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Organic amendment, biocontrol agents and soil solarization practice in management of Fusarium wilt of carnation caused by *Fusarium oxysporum* Schledit. f.sp. *dianthi* (Prill. and Del.) Snyd. and Hans.

■ SUNITA CHANDEL

Department of Plant Pathology, Dr. Y.S.P University of Horticulture and Forestry, Nauni, SOLAN (H.P.) INDIA

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***Corresponding author:**
Email: schandelmpp@rediffmail.com

ABSTRACT

Carnation is severely affected by *Fusarium oxysporum* f.sp. *dianthi* which considerably affect the yield and quality of the flowers. Use of organic amendments, biological control agents and soil solarization alone and in combination with antagonists was tried in the present investigation. The results revealed that neem cake and pine needles out of nine organic amendments gave 77.49 and 72.49 per cent disease control with minimum disease incidence. Combined application of two antagonists *Trichoderma viride* and *T.harzianum* after 60 days of soil solarization practices registered minimum incidence (16.25%) of the disease followed by *T. viride* and *T. harzianum*. The growth characteristics stem length, number of flowers and flower size per plant also increased significantly in these treatments.

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INTRODUCTION

Carnation botanically known as *Dianthus caryophyllus* L. is one of the major commercial cut flowers in the florists trade in the world flower market belonging to family Caryophyllaceae. In India, it occupies an area of 65.30 ha with an average estimated production of 63341000 flowers annually while in Himachal Pradesh, it is grown over an area of 9-10 ha with over return of approximately Rs. 8.6 crore (Jyotsna, 2001). The flower is infected heavily by wilt causing fungus, *Fusarium oxysporum* f.sp. *dianthi*, which produces chlorosis and distortion of the lower leaves often on one side of the plant followed by vascular discoloration and stem necrosis. The wilted plants become stunted, yellow and dry often with hollow stem (Hood and Stewart, 1957 and Bowers and Locke, 2000).The pathogen is present in the soil profile in which carnation roots are distributed and may infect the plants at any time during the growing season (Ben-Yephet *et al*., 1992). The pathogen is widespread in soils worldwide. The disease regarded as most devastating causing huge losses upto the tune of 60 per cent among other diseases of carnation due to its widespread nature, encountred from United States, Britain (Hood and Stewart, 1957), Columbia and South America (Evans,1978), Nepal (Villiam *et al*., 1972), Germany (Jacob and Krebs, 1985), Italy (Filippi and Bagonoli, 1992), Poland (Manko and Fruzysiska-Jozwick, 1992), Israel (Ben-Yephet *et al*., 1993), Veramin area of Iran (Etabarian,1996) and other parts of the world including India (Katoch, 1999) where the losses attributed as high as 79 per cent in contaminated soils under protected cultivation. Looking into the severity of the disease, the present study was undertaken with the management of carnation wilt employing organic amendments, soil solarization individually and in combination with antagonists.

MATERIAL AND METHODS

Soil amendments :

Various organic amendments such as neem cake, cotton cake, mustard cake, cast or cake, soybean cake, apricot seed cake, olive cake, sunflower cake and dry pine needles in powdered form were added in formaline (5.0 %) sterilized soil, which was pre- inoculated with 40 g maize bran medium of the Fusarium pathogen. The organic amendments were mixed thoroughly after seven days of the pathogen addition @ 2 per cent (w/w/basis) in the earthen pots of 6 inches diameter. The one month old rooted cuttings of carnation cv. MASTER RUBESCO were planted after 15 days of the inoculation and amendment mixing in the soil. Three cuttings were planted in earthen pots with four replications along with control treatment. The data on disease incidence was recorded after 35 and 60 days.

Soil solarization individually and in combination with antagonists on diseases and plant growth characters :

The effect of soil solarization alone and in combination with antagonist was ascertained on the Fusarium wilt development. The biocontrol agents were procured from the Department of Plant Pathology. The bed size of 8x1m was maintained in the research field of Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P). The beds were inoculated with maize grain medium of *Fusarium oxysporum* f. sp. *dianthi* @200 g/m^2 before planting of the cuttings and the initial pathogen (*Fusarium oxysporum* f .sp. *dianthi*) population was also estimated by taking the soil samples randomly from the field. After 15 days of inoculation the irrigated beds were covered with transparent polythene mulch of 25 µ thickness for two months (April-May, 2011). The edge of the mulch was buried in the soil to make them air tight. In control, the beds remained uncovered and the soil samples from polythene covered and uncovered soil were analyzed regularly every 15 days upto 2 months for the pathogen population. In case of combined effect along with antagonists, the carnation cuttings were dipped in the spore suspension at dilution factor of 10^{-6} for 20 minutes in different antagonists *Trichoderma viride, T. harzainum, T. virens, Bacillus* sp. and *Aspergillus* sp. and planted in solarized and unsolarized beds. The control treatment remained without antagonist, only water was used and every treatment was replicated thrice following Randomized Block Design (RBD). On outbreak of the disease, the soil drench with the antagonists was given twice in the growing season. The data for disease incidence and plant growth characteristic were recorded after 35 and 60 days, respectively.

RESULTS AND DISCUSSION

Two organic amendments neem cake and pine needles out of nine found statistically superior in reducing the disease by giving 41.39 and 28.46 per cent disease control. Whereas mustard cake and cotton seed cake gave 47.42 and 37.75 per cent disease control, respectively which was found statistically at par with each other. Castor cake however recorded minimum per cent disease control 25.59 (Table 1). The results are in conformity with those reported by Singh (1983) and Sharma and Bedi (1988) who observed the role of neem extract and mustard cakes in control of chickpea and cotton wilt, respectively. The population of the test fungus was reduced quite drastically to 5.50x10^3/g soil from initial count of

Table1: Management of Fusarium wilt of carnation using organic amendments

Organic amendment	Per cent disease incidence 35 days	60 days	Mean	Per cent disease control
Pine needles	20.83(27.06)	25.00(29.85)	22.92(28.46)	72.49
Cotton seed cake	35.41(36.52)	39.58(38.99)	37.50(37.75)	54.99
Mustard cake	33.33(35.20)	37.50(37.75)	54.17(47.42)	57.49
Soybean cake	52.08(46.22)	56.25(48.62)	41.67(40.19)	35.00
Apricot seed cake	39.58(49.82)	43.75(41.42)	60.42(51.06)	50.00
Castor cake	58.33(49.82)	62.50(52.29)	18.75(25.59)	27.49
Neem cake	16.67(24.11)	20.83(27.06)	43.75(41.39)	77.49
Olive cake	41.66(40.15)	45.83(42.62)	50.00(45.02)	39.58
Sunflower cake	47.92(43.82)	52.08(46.22)	83.33(66.11)	40.00
Control	81.25(64.46)	85.41(67.77)	--	--
Mean	42.71(40.59)	46.87(43.26)	--	--

Fig. in parenthesis are arc sine transformed values; C.D. (P = 0.05) Treatment: 3.52, Days: 1.57, Treatment x days: 4.80

13.75×10^3/g soil. The present finding are in agreement with Katoch (1999) and Singh *et al.* (2002) who studied the effect of neem oil-cake amendment on soil mycoflora.

There is drastic reduction in disease incidence in solarized soil (31.25%) than unsolarized soil (85.0%) (Table 2). The population count of *Fusarium* pathogen minimized to 5.50×10^3 /g soil from the initial count of 13.75×10^3 /g soil in solarized soil. Although an additive effect of soil solarization and antagonist application was observed on wilt incidence (Table 2). It was revealed that antagonists *Trichoderma viride* and *T. harzianum* together registered minimum incidence (20.12 %), followed by alone treatments of these antagonists that resulted in least disease percentage of 13.75 and 16.25 after 35 and 60 days than the untreated soils that yield the disease incidence upto 91.67 per cent (Table 3). A positive correlation also existed on plant growth parameters in the above treatments. Average maximum spike length, diameter of flowers, flower size also increased simultaneously in antagonists treated solarized soils. The average maximum spike length (65.45cm) was observed in case of S + *T. viride* followed by S + *T. harzianum* (65.05cm), S+ *T. virens* (64.67cm) and S+*T. viride* + *T. harzianum* (64.60cm) (Table 3). All the treatments were statistically at par with each other and superior to control (24.37cm). Maximum number and diameter of flowers were also comparatively high in these treatments (Table 4). Similarly the studies conducted by Raj and Gupta (1995) revealed the effectiveness of soil solarization against *Fusarium solani* causing mango wilt. Wong (1985) and Tjamos

Table 2: Effect of soil solarization on carnation wilt

Treatments	Per cent disease incidence		Mean
	35 days	60 days	
Solarized soil	30.00(33.23)	32.50(34.76)	31.25(33.99)
Unsolarized soil	83.75(66.45)	86.25(68.34)	85.00(67.40)
Mean	56.88(49.84)	59.38(51.55)	--

Fig. in parenthesis are arc sine transformed values;

Population of test pathogen:	Initial	Final
Unsolarized soil	14.00×10^3/g soil	23.00×10^3/g soil
Solarized soil	13.75×10^3/g soil	5.50×10^3/g soil

C.D. (P = 0.05) Treatment: 1.80; Days: 1.66, Treatments x days: 2.46

Table 3 : Combined effect of soil solarization and antagonist on the incidence of carnation wilt

Antagonist	Per cent disease incidence				Mean
	Solarized soil		Unsolarized soil		
	35 days	60 days	35 days	60 days	
T. viride	12.50(20.62)	15.00(22.80)	22.92(28.54)	31.54(33.96)	20.49(26.48)
T. harzianum	16.25(23.74)	18.75(25.63)	22.83(27.06)	25.00(29.86)	20.70(25.58)
T. virens	20.00(26.49)	22.50(28.30)	33.33(35.28)	43.75(41.42)	29.40(33.51)
Aspergillus sp.	23.75(29.16)	26.50(30.82)	39.58(38.99)	47.92(43.82)	34.44(35.71)
T. viride+ *T. harzianum*	13.75(21.57)	16.25(23.74)	22.83(27.06)	27.68(31.33)	20.12(25.92)
Control	30.00(33.23)	32.50(34.76)	81.25(64.46)	91.67(73.26)	58.85(51.39)
Mean	19.38(25.80)	21.92(27.68)	36.45936.45)	44.49(42.28)	--

Fig. in parenthesis are arc sine transformed values; Overall mean of solarized soil: 20.65(26.74); Overall mean of unsolarized soil: 40.47(39.58); C.D. (P = 0.05) Antagonist: 2.14; Treatment: 1.07; Antagonist x treatment: 4.09; Antagonist x days: 4.09; Treatment x days: 2.05; Antagonist x days: 5.89

Table 4 : Combined effect of soil solarization and biocontrol agents on plant growth parameters of carnation

Treatments	Plant growth parameters		
	Avg. stem length/plant (cm)	Avg. number of flowers/ plant	Avg. size of flower/plant (cm)
Solarized soil(S)	54.62	3.75	6.08
S + *T. viride*	65.45	4.75	7.48
S + *T. harzianum*	65.05	4.75	7.55
S + *T. virens*	64.67	4.50	7.2
S + *Aspergillus* sp.	55.67	4.00	6.65
S + *T. viride* + *T. harzianum*	64.60	4.75	6.42
Control	24.37	1.25	2.35
C.D. (P = 0.05)	0.93	0.94	0.32

(1997) also found that effectiveness of *Trichoderma harzianum* in solarized soil in controlling wilt of carnation *vis a vis* improving the growth parameters. Lingan *et al*.(2014) used talc based consortium of *Pseudomonas florescence* and *T. harzianum* as root dipping, soil application and foliar sprays which reduced wilt of carnation to 7.8 per cent and enhaced the otherplant and flower parameters.

Neem cake, pine needles as organic amendments and *Trichoderma viride*, *T. harzianum* antagonists in combination as root and soil drench after soil solarization practice can thus become an effective component in organic management of carnation wilt by giving their additive effect in disease reduction and growth promoting parameters. Green house experiments showed that plant growth medium based on grape marc compost (compost : peat 1:1, v/v) amended with the biological control agent *Trichoderma asperellum* strain T34, restores composts'suppressive capacity against Fusarium wilt of carnation compared with the non-amended medium. Standard chemicals (tocloflos-methyl 50% and captan 85%) used in the cultivation of carnation crops did not improve the suppressive capacity of the growth media or the T34 populations (Sant *et al.,* 2010 and Dabbas *et al.,* 2012).

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