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INTEGRATED MANAGEMENT OF FUSARIUM WILT OF GLADIOLUS

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Abstract

Integrated management of Fusarium wilt of gladiolus was studied at Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Gazipur during 2011-2013 following RCB design with four replications. Seven treatment such as (1) Corm treated with Bavistin @ 0.1% for 15 minutes, (2) Corm treated with hot water @ 54ºc for 5 minutes, (3) Corm treated with hot water @ 52ºc for 10 minutes, (4) Poultry refuse @ 5t/ha, (5) Mustard oil cake @ 600 kg/ha, (6) Bio-pesticide @ 64kg/ha, (7) Bavistin @ 0.1% as soil drenching were evaluated in nine different combinations against the Fusarium wilt of gladiolus (*Fusarium oxysporum* f. sp. g*ladioli*) under naturally infested field condition. Corm treated with Bavistin (0.1%) for 15 minutes + Poultry refuse @ 5t/ha in soil application 25 days before corm sowing + Bavistin @ 0.1% as soil drenching at 45 days after corm sowing gave best integrated management option for reducing Fusarium wilt of gladiolus and thereby resulting maximum germination, spike length, rachis length, florets spike^{-1}, flower sticks, corm and comel yield. Besides, integration of Bavistin (0.1%) as corm treatment for 15 minutes + Mustard oil cake @ 600 kg/ha in soil application 25 days before corm sowing + Bavistin (0.1%) as soil drenching at 45 days after corm sowing was also better option for combating Fusarium wilt of gladiolus. The alternate option was integration of Bavistin (0.1%) as corm treatment for 15 minutes + Bio-pesticide in soil application 7 days before corm sowing + Bavistin (0.1%) as soil drenching at 45 days after corm sowing was effective against the disease incidence as well as better spike length, rachis length, florets spike^{-1}, flower sticks, corm and cormel yield.

Keywords: Gladiolus, *Fusarium oxysporum* f. sp. g*ladioli,* Fusarium wilt, Bavistin, Poultry refuse, Mustard oil cake and Bio-pesticide.

Introduction

Gladiolus (*Gladiolus* sp) is one of the most popular commercial flower in Bangladesh. The agro-ecological conditions of the country are very much conducive for the survival and culture of gladiolus. The major production belts of this Sharsha flower are Jessore sadar, Sharsha, Jhikargacha, Kushtia, Chuadanga, Satkhira, Khulna, Chittagong, Mymensingh, Dhaka, Savar and Gazipur.

It has great economic value as a cut-flower and its cultivation is relatively easy. Income from gladiolus flower production is six times higher than that of rice in Bangladesh (Momin, 2006).

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The major obstacle of gladiolus cultivation in the Subtropical and Mediterranean regions is the diseases caused by fungi, bacteria and viruses of which Fusarium wilt disease caused by *F. oxysporum* f. sp. *gladioli* is a major one in all over the gladiolus growing areas causing 60-70% yield loss (Vlasova and Shitan, 1974) and the damage may reach upto 100% (Pathania and Misra, 2000). Crop loss of 30% in Germany and 60-80% in Russia was estimated due to Fusarium wilt of gladiolus (Bruhn, 1955). It is also a serious threat in India and reduced plant growth and flowering upto 15- 28% in the number of florets/spike (Misra *et al.*, 2003).

The pathogen is both seed and soil borne (Cohen and Hass, 1990; Mukhopadhyay, 1995). It causes curving, blending, arching, stunting, yellowing and drying of leaves associated with root and corm rot in the field as well as in the storage. *F. oxysporum* f. sp. *gladioli* causes three types of rot e.g. vascular corm rot, brown rot and basal rot (Partridge, 2003). Vascular rot is also called yellows and is characterized by a brown discoloration in the centre of the corm and extending into the flesh. The leaf symptoms start at the tip of the leaf blade and gradually spread all over the leaf blade. If the plant is infected at later stage, it produces weak or small florets. When the plant is infected at early stage and infection is severe, whole plant becomes dry and dies within few days (Misra and Singh, 1998). Fusarium wilt of gladiolus may be minimized by the integrated management approach under pot culture and polyhouse conditions (Sharma *et al.* 2005). The integrated approach using pots treated with neem cake, carbendazim and *Trichoderma harzianum* revealed the highest disease control and enhanced plant health and corm yield. Application of carbendazim (200 ppm), *T. harzianum* (P=0.001) and *Pseudomonas fluorescence* (P= 0.05) decreased corm rot, yellows and the pathogen population in soil resulting increased plant growth and flowering (Khan and Mustafa, 2005). Singh and Arora (1994) reported that Bavistin-HCl and Emisan as better fungicides in reducing disease severity (%) and enhancing corm and cormel yield.

Different workers practiced biological, cultural and chemicals means in controlling the disease. It is difficult to control Fusarium wilt of gladiolus with a single component. Considering the above situation the present work was under taken to find out an effective integrated approach for controlling Fusarium wilt disease (*Fusarium oxysporum* f. sp. g*ladioli*) of gladiolus.

Materials and methods

The experiment was conducted at the Floriculture Field under the Horticulture Research Centre (HRC) of Bangladesh Agricultural Research Institute (BARI), Gazipur during the period from 2011-2013. The experiment was set in previously *Fusarium oxysporum* f. sp. g*ladioli* infested soil. It was laid out in the Randomized Complete Block Design (RCBD) with four replications. The management options were (1) Corm treated with hot water @ 54^{o}c for 5 minutes ,

(2) Corm treated with hot water @ 52ºc for 10 minutes, (3) Corm treated with Bavistin @ 0.1% for 15 minutes, (4) Poultry refuse @ 5t/ha, (5) Mustard oil cake @ 600 kg/ha, (6) Bio-pesticide @ 64kg/ha, (7) Bavistin @ 0.1% as soil drenching and nine treatment combinations.

Corms were treated with hot water and dried in shade before 24 hours of seed sowing. The corms were treated by Bavistin just before seed sowing. Poultry refuse and mustard oil cake were applied before 25 days and bio-agents were applied before 7 days of seed sowing. Bavistin @ 0.1% was applied as soil drenching around the base of the plants at 45 days after sowing.

The recommended dose of fertilizers cowdung @ 10 t/ha, TSP @ 225 kg/ha and MoP 190 kg/ha were applied to the soil during land preparation and thoroughly mixed with the soil. Urea @ 200 kg/ha was top dressed in two equal splits, one at the four leaf stage and another at spike initiation stage (Woltz, 1976).

The unit plot size was 1.25 m × 1.6 m. Spacing was maintained at 25 cm between the rows and 20 cm between the plants. Depth of planting of the corms was 6 cm. The space between plots and block were 50 cm and 75 cm respectively. Germination (%), Plant height (cm) , Spike length (cm), Rachis length (cm), Florets spike^{-1}, Flower stick weight (g), Flower sticks plot^{-1}, Flower sticks ha^{-1}, Pre-germination corm rot (%), Wilted plant (%), Disease incidence (%), Percent disease index (PDI), Corms hill^{-1}, Corm yield, Cormels hill^{-1} and Cormels yield (g) were rcorded. The disease incidence, Percent disease index and wilted plant were calculated using following formula (Singh and Arora, 1994):

$$\text{Disease incidence (\%)} = \frac{\text{Number of infected plants plot}^{-1}}{\text{Number of total plants plot}^{-1}} \times 100$$

$$\text{Percent disease index (\%)} = \frac{\text{Class frequency}}{\text{Total number of sample} \times \text{Maximum grade of scale}} \times 100$$

$$\text{Wilted plant (\%)} = \frac{\text{Number of wilted plants plot}^{-1}}{\text{Total number of plants plot}^{-1}} \times 100$$

Results and Discussion

Effect of integrated management option on vegetative growth of gladiolus was significantly different (Table 1). Higher germination was recorded in the treatment combination A_1 (99.98%) which was statistically identical with that of A_2, A_3 and A_4. The lowest germination was 93.75% in control (A_{10}). There was no significant difference among the treatment combinations A_5, A_6, A_7, A_8 and A_9 on corm germination.

Table 1. Effect of integrated management option on vegetative growth of gladiolus

Treatment combinations	Germination (%)	Days to 50% germination	Plants/hill	plant height (cm)
A_1= T_1+T_4+T_7	99.98 a (10.0)	11.50 b	1.74 a	42.77 a
A_2= T_1+T_5+T_7	99.36 ab (9.97)	12.00 ab	1.68 ab	41.47 ab
A_3= T_1+T_6+T_7	99.36 ab (9.97)	12.25 a	1.65 ab	42.26 ab
A_4= T_2+T_4+T_7	98.74 abc (9.94)	11.50 b	1.60 ab	41.99 ab
A_5= T_2+T_5+T_7	98.12 bcd (9.90)	11.50 b	1.55 ab	40.95 b
A_6= T_2+T_6+T_7	98.12 bcd (9.90)	12.00 ab	1.53 ab	41.01 b
A_7= T_3+T_4+T_7	97.50 cd (9.87)	12.50 a	1.48 b	41.70 ab
A_8= T_3+T_5+T_7	96.88 d (9.84)	12.00 ab	1.48 b	42.48 a
A_9= T_3+T_6+T_7	96.88 d (9.84)	12.25 a	1.45 bc	42.10 ab
A_{10} = Control	93.75 e (9.69)	12.50 a	1.23 c	40.86 b
CV%	0.43	3.74	10.25	2.11

Means followed by the same letter do not differ significantly at the 5% level by DMRT.

Values within paranthesis were square root transformation.

T_1= Corm treated with Bavistin @ 0.1% for 15 minutes, T_2= Corm treated with hot water @ 54ºc for 5 minutes, T_3= Corm treated with hot water @ 52ºc for 10 minutes, T_4= Poultry refuse @ 5t/ha, T_5= mustard oil cake @ 600 kg/ha, T_6= bio-pesticide @ 64kg/ha, T_7= Bavistin @ 0.1% as soil drenching.

The minimum days (11.50) required to reach 50% germination was observed in A_1, A_4 and A_5 which were followed by A_2, A_6 and A_8. The maximum days (12.50) required to reach 50% germination was noticed in A_{10} and A_7 which were statistically identical to A_3, A_9, A_2, A_6 and A_8. The maximum numbers of plants hill^{-1} was 1.74 recorded in A_1 which was statistically similar to A_2, A_3, A_4, A_5 and A_6 while minimum numbers of plants hill^{-1} was 1.23 recorded in A_{10}. The taller plant was 42.77 cm was recorded in case of poultry refuse, corm treated with Bavistin @ 0.1% for 15 minutes and soil drenching with Bavistin (A_1) which was followed by A_8, A_3, A_9, A_4, A_7 and A_2. The shorter plant (40.86 cm) was recorded from A_{10} which was followed by A_5 and A_6.

All the parameters of disease infestation showed significant variations due to various treatments combinations (Table 2). Corm and soil treatment showed significant effect on the pre germination corm rot. The highest pre germination corm rot was 6.75% recorded in A_{10} and the lowest was 0.50% recorded in A_1 which was followed by A_2 and A_3. There was no significant variation of pregermination among A_5, A_6, A_7, A_8 and A_9. The highest wilted plant (10.12%) was recorded in A_{10} and lowest (1.13%) was observed in A_1 which was statistically similar to A_2, A_3, A_4, A_5 and A_6. Incidence of plant infection was the highest in control (57.50%) whereas the minimum plant infection was 47.0% in A_1. There was no significant differences among the rest options with respect to disease incidence. Percent disease index (PDI) was minimum (21.25%) in A_1 and A_2 where rest of the options showed statistically similar. PDI ranging from 21.88 to 25.63%.

Table 2. Effect of integrated management options on disease infestation of gladiolus

Treatment combinations	Pre germination corm rot (%)	Wilted plant (%)	Incidence of plant infection (%)	Percent disease index (PDI)
A_1= T_1+T_4+T_7	0.50 e	1.13 c	47.0 b	21.25 b
	(0.71)	(0.97)	(6.86)	(26.44)
A_2= T_1+T_5+T_7	1.13 de	1.75 c	47.75 b	21.25 b
	(0.97)	(1.22)	(6.91)	(26.44)
A_3= T_1+T_6+T_7	1.13 de	1.75 c	48.0 b	21.88 b
	(0.97)	(1.22)	(6.93)	(26.88)
A_4= T_2+T_4+T_7	1.75 cd	1.13 c	49.50 b	23.75 b
	(1.22)	(0.97)	(7.04)	(28.10)
A_5= T_2+T_5+T_7	2.38 bc	1.13 c	49.50 b	23.75 b
	(1.48)	(0.97)	(7.04)	(28.10)
A_6= T_2+T_6+T_7	2.38 bc	1.77 c	50.0 b	24.38 b
	(1.48)	(1.23)	(7.07)	(28.51)
A_7= T_3+T_4+T_7	3.00 b	4.35 b	51.0 b	25.63 b
	(1.73)	(2.06)	(7.14)	(29.28)
A_8= T_3+T_5+T_7	3.63 b	4.36 b	52.0 b	25.63 b
	(1.89)	(2.07)	(7.21)	(29.28)
A_9= T_3+T_6+T_7	3.63 b	4.36 b	52.25 b	25.63 b
	(1.89)	(2.07)	(7.23)	(29.28)
A_{10} = Control	6.75 a	10.12 a	57.50 a	31.25 a
	(2.59)	(3.18)	(7.58)	(32.77)
CV%	20.39	30.19	6.42	7.93

Means followed by the same letter do not differ significantly at the 5% level by DMRT. All values within paranthesis were square root transformation but PDI values within paranthesis were Arcsin transformation.

T_1= Corm treated with Bavistin @ 0.1% for 15 minutes, T_2= Corm treated with hot water @ 54^{o}c for 5 minutes, T_3= Corm treated with hot water @ 52^{o}c for 10 minutes, T_4= Poultry refuse @ 5t/ha, T_5= mustard oil cake @ 600 kg/ha, T_6= bio-pesticide @ 64kg/ha, T_7= Bavistin @ 0.1% as soil drenching.

Effect of integrated management options varied statistically with respect to different parameters on flower production of gladiolus (Table 3). The highest spike length (77.23 cm) was recorded in the treatment of A_1 which was statistically similar to A_2, A_3 and A_4. The minimum spike length (70.25 cm) was recorded in A_{10} which was followed by A_9, A_8 and A_7. The maximum rachis length (45.18 cm) was observed in A_1 which was followed by A_2 and A_3 and minimum rachis length (38.75 cm) was observed in A_{10}. The rachis length of the other options ranged from 41.63 cm to 43.50 cm. The highest number of florets (12.73) spike^{-1} was recorded in A_1 which was followed by A_5, A_4, A_8, A_2 and A_6 while the lowest number of florets (11.60) spike^{-1} was recorded in A_{10} which was statistically similar to A_9, A_7 and A_3.

Table 3. Effect of integrated management options on flower production of gladiolus

Treatment combinations	spike length (cm)	Rachis length (cm)	Florets spike^{-1}	Flower stick weight(g)	Flower sticks plot^{-1}	Flower sticks ha^{-1}
A_1= T_1+T_4+T_7	77.23 a	45.18 a	12.73 a	68.71 a	40.75 a	97000 a
A_2= T_1+T_5+T_7	76.00 ab	44.57 ab	12.25 ab	68.13 a	40.00 ab	95250 ab
A_3= T_1+T_6+T_7	75.40 ab	44.00 abc	12.11 bc	67.88 a	39.75 ab	94750 ab
A_4= T_2+T_4+T_7	75.25 ab	43.50 bc	12.36 ab	67.88 a	39.25 ab	93250 ab
A_5= T_2+T_5+T_7	74.54 bc	43.00 cd	12.40 ab	67.50 a	39.00 b	92750 b
A_6= T_2+T_6+T_7	74.25 bcd	42.75 cde	12.23 ab	67.00 a	38.75 b	92250 b
A_7= T_3+T_4+T_7	72.63 cde	42.13 de	11.93 bc	64.45 b	36.50 c	87000 c
A_8= T_3+T_5+T_7	72.25 cde	41.50 e	12.34 ab	64.13 b	36.25 c	86000 c
A_9= T_3+T_6+T_7	71.75 de	41.63 e	11.85 bc	63.88 b	36.00 c	85000 c
A_{10} = Control	70.25 e	38.75 f	11.60 c	61.00 c	33.00 d	78000 d
CV%	2.16	1.94	2.84	2.51	2.65	2.65

Means followed by the same letter do not differ significantly at the 5% level by DMRT.

T_1= Corm treated with Bavistin @ 0.1% for 15 minutes, T_2= Corm treated with hot water @ 54°c for 5 minutes, T_3= Corm treated with hot water @ 52°c for 10 minutes, T_4= Poultry refuse @ 5t/ha, T_5= mustard oil cake @ 600 kg/ha, T_6= bio-pesticide @ 64kg/ha, T_7= Bavistin @ 0.1% as soil drenching.

The heaviest flower stick (68.71 g) was produced by the treatment combination A_1 which was statistical similar to A_2, A_3, A_4, A_5, and A_6 (Table 3). On the other hand, the lightest flower stick (61.0 g) was produced by A_{10} where A_9, A_8 and A_7 showed statistically similar trend. The highest number of sticks plot-^{1} (40.75) was produced by A_1 which was statistically similar to A_2, A_3 and A_4. The lowest number of sticks plot-^{1} (33.0) was found in control plot (A_{10}). A_1 produced maximum number (97000/ha) flower sticks followed by the treatment combinations A_2, A_3 and A_4 while minimum number (79000/ha) flower sticks were recorded in A_{10}.

Effect of integrated management options on corm production of gladiolus varied significantly among the treatments (Table 4). The maximum number of corms (1.58) hill^{-1} was recorded in the treatment A_1 which was statistically similar to the treatments A_2, A_3, A_4, A_5, A_6 and A_7. The minimum number of corms (1.30) hill^{-1} was recorded from A_{10} which was followed by A_8, A_9 and A_7. The heaviest corm (20.0 g) was recorded by the treatment A_1 which was statistically identical to A_2, A_3, A_5, A_6, A_4, A_7 and A_8 and the lightest corm (16.25 g) was recorded from A_{10}. The largest corm (3.53 cm) was noticed in A_1 which was statistically similar to A_2, A_3, A_4, A_8 and A_{10} and the smallest corm (3.17 cm) was recorded in the treatment A_7 which was followed by A_6, A_9, A_5 and A_{10}. The maximum number of corms plot^{-1} (62.65) was produced by A_1 which was statistically identical to A_2, A_3, A_4, A_5 and A_6. The minimum corms plot^{-1} (43.88) was produced by A_{10} while no significant difference existed among A_6, A_7, A_8 and A_9. The treatment combination A_1 produced the highest number of corms ha^{-1} (149000) which was statistically similar A_2, A_3, A_4, A_5 and A_6 (Table 4). The lowest number of corms ha^{-1}(104000) was recorded in A_{10} which was followed by A_9, A_8 and A_7.

Table 4. Effect of integrated management options on corm production of gladiolus

Treatment combinations	Corms hill^{-1}	Corm weight (g)	Corm diameter (cm)	Corms plot^{-1}	Corms ha^{-1} (000)
A_1= T_1+T_4+T_7	1.58 a	20.00 a	20.00 a	62.65 a	149.0 a
A_2= T_1+T_5+T_7	1.55 ab	19.00ab	19.00ab	60.85 a	144.8 a
A_3= T_1+T_6+T_7	1.53 ab	18.88 ab	18.88 ab	59.88 a	142.5 a
A_4= T_2+T_4+T_7	1.50 ab	18.38 ab	18.38 ab	58.85 ab	140.0 ab
A_5= T_2+T_5+T_7	1.50 ab	18.88 ab	18.88 ab	58.50 ab	139.3 ab
A_6= T_2+T_6+T_7	1.48 ab	18.43 ab	18.43 ab	57.18 abc	136.3 abc
A_7= T_3+T_4+T_7	1.43 abc	18.25 ab	18.25 ab	53.43 bc	127.5 bc
A_8= T_3+T_5+T_7	1.40 bc	18.13 ab	18.13 ab	52.18 c	124.3 c
A_9= T_3+T_6+T_7	1.40 bc	17,75 bc	17,75 bc	52.18 c	124.3 c
A_{10} = Control	1.30 c	16.25 c	16.25 c	43.88 d	104.3 d
CV%	6.63	6.60	6.60	6.72	6.73

Means followed by the same letter do not differ significantly at the 5% level by DMRT.

T_1= Corm treated with Bavistin @ 0.1% for 15 minutes, T_2= Corm treated with hot water @ 54^{o}c for 5 minutes, T_3= Corm treated with hot water @ 52^{o}c for 10 minutes, T_4= Poultry refuse @ 5t/ha, T_5= mustard oil cake @ 600 kg/ha, T_6= bio-pesticide @ 64kg/ha, T_7= Bavistin @ 0.1% as soil drenching.

All the parameters of cormel production of gladiolus showed significant variations among the treatments (Table 5). The maximum number of cormels hill^{-1} (21.63) was recorded in A_1 which was statically identical to A_2 and A_3 while minimum number of cormels hill^{-1} (14.38) was produced by A_{10}.

Table 5. Effect of integrated management options on cormel production of gladiolus

Treatment combinations	Cormels hill^{-1}	Cormel weight hill^{-1} (g)	Cormel yield plot^{-1}(g)	Cormel yield ha^{-1}(t)
A_1= T_1+T_4+T_7	21.63 a	29.75 a	1183 a	2.82 a
A_2= T_1+T_5+T_7	21.25 a	29.00 a	1139 a	2.71 ab
A_3= T_1+T_6+T_7	20.40 ab	28.25 ab	1108 ab	2.64 abc
A_4= T_2+T_4+T_7	18.83 bc	27.85 abc	1092 ab	2.60 abc
A_5= T_2+T_5+T_7	17.13 cd	26.00 abcd	1014 abc	2.42 abcd
A_6= T_2+T_6+T_7	16.63 d	25.25 abcd	978 abcd	2.33 bcd
A_7= T_3+T_4+T_7	16.13 de	24.50 abcd	919 bcde	2.19 cde
A_8= T_3+T_5+T_7	15.50 de	23.25 bcd	866 cde	2.07 de
A_9= T_3+T_6+T_7	15.13 de	22.75 cd	849 de	2.02 de
A_{10} = Control	14.38 e	22.00 d	744 e	1.77 e
CV%	7.64	12.37	15.83	15.77

Means followed by the same letter do not differ significantly at the 5% level by DMRT.

T_1= Corm treated with Bavistin @ 0.1% for 15 minutes, T_2= Corm treated with hot water @ 54ºc for 5 minutes, T_3= Corm treated with hot water @ 52ºc for 10 minutes, T_4= Poultry refuse @ 5t/ha, T_5= mustard oil cake @ 600 kg/ha, T_6= bio-pesticide @ 64kg/ha, T_7= Bavistin @ 0.1% as soil drenching.

The highest cormel weight hill^{-1} (29.75 g) was recorded in A_1 followed by A_2, A_3 A_4, A_5, A_6 and A_7 and the lowest weight of cormel hill^{-1} (22.00 g) was found A_{10} followed by A_9, A_8, A_7, A_6 and A_5. The maximum cormel yield plot^{-1} (1183 g) was produced by the treatment option A_1 which was statistically identical to A_2, A_3 A_4, A_5 and A_6. The minimum cormel yield plot^{-1} (744g) was found in the treatment A_{10} followed by A_9, A_8 and A_7. Treatment A_1 produced the highest cormel yield ha^{-1} (2.82 t) which was statistically identical to A_2, A_3 A_4 and A_5 and the lowest yield (1.77 t ha^{-1}) was recorded A_{10} followed by A_9, A_8 and A_7.

Integrated management of Fusarium wilt of gladiolus was performed by incorporating the treatments and it appeared from the results that Poultry refuse @ 5t/ha in soil at 25 days before sowing in addition corm treated with Bavistin @ 0.1% for 15 minutes and soil drenching with Bavistin @ 0.1% at 45 days after sowing gave better control of the disease and increased germination, plants hill^{-1}, spike number and quality, corm and cormel production. Hossain *et al.* (2007) reported that use of poultry manures and seed treatment with Vitavax-200 and poultry manures and soil drenching with Bavistin showed better performance in reducing stem canker and black scurf disease of potato.

The another combination was mustard oil cake (600 kg/ha) applied in soil at 25 days before sowing including corm treated with Bavistin @ 0.1% for 15 minutes and soil drenching with Bavistin @ 0.1% at 45 days after sowing performed better in controlling disease infestation as well as increased yield. This findings is supported by Nikam *et al.* (2007) who reported chickpea wilt due to *Fusarium oxysporum* f. sp. *ciceri* being soil borne disease could be managed by integrating varoius practices like using resistant varieties, seed treatment with chemicals, seed and soil application of bio-agents and amendments of soils with oils seeds cake. Sharma *et al.* (2005) studied integrated approach using pots treated with neem cake, carbendazim and *Trichoderma harzianum* revealed the highest disease control (Fusarium yellows), enhanced corm yield and improved plant health of gladiolus. Sultana and Ghaffar (2010) reported Carbendazim and soil amendments with mustard oil cake as more effective to control *Fusarium solani* in other crops.

Another combination was bio-pesticide (64 kg/ha) incorporation in soil at 7 days before sowing, corm treated with Bavistin @ 0.1% for 15 minutes and soil drenching with Bavistin @ 0.1% at 45 days after sowing was also better in controlling disease infestation as well as increased yield. Khan and Mustafa (2005) reported application of carbendazim, *T. harzianum* and *Pseudomonas fluorescence* decreased the corm rot and yellows scores and the soil population of the pathogen and increased plant growth and flowering. Mishra *et al*. (2005) studied the effect of integration of chemicals and biological control agents against gladiolus corm rot. Mirsha *et al.* (2000) used *Trichoderma virens*, carboxin and a combination of both and found good for the control of gladiolus corm rot and wilt caused by *Fusarium oxysporum* f. sp. *gladioli* in glasshouse and field experiment.

Conclusion

Corm treated with Bavistin (0.1%) for 15 minutes + Poultry refuse @ 5t/ha in soil application 25 days before corm sowing + Bavistin @ 0.1% as soil drenching at 45 days after corm sowing gave best option for integrated management of Fusarium wilt of gladiolus and thereby resulting maximum germination, spike length, rachis length, florets spike^{-1}, flower sticks, corm and comel yield. On the other hand, integration of Bavistin (0.1%) as corm treatment for 15 minutes + Mustard oil cake @ 600 kg/ha in soil application 25 days before corm sowing + Bavistin (0.1%) as soil drenching at 45 days after corm sowing also reduced Fusarium wilt of gladiolus. Similarly, integration of Bavistin (0.1%) as corm treatment for 15 minutes + Bio-pesticide in soil application 7 days before corm sowing + Bavistin (0.1%) as soil drenching at 45 days after corm sowing also effective in inhibiting the disease incidence as well as better spike length, rachis length, florets spike^{-1}, flower sticks, corm and cormel yield.

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