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Efficacy of different bio-control agent on flowering and disease management of chrysanthemum (*Dendranthema grandiflora* Tzvelev) cv. Marigold

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Abstract
Present investigation was carried out to examine the efficacy of different bio-agents on disease parameters and microbial population of chrysanthemum at Department of Floriculture and Landscaping, College of Horticulture and Forestry, Jhalawar. For this formulations of different bio-agents like *Pseudomonas fluorescens* (125g and 175g and 250g per plot area), *Trichoderma harzianum Trichoderma viride, Trichoderma longibrachiatum, Bacillus subtilis* used as root application. *Pseudomonas fluorescens* (250g) treatment was found effective and significantly affected disease management and microbial population. Plant treated with 250g *Trichoderma viride* had minimum number of days to first flower bud emergence (35.53 days), minimum days taken to 50 per cent flowering (65.33 days), maximum number of flower plucked (6.80) and maximum duration of flowering (32.75 days) and minimum disease incidence (10.00%), minimum mortality (10.00%), minimum per cent disease incidence (12.50%) and microbial population count after treatment application.

Keywords: Chrysanthemum, bio-agent, *Trichoderma viride*, microbial population, disease management

Introduction
Chrysanthemum also called as mums or chrysanths is flowering plant belongs family Asteraceae. They have native to East Asia and Northeastern Europe. Most species originated from East Asia and center of diversity is in China. About 160 species of this Chrysanthemum exist in the world. Mostly annual chrysanthemum in commercial cultivation in India. In India chrysanthemum ranks second in area and production among the loose flowers. The major chrysanthemum growing states are Tamil Nadu, Karnataka, Andhra Pradesh, Madhya Pradesh, Himachal Pradesh, West Bengal, Maharashtra, Assam, Jammu & Kashmir and Telangana etc. In India, The area under total flower cultivation in India 2017-18 was (324 '000ha.) with production of (1962 '000 MT) of loose flower and 1962 million cut flower (Anonymous, 2018) [1]. The area in chrysanthemum cultivation ranks third position (25.76 '000ha.) in India. The area under chrysanthemum cultivation in India was (25.76 '000ha.) with production of (464.41 '000MT) of loose flower and 14.85 million cut flower (Anonymous, 2018) [1]. In Rajasthan region, chrysanthemum is mostly growing in winter season. The loose flowers are mainly used in social and religious ceremonies. Flowers are frequently used as cut flowers for bouquets, vases and flower arrangements for interior decorations and as loose flowers for garlands, gajra, rangoli and veni making along with uses in worshipping, flower showers in receptions, wedding etc. However, the growers are unaware of suitable bio-control agents for their location and selecting based on fellow farmer recommendation. The bio-control agent (BCAs) can inhibit the growth of soil borne pathogens through various bio-control mechanisms such as ability to grow much faster than them for space and nutrients, producing many powerful plant degrading enzymes such as lytic enzymes, proteolytic enzymes and more than 200 types of antibiotics which are highly toxic to any macro- and microorganism. The ability to produce multiple antibiotics probably helps to suppress diverse microbial competitors, some of which are likely to be plant pathogens and thus enhance biological control. The role of *Trichoderma* species is not only to control the growth of pathogenic microbes, but there are various other uses for *Trichoderma* species such as, enhance plant defense responses, stimulate colonization of rhizosphere and stimulates plant growth, root growth. *Trichoderma* species is considered as promising biological control agents against numerous phytopathogenic fungi since it is able to inhibit the phytopathogenic fungi either by including resistance and plant defense reaction or by direct confrontation through mycoparasitism and competition or by producing antibiotics.

Materials and Methods

The present investigation was carried out during winter season of the year 2019-20 in the college of Horticulture and Forestry, Jhalawar. The district is situated between 23º45'20" and 24º52'17" North latitudes and 75º27'35" and 76º56'46" East longitudes at 317 meter above mean sea level. The experimental field was laid out in Randomized Block Design with three replications. The materials utilized for the present study consisted of sixteen different doses of different bio-control agents. In field trials with Sixteen treatments *viz.* T_0 (Control), T_1 (*Pseudomonas fluorescens* 125g per plot area), T_2 (*Pseudomonas fluorescens* 175g per plot area), T_3 (*Pseudomonas fluorescens* 250g per plot area), T_4 (*Trichoderma harzianum* 125g per plot area), T_5 (*Trichoderma harzianum* 175g per plot area), T_6 (*Trichoderma harzianum* 250g per plot area), T_7 (*Trichoderma viride* 125g per plot area), T_8 (*Trichodermaviride* 175g per plot area), T_9 (*Trichoderma viride* 250g per plot area), T_{10} (*Trichoderma longibrachiatum* 125g per plot area), T_{11} (*Trichoderma longibrachiatum* 175g per plot area), T_{12} (*Trichoderma longibrachiatum* 250g per plot area), T_{13} (*Bacillus subtilis* 125g per plot area), T_{14} (*Bacillus subtilis* 175g/ plot area), T_{15} (*Bacillus subtilis* 250g per plot area). The rooted cuttings of chrysanthemum were procured from Department of Floriculture and Landscaping, College of Horticulture, Arabhavi (Karnataka) and One month old, healthy, vigorous and uniform seedlings were selected and transplanted during June-July. The bio-control agent were procured from various places such as *Trichoderma longibrachiatum* from Central Arid Zone Research Institute (CAZRI) Jodhpur and other bio-control agent like *Bacillus subtilis*, *Trichoderma viride*, *Trichoderma harzianum*, *Pseudomonas fluorescens* from National Research Centre on Seed Spices (NRCSS) Ajmer. All treatments were replicated thrice with a plot size of 2.4 m x 2.4 m for each treatment and replication and each plot consisted of 25 plants and they were transplanted at a spacing of 40 x 40 cm. Five plants were selected at random and tagged in each treatment, for the purpose of recording observations on various parameters of growth and flowering parameters. The mean value of the data observed was taken to represent a particular variety with respect to character. The disease parameters *viz.* disease incidence, mortality and per cent disease incidence were recorded at first harvesting stage.

Result and Discussion

Data with respect to flowering, disease incidence, mortality, per cent disease incidence in different treatments of chrysanthemum are presented in Table 1, Table 2 and Table 3.

Flower parameters

Number of days to first flower bud emergence

The evaluated data was highly significantly in number of days to first flower bud emergence, Minimum number of days to first flower bud emergence (35.53 days) was recorded in T_9 treatment (*Trichoderma viride* 250 g per plot area). While, maximum number of days to first flower bud emergence (39.60 days) was recorded in T_{13} treatment (*Trichoderma longibrachiatum* 250 g plot area) (Table.1). The application of *Trichoderma* would have helped in uptake of micronutrients and provided essential plant growth promoting substance which results in first flower bud emergence (Dubey *et al.*, 2008) [4]. The results are in conformity with the finding of Srivastava *et al*. (2013) [13] in tuberose and Roopa *et al*. (2018) [10] in chrysanthemum, Sharma and Chandel, (2011) [2] in carnation.

Days taken to 50 per cent flowering

The studied treatments showed significantly effect and reported that the minimum days taken to 50 per cent flowering was recorded in T_9 (*Trichoderma viride* 250 g per plot area) (65.33 days) and maximum days taken to 50 per cent flowering (71.00 days) was recorded in T_7 (*Trichoderma viride* 125g per plot area) (Table.4.2.1). The application of *Trichoderma* would have helped in uptake of macro and micronutrients and provided essential plant growth promoting substance which promoted reproductive phase resulting in lesser time required for 50% flowering (Dubey *et al*., 2008) [4]. The results are in conformity with the finding of Roopa *et al*. (2018) [10] in chrysanthemum.

Duration of flowering (days)

It is evident from the results that the application of biocontrol agents at different doses had significantly influenced duration of flowering as compared to control. The longest duration of flowering (32.75 days) was observed in T_9 treatment (*Trichoderma viride* 250 g per plot area).While, the minimum duration of flowering (28.33 days) was observed in T_0 (control) (Table.1). This may be due to optimum level of soil nutrients (organic acid, phosphates, micronutrients and minerals) mobilized by root application of *Trichoderma viride* and taken up by plants increased the duration of flowering (Vinale *et al*., 2014) [14]. The results are in conformity with the finding of Dubey *et al*. (2008) [4] in gladiolus and Sisodia *et al.* (2018) [12] in gladiolus.

Number of plucking

The results revealed that there were highly significant differences in number of plucking in different treatments. The maximum number of flower plucked (6.80) was recorded in T_9 treatment (*Trichoderma viride* 250 g per plot area). While, the minimum flower plucked (5.00) was recorded in T_0 (control) (Table.1). This was may be due to application in *Trichoderma viride* reduced disease incidence, mortality, percent disease incidence and increased number of branches per plant, number of flowers per plant and increase flower yield.

Table 1: Effect of different bio-control agents on number of days taken to first flower bud emergence, Number of days taken to 50 per cent flowering, duration of flowering (days), Number of plucking of chrysanthemum (*Dendranthema grandiflora* Tzvelev) cv. Marigold

Treatments	Number of days taken to first flower bud emergence	Number of days taken to 50 per cent flowering	Duration of flowering (days)	Number of plucking
T_0 (Control)	36.10	69.66	28.33	5.00
T_1	37.65	68.67	30.10	5.50
T_2	37.90	69.49	31.23	6.00
T_3	38.10	68.46	31.80	6.30
T_4	36.98	68.32	29.85	5.70
T_5	37.26	68.33	31.70	6.18
T_6	37.96	68.83	30.50	6.28

T_7	38.20	71.00	30.96	6.60
T_8	36.88	69.20	31.86	6.70
T_9	35.53	65.33	32.75	6.80
T_{10}	38.60	70.70	31.10	6.10
T_{11}	37.22	70.66	31.80	5.98
T_{12}	38.11	67.67	31.20	5.90
T_{13}	39.60	69.19	30.92	6.10
T_{14}	37.52	69.44	31.50	6.30
T_{15}	37.80	70.66	29.83	6.50
S.Em (±)	0.45	0.84	0.07	0.07
CD 5%	1.28	2.39	0.21	0.20

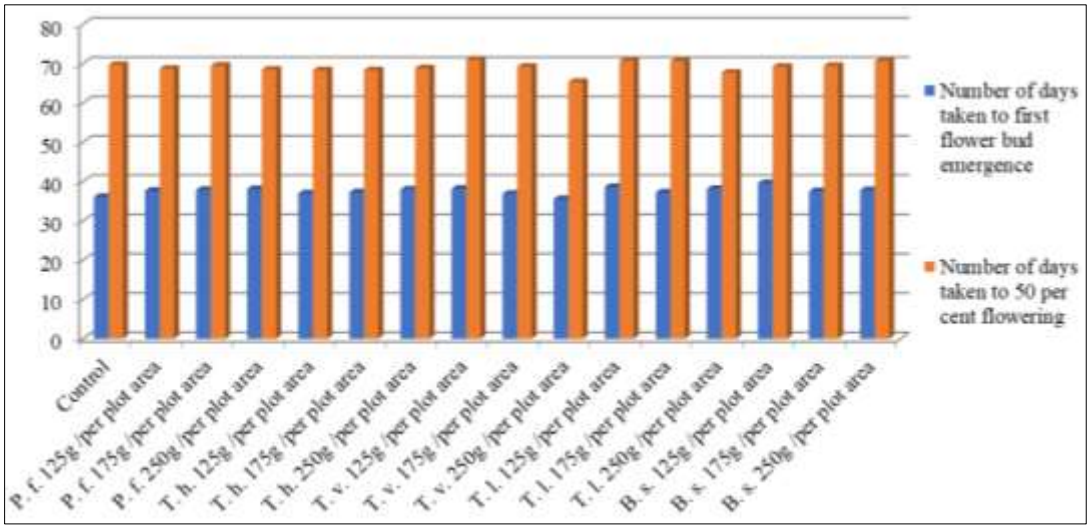

Fig 1a: Effect of different bio-control agents on number of days taken to first flower bud emergence, Number of days taken to 50 per cent flowering of chrysanthemum (*Dendranthema grandiflora* Tzvelev) cv. Marigold

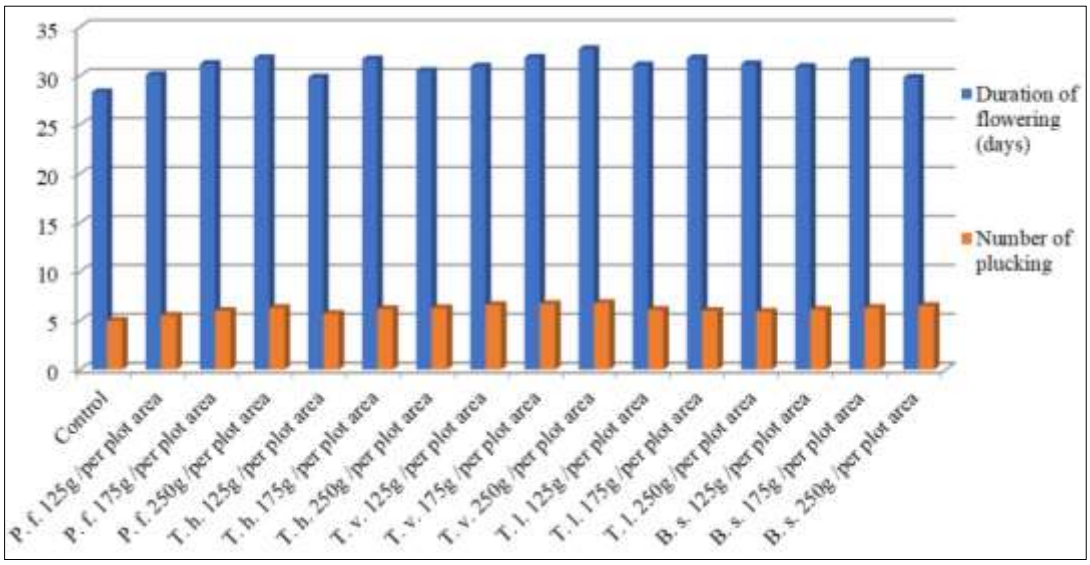

Fig 1b: Effect of different bio-control agents on duration of flowering (days), Number of plucking flowering of chrysanthemum (*Dendranthema grandiflora* Tzvelev) cv. Marigold

Disease parameters

Disease incidence (%)

The treatments were significant difference and the lowest disease incidence 10.00% (18.85) was recorded in the T_9 treatment (*Trichoderma viride* 250 g per plot area) followed by T_6 (*Trichoderma harzianum* 250 g per plot area).While, the highest disease incidence 48.33% (44.04) was observed in T_0 (control) (Table.2). *Trichoderma spp.* have the advantage of fast growth and vigorous vitality, thus, they can occupy the growing space quickly and absorb the required nutrients. At the same time, *Trichoderma spp.* can secrete cell wall-degrading enzymes including chitinases, cellulases, xylanases, glucanases and proteinases, which can degrade microbial cells in the soil environment to absorb nutrients, thus changing the structure of the microbial community (Zhang *et al.*, 2015) [15]. The results are in conformity with the finding of (Sharma and chandel, 2013) [11] in carnation, Gupta *et al.* (2006) [5] in chickpea, Mishra *et al.* (2008) [8] in gladiolus and Raj *et al.* (2007) [9] in gladiolus.

Mortality (%)

The result showed that had significantly differences in mortality per cent among the treatments and minimum mortality 10.00% (18.43) was recorded in T_9 treatment

(*Trichoderma viride* 250 g per plot area) followed by T_6 (*Trichoderma harzianum* 250 g per plot area) 11.00% (19.37), while the maximum mortality 30.00% (33.21) was recorded in T_0 (control) (Table.2). Several studies reported that β-1-3 glucanase are the main skeletal polysaccharides of fungal cell wall during the antagonistic action of *Trichoderma*, hence fugal cell wall degrading enzyme of *Trichoderma spp.* are special importance in plant defense mechanisms (Lorito *et al*., 1998 and Kucuk *et al*., 2003) [7, 6]. The similar results were also obtained by Mishra *et al*. (2008) [8] in gladiolus, Dubey *et al*. (2007) [3] gladiolus and Raj *et al.* (2007) [9] in gladiolus.

Per cent disease incidence (%)

The application of different doses of bio-control agents had significantly effect on per cent disease incidence. The minimum per cent disease incidence 12.50 (20.70) was observed under T_9 treatment (*Trichoderma viride* 250 g per plot area). This may be due to *Trichoderma viride* have the advantage of fast growth and vigorous vitality, thus, they can occupy the growing space quickly and absorb the required nutrients. At the same time, *Trichoderma spp.* can secrete cell wall-degrading enzymes including chitinases, cellulases, xylanases, glucanases, and proteinases, which can degrade microbial cells in the soil environment to absorb nutrients, thus changing the structure of the microbial community (Zhang *et al.*, 2015) [15]. The results are in conformity with the finding of (Sharma and Chandel, 2013) [11] in carnation, Gupta *et al.* (2006) [5] in chickpea, Mishra *et al.* (2008) [8] in gladiolus and Raj *et al*. (2007) [9] in gladiolus.

Table 2: Effect of different bio-control agents on disease incidence (%), Mortality (%) and PDI (Percent disease incidence) of chrysanthemum (*Dendranthema grandiflora* Tzvelev) cv. Marigold

Treatments	Disease incidence (%)	Mortality (%)	PDI (Percent disease incidence)
T_0 (Control)	48.33 (44.04)	30.00 (33.21)	20.00 (26.57)
T_1	32.00 (34.45)	22.00 (27.97)	18.78 (25.68)
T_2	26.88 (31.23)	18.00 (25.10)	15.22 (22.96)
T_3	20.00 (26.57)	13.00 (21.13)	14.60 (22.46)
T_4	21.33 (27.51)	15.00 (22.79)	15.80 (23.42)
T_5	16.30 (23.81)	13.10 (21.22)	13.10 (21.22)
T_6	10.44 (18.85)	11.00 (19.37)	12.90 (21.05)
T_7	18.00 (25.10)	16.00 (23.58)	15.22 (22.96)
T_8	13.66 (21.69)	12.00 (20.27)	14.67 (22.52)
T_9	10.00 (18.43)	10.00 (18.43)	12.50 (20.70)
T_{10}	40.00 (39.23)	21.00 (27.27)	16.40 (23.89)
T_{11}	32.65 (34.85)	17.00 (24.35)	14.67 (22.52)
T_{12}	25.50 (30.33)	12.20 (20.44)	13.90 (21.89)
T_{13}	36.00 (36.87)	27.00 (31.30)	17.20 (24.50)
T_{14}	23.30 (28.79)	24.00 (29.33)	14.22 (22.15)
T_{15}	29.77 (33.06)	17.00 (24.35)	13.38 (21.46)
S.Em(±)	1.12	0.67	0.23
CD $_{(5\%)}$	3.19	1.92	0.64

*Figures in parentheses indicate transformed value

Microbial population

The data indicate that, the microbial population influenced by root application of different bio-control agents and different doses affect presented in Table 3 and depicted in Fig. 2.

The observation of the data reveals that, microbial population of fungi colony before treatment application (4.96 x 10^3) and bacteria colony count (1.25 x 10^6), while fungi colony count after treatment application maximum recorded in treatment T_2 (59.63 x 10^4) and bacteria colony count was maximum recorded (9.63 x 10^6) in treatment T_3 and minimum fungi colony count (24.19 x 10^4) was recorded in T_7 and minimum bacteria colony count (2.85 x10^6) was recorded in T_{12}, T_{15}.

Table 3: Effect of different bio-control agents on microbial population of chrysanthemum (*Dendranthema grandiflora* Tzvelev) cv. Marigold

Treatments	Fungi colony count x 10^4	Bacteria colony count x 10^6
T_0 (Control)	31.70	5.60
T_1	47.52	5.63
T_2	59.63	7.48
T_3	45.52	9.63
T_4	47.15	4.70
T_5	52.48	6.56
T_6	34.22	7.48
T_7	24.19	3.78
T_8	38.85	8.61
T_9	29.19	4.70
T_{10}	38.81	7.48
T_{11}	43.52	5.63
T_{12}	47.15	2.85
T_{13}	52.81	4.70
T_{14}	43.44	3.78
T_{15}	48.85	2.85
S.Em(±)	1.47	0.22
CD $_{(5\%)}$	4.20	0.62

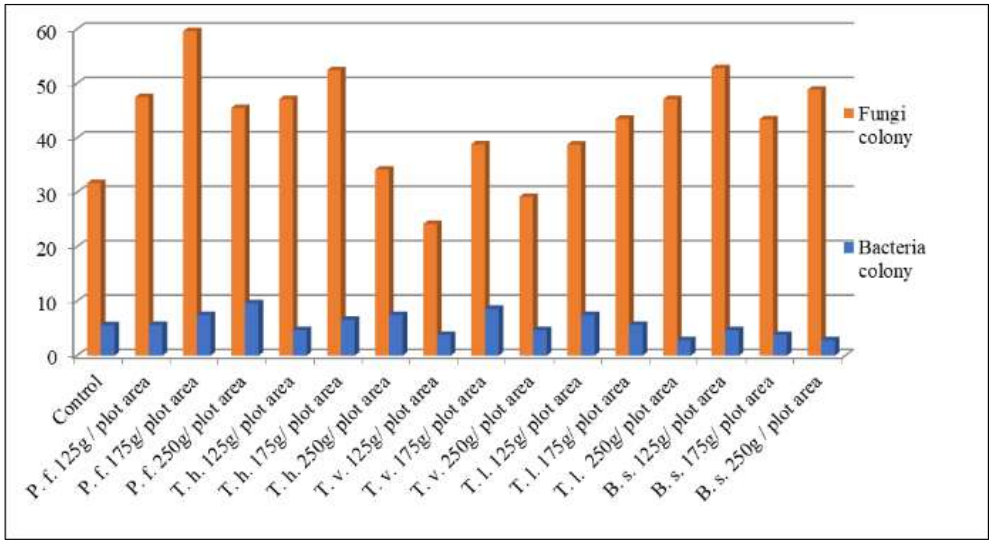

Fig 1b: Effect of different bio-control agents on microbial population of chrysanthemum (*Dendranthema grandiflora* Tzvelev) cv. Marigold

Conclusion

Therefore, based on the present investigation, it may be concluded that the treatments T_3 was found better in flowering parameters *viz*. minimum number of days to first flower bud emergence (35.53 days)), minimum days taken to 50 per cent flowering (65.33 days), longest duration of flowering (32.75 days), maximum number of flower plucked (6.80), and treatments T_9 was found better in disease parameters *viz*. lowest disease incidence 10.00% (18.85), minimum mortality 10.00% (18.43), minimum per cent disease incidence 12.50 (20.70) and microbial population compare than all other treatments.

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