is quite low due to poor soil fertility, traditional system of crop management and poor nutrient management. All these constraints regarding cultivation of this flower make it less popular among the farmers.

The quality of flowers is greatly influenced by the quantity of nutrients and source of nutrients. Boodley (1975) considered quality to be a function of nutrient level. Excessive use of chemical fertilizers by chrysanthemum growers possesses problems of environmental pollution. However, only use of organic manures may not be able to maintain the quality of produce in commercial floriculture, where the main concern is focused on yield. Thus, Current development in sustainability involves a rational exploitation of soil microbial activities and the use of less expensive source of plant nutrients which may be made available to the plants by microbiologically mediated process. The organic nutrient like vermi-compost and bio-fertilizer like Arbuscular mycorrhizal fungi are rich source of nutrients. Arbuscular mycorrhizal fungi have been found to increase plant growth, increase chlorophyll content, phosphorus content, increase resistance to cultural and environmental stresses. Vessicular Arbuscular Mycorrhizal (VAM) fungi enhance the plant growth by providing extra absorptive surface which takes up relatively immobile compounds from the soil. The use of efficient strains of AM fungi into soils results in improving the growth and yield of many plants (Krajinski *et al.*, 2000; Soroa *et al.*, 2003 and Attia and Eid, 2005).

Addition of organic amendments to soil has been reported to enhance plant biomass, mycorrhizal infectivity and proliferation of AM fungal hypahe in soil. Decomposition of many organic materials by earthworms to vermi-compost has been known as a cheaper and environment friendly process. It is a rich source of different essential nutrients which improve overall soil condition and promote yield and growth of plant. Vermi-compost contain different types of soil beneficial microbes that can improve plant growth through release of vitamins and hormones. Vermi-compost when added to soil loosens the soil and improves the physical and biological properties of the soil including structure of the soil, aeration and water-holding capacity of the soil. (Jain *et al*, 2012, Dhayal and Aravind kshan 2018). Thus, integrated use of organic manures and bio-fertilizers improve plant growth, overcome rivalry between vegetative and reproductive stage and increasing the yield potential (Xie and Wu, 2017) and and possess a great great potential in sustainable agriculture systems (Kumar *et al.* 2012, Pezeshkpour *et al.* 2014). Therefore, the objective of our study was to evaluate the effect of different mycorrhizal strains and vermicompost on growth and flowering of *Chrysanthemum coronarium* and to develop sustainable nutrient management schedule for profitable flower production.

2. Material and Methods

A field experiment was conducted during *Rabi* season of 2018-19 at the Experimental Farm, Division of Vegetable Science & Floriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu. The experimental site is located at 32 $^{\circ}$40’N latitude and

74° 58’ E longitude at an elevation of 332 m above mean sea level falling in the sub-tropical foot hill lands of Shiwaliks in Jammu and Kashmir. The climate of this place is bestowed with hot and dry early summers followed by hot and humid monsoon season and cold winters. The maximum temperature goes up to 45° C during summers (May to June) and minimum temperature falls to 1°C during winters. The mean annual rainfall is about 1000-1200 mm. The experiment was conducted out in factorial randomized block design with three replications. The treatments comprise of 4 mycorrhiza treatments (No application, *Glomus mosseae*, *Acaulospora laevis*, *Gigaspora margarita*) and 4 vermicompost doses (0 g/ m^2, 500 g/ m^2, 750 g/ m^2, 1 kg/ m^2). The experimental field was prepared to a fine tilth and beds of the required dimension were made according to the lay out plan. Healthy seedlings were transplanted on 25/10/2019 in the experimental plots at a spacing of 30 cm x 30 cm thereby accommodating 20 seedlings per bed size of 1.5 m × 1.2 m. At the time of planting, vermicompost at different doses were incorporated into the beds according to the treatment requirements. Vesicular arbuscular mycorrhiza (*Glomus mosseae*, *Acaulospora laevis* and *Gigaspora margarita*) were applied @ 2 g/plant and were incorporated in the planting pits at the time of planting. All other intercultural operations were carried out as and when required during the crop growth. No disease incidence was recorded during the experiment.

Data on various growth and quality attributes were recorded for studied treatments. In each treatment, five plants were randomly selected and tagged for recording data on growth and flowering parameters. The chlorophyll content of leaf was recorded by using SPAD - 502 chlorophyll meter and expressed in percentage. The partitioning coefficient of root and shoot was measured at peak flowering stage. It was calculated by using the formula

$$\text{Partitioning coefficient of shoot (\%)} = \frac{\text{Dry weight of shoot (g) x 100}}{\text{Total dry weight of plant (g)}}$$

$$\text{Partitioning coefficient of root (\%)} = \frac{\text{Dry weight of root (g) x 100}}{\text{Total dry weight of plant (g)}}$$

The data relating to each parameter were statistically analyzed by applying the technique of analysis of variance using Factorial Randomized Block Design (Gomez and Gomez 1985). The level of significance for f-test and t-test were kept at 5% (P=0.05).

3. Results and Discussion

3.1 Growth parameters

Growth of chrysanthenum in terms of plant height, number of side shoots per plant and plant spread as reported in Table 1 revealed that the maximum plant height (100.33 cm) and number of side shoots per plant (13.66) was recorded with the application of *Glomus mosseae* and lowest with control. However, maximum plant spread was recorded with the application of *Acaulospora laevis* which was at par with those of *Glomus mosseae* and *Gigaspora margarita.* Among the vermi-compost doses, highest plant height (102.58 cm), number of side shoots (13.66) and plant spread of 1582.28 cm^2 were recorded with vermi-compost application @1 kg/m^2. Increase in the parameters with application of mycorrhiza may be due to effective root colonization *viz.a viz.* enhanced phosphorus uptake of roots due to exploration of soil volume and increase in the surface area for absorption of nutrients (Tinker *et al.* 1978). On the other hand vermi-compost is a rich source of different essential nutrients which improve overall soil physical condition and promote yield and overall growth of plant (Alizadeh and Alizadeh 2011; Pezeshkpour *et al.* 2014). Similar findings have been reported by Asrar and Elhindi (2011) and (Hussain *et al*. 2016).

Interaction effect revealed highest plant height and number of shoots with the conjoint application of *Glomus mosseae* + vermi-compost @1 kg/m^2. Interaction effect also shows maximum plant spread (1847.67 cm^2) with the conjoint application of *Glomus mosseae*and vermicompost @ 750 g/m^2. This might be due to additive effect of vermi-compost and VAM which has resulted in increased plant height and number of side shoots. Similar findings have been reported by Naeni *et al.* (2017) who also found an increase in plant height with the conjoint application of 75% vermi-compost and *Glomusmosseae* in milk thistle (*Silybum morianum*).

With respect to chlorophyll content measured by SPAD meter, revealed that highest chlorophyll content (27.89 SPAD value) was recorded with *Glomus mosseae* whereas lowest chlorophyll content (17.81 SPAD value) was recorded with control. However, among the various vermi-compost doses tested, maximum chlorophyll content (24.98 SPAD value) was recorded with vermi-compost @ 1kg/m^2 which was statistically at par with vermi-compost @ 750 g/m^2. Vermi-compost increase the amount of nutritional substances such as nitrogen available to the plants and as a result increase the overall chlorophyll and carotenoid content (Asghari *et al.* 2016). Asrar and Elhindi (2011) reported that in marigold plants, total photosynthetic pigments increased due to mycorrhizal colonization by 60%. The increase in photosynthetic pigments as a result of mycorrhizal colonization was also supported byAboul Nasr (1996) and Wu and Xia (2006). Janowska and Andrzejak (2017) reported higher index of greenness in mycorhizal inoculated plants of *Tagetes patula* L.

Data on various shoot attributes as presented in Table 2 revealed that maximum shoot fresh weight (695.83 g), shoot dry weight (216.00 g), shoot: root ratio (12.84) and partitioning coefficient of shoot (87.17 %) was recorded with the application of *Gigaspora margarita* whereas lowest of all the above values was recorded with control. The effect of vermi-compost on shoot fresh weight (671.08 g), root fresh weight (53.83 g) and shoot dry weight (38.97g) was recorded highest with the application of vermi-compost @ 1 kg/m^2. Interaction effects shows highest shoot fresh weight and shoot dry weight with the conjoint application of *Gigaspora margarita* + vermicompost @ 1 kg/m^2. The higher shoot fresh weight and shoot dry weight with the above treatment may correlate to the increase in plant height and number of side shoots with the same treatment. Mycorrhizal inoculation increased plant biomass and the percent root symbiosis (Kapoor *et al*. 2004 and Alizadeh and Alizadeh 2011). Aboul Nasr (1996) found *Glomus mosseae* to be the most effective species of mycorrhiza for zinnia which when applied increase shoot biomass by three fold. Anwar *et al*. (2005) suggested that addition of vermi-compost improve soil biological condition and provide required nutrient for plant, increase growth and biomass production. Mycorhizal symbiosis enhance the photosynthetic source of plants through the increase in the leaf area index, so that plants with higher production capabilities produce higher shoot fresh weight (Gholamhoseini *et al*. 2013).

Data with respect to root attributes as presented in Table 2 revealed that highest root fresh weight (58.67g) and root dry weight (45.78g) was recorded with (*Gigaspora margarita* + vermicompost @ 750g/m^2). Highest partitioning coefficient of root (19.41 %) was recorded with *Acaulospora laevis* + vermicompost @ 750 g/m^2. Arbuscular mycorhizal inoculations have a significant effect on dry weight of the roots and shoots based on physiological characteristics, growth parameters, photosynthetic pigments, total sugars and total protein (Khalighi Jamalabedi 2011). Adhikary (2012) reported that vermicompost enhanced vegetative root and shoot growth and also change root morphology such as increased number of branches in root. Akhzari *et al*. (2015) reported that mycorhizal inoculation with vermi-compost has the highest root dry weight as compared to control.

3.2. Flowering and yield parameters

Data with respect to yield attributes revealed that maximum number of flowers per plant (103.58), flower diameter (7.30 cm) and flowering duration (49.33 days) was recorded with the application of *Glomus mosseae*. However, Maximum flower weight (7.84 g), flower yield per plant (767.69 g) and highest shelf life (7.75 days) was recorded with the application of *Gigaspora margarita*. However, the effect of mycorrhiza on days to 50% flowering was found to be non-significant. Asrar and Elhindi (2011) also reported that under well-watered conditions, mycorrhizal fungi significantly increased flower diameter and flower weight of marigold plants compared to non-mycorrhiza plants. The promotion of flowering by mycorrhizal inoculation might be the result of improved plant nutrient concentrations like potassium and a possible hormonal effect by fungal colonization (Perner *et al*. 2007 and Meir *et al*. 2010). Mycorrhizal root systems influence the source to sink balance by utilizing recent photosynthate supplied by photosynthesis in leaves and a considerable proportion of the assimilated carbon (Douds *et al*. 2000, Smith and Read 2008). The enhanced flowering of plants associated with *G. mosseae* may be the consequence of higher carbohydrate production, especially at the beginning of flower production, and/or more efficient carbohydrate use of these plants during the reproductive phase. This confirms the earlier findings of Dufault *et al.* (1990) that mycorrhizal inoculation in gerbera improves the phosphorus and potassium uptake which results in improved flower quality.

Among the vermi-compost doses, earliest 50% flowering (148.83 days) was recorded with the application of vermi-compost @ 1kg/m^2.Maximum number of flowers per plant (102.88), flower weight (7.78 g), flower diameter (7.4 cm), flowering duration (51.92 days), flower yield per plant (799.90 g) and maximum shelf life (7.89 days) was recorded with the treatment of vermi-compost @1kg/m^2. The earliness of flowering might also be attributed to the supply of macro and micro nutrients, enzymes and growth hormones by vermi-compost. These results are in line with the findings of Gayathri *et al.* (2004) in limonium. Advanced flowering due to VAM have also been reported by Gaur *et al.* (2000) in *Petunia hybrida, Callistephus chinensis* and *Impatiens balsamina.* Vermicompost also contains humic acid which is known to increase nutrient accumulation in conditions of limited nutrient availability and when additional nutrients were supplied (David *et al.* 1994). The higher flower yield due to application of vermicompost has also been reported in marigold (Mashaldi 2000) and golden rod (Kusuma 2001).

Interaction effect revealed least number of days for 50% flowering (146.67 days) with the application of no Mycorrhiza + vermi-compost @ 1kg/m^2 days). Maximum number of flowers per plant (107.88), flower diameter and flowering duration (57.00 days) was recorded with *Glomus mosseae* + vermicompost @ 1 kg/m^2). However, maximum flower weight (8.64 g), maximum flower yield (902.36 g) and shelf life (8.40 days) was recorded with Gigaspora margarita + vermi-compost @ 1 kg/m^2). Longer shelf life might also be attributed to the better overall food and nutrient status of the flower under these treatments.

Conclusion:

It is concluded that among the various mycorrhizal treatments *Glomus mossea* and *Gigaspora margarita* performed better in terms of better vegetative as well as floral parameters of economic importance. Further vermi-compost application @ 1 kg/ m^2 recorded highest number of flowers per plant, flower weight, flowering duration and flower yield per plant. Thus, the integrated application of *Glomus mosseae* + vermicompost @ 1 kg/ m^2 proved to be beneficial for cultivation of *Chrysanthemum coronarium* L. under agro climatic conditions of Jammu.

DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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Table 1. Effect of mycorrhiza and vermi-compost on growth attributes and chlorophyll content (SPAD value) of *Chrysanthemum coronium* L.

Treatments	Plant height (cm)	Number of side shoots per plant	Plant spread (cm^2)	Chlorophyll content (SPAD value)
Mycorrhiza treatments				
No Mycorrhiza(M_0)	94.28	10.22	1352.64	17.81
Glomus mosseae (M_1)	100.33	13.08	1492.28	27.89
Acaulospora laevis(M_2)	95.39	11.67	1577.42	18.44
Gigaspora margarita(M_3)	99.17	11.58	1431.25	20.63
SEm (±)	1.63	0.47	111.45	2.07
$CD_{0.05}$	3.22	0.93	220.68	4.09
Vermi-compost Doses				
0 g/ m^2(V_0)	90.44	9.81	1290.56	17.66
500 g/ m^2 (V_1)	96.33	11.05	1447.81	19.87
750 g/ m^2 (V_2)	9980	12.02	1532.95	22.25
1 kg/ m^2 (V_3)	102.58	13.66	1582.28	24.98
SEm (±)	1.63	0.47	111.45	2.07
$CD_{0.05}$	**3.22**	**0.93**	**220.68**	**4.09**
Interaction between mycorrhiza and vermi-compost				
M_0 V_0	87.44	8.80	1127.44	16.70
M_1 V_0	94.88	10.55	1132.00	23.13
M_2 V_0	90.44	9.33	1351.89	17.29
M_3 V_0	89.00	10.55	1550.89	13.52
M_0 V_1	92.22	10.33	1419.44	17.22
M_1 V_1	98.77	11.66	1470.00	25.04
M_2 V_1	94.78	10.66	1541.00	17.40
M_3 V_1	99.55	11.55	1360.78	19.83
M_0 V_2	98.22	10.66	1328.78	18.24
M_1 V_2	100.66	11.88	1847.67	29.80
M_2 V_2	97.44	13.67	1769.56	18.95
M_3 V_2	102.89	11.89	1185.78	22.02
M_0 V_3	99.22	11.11	1534.89	19.06
M_1 V_3	107.00	18.22	1519.44	33.59
M_2 V_3	98.88	13.00	1647.22	20.12
M_3 V_3	105.22	12.33	1627.56	27.14
SEm (±)	3.25	0.93	222.91	NS
$CD_{0.05}$	**6.44**	**1.85**	**441.37**	**NS**

Table 2. Effect of mycorrhiza and vermi-compost on shoot and root attributes of *Chrysanthemum coronium* L.

Treatments	Shoot fresh weight (g)	Root fresh weight (g)	Shoot dry weight (g)	Root dry weight (g)	Shoot : Root ratio	Partitioning coefficient of shoot (%)	Partitioning coefficient of root (%)
Mycorrhiza treatments							
No Mycorrhiza(M_0)	517.75	44.75	161.62	32.22	11.60	83.43	16.58
Glomus mosseae (M_1)	543.75	44.33	171.12	31.15	12.27	84.39	15.61
Acaulospora laevis(M_2)	583.58	53.83	181.33	38.86	10.90	82.47	17.54
Gigaspora margarita(M_3)	695.83	52.58	216.00	31.89	12.84	87.17	12.83
SEm (±)	23.04	1.66	20.20	1.95	0.74	0.52	0.52
$CD_{0.05}$	**45.61**	**3.29**	**40.00**	**3.87**	**1.47**	**1.02**	**1.02**
Vermicompost Doses							
0 g/ m^2(V_0)	520.92	41.92	161.77	28.94	12.65	84.65	15.35
500 g/ m^2 (V_1)	561.00	46.67	172.84	30.56	11.97	84.79	15.21
750 g/ m^2 (V_2)	587.25	53.08	186.69	35.66	11.02	83.81	16.19
1 kg/ m^2 (V_3)	671.75	53.83	208.78	38.97	12.51	84.19	15.81
SEm (±)	23.04	1.66	20.20	1.95		0.52	0.52
$CD_{0.05}$	**45.61**	**3.29**	**40.00**	**3.87**	**NS**	**1.02**	**1.02**
Interaction between mycorrhiza and vermi-compost							
M_0 V_0	483.33	38.67	152.99	22.55	12.50	87.15	12.85
M_1 V_0	418.00	33.00	130.40	28.86	12.66	81.88	18.12
M_2 V_0	544.67	55.00	165.40	37.90	9.90	81.36	18.64
M_3 V_0	637.67	41.00	198.30	26.45	15.55	88.23	11.77
M_0 V_1	490.00	43.67	147.12	33.65	11.22	81.39	18.61
M_1 V_1	514.67	45.00	160.40	29.35	11.43	84.53	15.47
M_2 V_1	561.33	46.00	175.44	27.15	12.20	86.60	13.40
M_3 V_1	678.00	52.00	208.40	32.09	13.03	86.66	13.34
M_0 V_2	492.00	47.33	156.68	35.22	10.40	81.65	18.35
M_1 V_2	550.33	49.33	180.09	30.03	11.15	85.71	14.29
M_2 V_2	584.33	57.00	185.29	44.62	10.25	80.59	19.41
M_3 V_2	722.33	58.67	224.69	32.75	12.31	87.28	12.72
M_0 V_3	605.67	49.33	189.70	37.46	12.28	83.51	16.49
M_1 V_3	692.00	50.00	213.60	36.36	13.84	85.45	14.55
M_2 V_3	644.00	57.33	199.20	45.78	11.23	81.31	18.69

M_3 V_3	745.33	58.67	232.62	36.28	12.70	86.51	13.49
SEm (±)	46.08	3.32	40.41	3.91	1.48	1.03	1.03
$CD_{0.05}$	**91.23**	**6.57**	**80.01**	**7.75**	**2.93**	**2.04**	**2.04**

Table 3: Effect of mycorrhiza and vermicompost treatments on flowering and yield attributes of *Chrysanthemum coronarium* L. flower production

Treatments	**Days to 50% flowering**	**No. of flowers / plant**	**Flower weight (g)**	**Flower diameter (cm)**	**Flowering duration (days)**	**Flower yield/ plant (g)**	**Shelf life (days)**
Mycorrhiza treatments							
No Mycorrhiza (M_0)	150.92	96.36	6.12	6.87	44.83	591.51	6.76
Glomus mosseae (M_1)	150.67	103.58	6.76	7.30	49.33	701.89	7.45
Acaulospora laevis (M_2)	151.33	96.86	7.66	6.85	45.56	743.50	7.32
Gigaspora margarita (M_3)	152.08	97.36	7.84	7.11	48.67	767.69	7.75
SEm (±)		0.96		0.15	0.68	10.10	0.14
$CD_{0.05}$	**NS**	**1.90**	**0.26**	**0.29**	**1.34**	**19.99**	**0.28**
Vermicompost Doses							
0 g/ m^2(V_0)	156.42	92.08	6.37	6.61	44.64	585.23	6.71
500 g/ m^2 (V_1)	150.25	98.16	6.75	6.98	45.45	663.67	7.23
750 g/ m^2 (V_2)	149.50	101.02	7.48	7.15	46.39	755.80	7.44
1 kg/ m^2 (V_3)	148.83	102.88	7.78	7.40	51.92	799.90	7.89
SEm (±)	1.45	0.96	0.13	0.15	0.68	10.10	0.14
$CD_{0.05}$	**2.88**	**1.90**	**0.26**	**0.29**	**1.34**	**19.99**	**0.28**
Interaction between mycorrhiza and vermi-compost							
M_0 V_0	162.00	93.44	5.09	6.05	43.44	475.61	5.66
M_1 V_0	155.67	99.00	6.31	6.96	45.44	624.69	6.63
M_2 V_0	151.67	92.78	7.11	6.68	44.56	659.67	7.15
M_3 V_0	156.33	83.11	6.99	6.74	45.11	580.94	7.39
M_0 V_1	148.00	95.77	5.69	6.98	43.67	544.93	6.66
M_1 V_1	150.00	99.55	6.67	7.30	46.78	664.00	7.46
M_2 V_1	151.33	97.11	7.22	6.75	44.89	701.13	7.22
M_3 V_1	151.67	100.22	7.43	6.90	46.45	744.63	7.58
M_0 V_2	147.00	96.22	6.73	7.10	44.89	647.56	7.18
M_1 V_2	149.67	107.87	6.99	7.41	48.11	754.01	7.53
M_2 V_2	151.00	98.33	7.92	6.78	45.55	778.77	7.43
M_3 V_2	150.33	101.67	8.29	7.30	47.00	842.84	7.64
M_0 V_3	146.67	99.99	6.98	7.36	47.33	697.93	7.54

M_1 V_3	147.33	107.88	7.09	7.52	57.00	764.87	8.16
M_2 V_3	151.33	99.22	8.41	7.20	47.22	834.44	7.47
M_3 V_3	150.00	104.44	8.64	7.51	56.11	902.36	8.40
SEm (±)	2.91	1.92	0.26	0.29	1.35	20.20	0.28
$CD_{0.05}$	**5.76**	**3.81**	**0.52**	**0.58**	**2.68**	**39.99**	**0.55**