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Studies on the interactive effect of *Meloidogyne incognita* and *Fusarium solani* on *Lycopersicon esculentum*, Mill

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Abstract: A disease complex involving *Meloidogyne incognita* and *Fusarium solani* was studied on tomato (*Lycopersicon esculentum*, Mill.) under glasshouse conditions. Pot experiments were conducted to determine the pathogenesis of both the pathogens individually, simultaneously and sequentially. Isolates of *M. incognita* and *F. solani* singly caused a significant reduction in plant height, fresh weight, dry weight, number of fruits and fruit weight over the un-inoculated one but the reduction was more by *M. incognita* as compared to *F. solani*. A significant reduction in different plant growth parameters was observed on simultaneous and sequential inoculation of *M. incognita* and *F. solani*. However, the reduction was more prominent on simultaneous inoculation of both the pathogens. Among the sequential inoculations more damages were assessed during inoculation of *M. incognita* followed by *F. solani* ($N+f_{10}$). Nematode multiplication, number of galls and number of females were adversely affected on simultaneous and sequential inoculation of both the pathogens in all the treatments. In the present study it was concluded that both the pathogens viz *M. incognita* and *F. solani* are virulent against the tomato c.v pusa ruby and therefore measures to prevent the spread of disease become important.

Key words: *Meloidogyne incognita*, *Fusarium solani,* disease complex, synergistic effect, tomato

INTRODUCTION

Tomato (*Lycopersicon esculentum*, Mill.) is one of the most important and widely grown vegetable crops in the world. It is grown all over the world because of its high nutritive value and an excellent source of vitamin A and C. It plays an important role in maintaining the human health. Being rich source of lycopene, tomato is used in the treatment of cancer, especially the prostate cancer (Giovannucci, 1999). According to the National Cancer Institute, there is now enough data to show that people who consume large amount of tomato products have significantly decreased risk of prostate, lung and stomach cancer. In India, tomato is being cultivated at an area of 5.99 lakh hectares with an annual production of 111.49 lakh metric tones (NHB Data Base, 1999). Root-knot nematodes which produce conspicuous galls on plant roots are considered among the top five major plant pathogens (Bharadwaj and Sharma, 2007). Root-knot nematode, *Meloidogyne incognita* is one of the major constraints in the production of vegetables including tomato. Among the various plant pathogens root-knot nematode *Meloidogyne* spp. is widespread, destructive, most dangerous and difficult to control in crop cultivation system (Fourie and McDonald, 2000; Sharma *et al*., 2007, 2008). Yield losses in tomato ranging from 28 to 70% have been reported by various researchers (Ibrahim *et al*., 2000; Rajinderan *et al*., 2003). It has been reported that *Meloidogyne* species alone cause 90-100% yield loss in tomato crop (Shahid *et al*., 2007; Olabiyi, 2008). Root-rot fungus is equally a well-known pathogen of many vegetable crops. *Fusarium* spp. is a highly destructive pathogen of both greenhouse and field grown tomatoes in warm vegetable production areas (Yigit and Dikilitas, 2007). The importance of disease complex has been matter of serious concern since the time of it's first report by Atkinson (1892) when wilt resistant cotton became susceptible in presence of root-knot nematode. Synergistic effect of root-knot nematodes with other pathogens in disease development causes severe damage (Pathak and Keshari, 2004; Anwar and Khan, 2002). These microbial infections are often more economically damaging than the direct effect of nematode feeding alone. Previous studies have observed that root-knot nematode *Meloidogyne* spp. enhances damage caused by various root-rot fungi (Singh and Goswami, 2001; Senthamarai *et al*., 2008; Mokbel *et al*., 2007). *Meloidogyne* and *Fusarium* are frequently associated with various crop plants resulting in their considerable damage (Bhagawati *et al*., 2000, 2007). Considering the

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damage and loss caused by these pathogens to various crop plants an attempt was made to know the inter relationship, if any between these two pathogens viz., *Meloidogyne incognita* and *Fusarium solani* on tomato c.v pusa ruby.

MATERIALS AND METHODS

The experiment was conducted under glass house conditions in the Department of Botany, Aligarh Muslim University (AMU) India during the year 2009. The earthen pots of 15 cm diameter were disinfected with 4% formaldehyde solution and filled with steam sterilized soil (1 kg pot^{-1}). The seeds of tomato c.v pusa ruby were seeded in the centre of each pot after surface sterilization with 0.1% mercuric chloride for 2 min. On germination, plants were thinned down to one plant/pot.

Fusarium solani was isolated from roots and collar region of the infected tomato plants. The diseased plants showed the symptoms of wilting and root browning. After purification it was grown on potato dextrose broth medium for 15 days at 25°C in BOD incubator.

Root knot nematode *M. incognita* was isolated from the infected roots of tomato plant. Nematodes were extracted by petridish assembly method (Chawla and Prasad, 1974). Pure culture was multiplied and after processing the number of larvae per ml suspension was counted before inoculation. The counting of nematode per millilitre suspension was done by means of specially made counting dish under the stereomicroscope.

For nematode and fungus inoculation the soil around plant collar region was removed carefully. The required quantity of nematode at the rate of 1 J_2/g soil and fungus 2 g mycellial mat/plant were inoculated and covered immediately with the top soil. The treatments of the interaction study consisted of nematode and fungus inoculated singly, nematode and fungus inoculated simultaneously (N+F), fungus inoculated at 10 days after nematode inoculation ($N+F_{10}$) and nematode inoculated at 10 days after inoculation of fungus ($F+N_{10}$). An un-inoculated pot was also kept which served as control. The treatments were in completely randomized design with three replicates of each treatment. The plants were regularly watered and due care was taken throughout the experimentation. Seventy five days after inoculation plants were uprooted carefully washed free of soil and observations regarding various plant growth parameters and nematode population were recorded.

Statistical analysis: Data were subjected to Analysis of Variance (ANOVA). The mean differences were evaluated for their significant level by Duncans Multiple Range Test (DMRT). The analysis of data was done by using SPSS16 software.

RESULTS AND DISCUSSION

Result of interactive effect of root-knot nematode *Meloidogyne incognita* and root-rot fungus *Fusarium solani* on plant length, fresh weight, dry weight, number of fruits and fruit weight are presented in Table 1. The results revealed that both the pathogens *Meloidogyne incognita* and *Fusarium solani* individually caused significant reduction in various plant growth parameters as compared to un-inoculated control. When pathogens were inoculated simultaneously or sequentially, the decline in plant growth parameters was greater than with either pathogen alone. Maximum reduction in shoot length (43.83%), root length (52.02%), fresh weight of shoot (52.81%) and root (60.99%) and dry weight of shoot (57.75%) and root (67.96%) was recorded on simultaneous inoculation of both the pathogens followed by treatments were nematode inoculation preceded fungus. In the present study, it was observed

Table 1: Interactive effect of *Meloidogyne incognita* and *Fusarium solani* on different plant growth parameters of tomato

	Length (cm)			Fresh weight (g)			Dry weight (g)				
Treatment	Shoot	Root	Total	Shoot	Root	Total	Shoot	Root	Total	No. of fruits	Fruit weight (g)
Control	45.4	39.6	85^{a}	160	90.5	250.0^{a}	37.4	20.6	58^{a}	12.0^{a}	250.0^{a}
N	36.5	30.2	66.7^{c}	123.5	64.7	188.2^{b}	26.5	13.3	39.8^{c}	9.0^{c}	185.4^{bc}
	(19.6)	(23.73)	(21.52)	(22.81)	(28.50)	(24.72)	(29.14)	(35.43)	(31.37)	(25.0)	(25.84)
F	41.3	34	75.3^{b}	132.6	70.2	202.8^{b}	29.4	14.5	43.9^{b}	10.6^{b}	205.0^{a}
	(9.03)	(14.14)	(11.41)	(17.12)	(22.43)	(18.88)	(21.39)	(29.61)	(24.31)	(11.66)	(18)
N+F	25.5	19	44.5^{e}	75.5	35.3	110.8^{d}	15.8	6.6	22.4^{e}	6.0^{e}	120^{d}
	(43.83)	(52.02)	(47.64)	(52.81)	(60.99)	(55.68)	(57.75)	(67.96)	(61.37)	(50)	(52)
$F+n_{10}$	32.3	25.5	57.8^{d}	105	51.6	156.6^{c}	22	10	32.0^{d}	7.5^{d}	172.6^{c}
	(28.85)	(35.6)	(32)	(34.37)	(42.98)	(37.36)	(41.17)	(51.45)	(44.82)	(37.5)	(30.96)
$N+f_{10}$	28	21.6	49.6^{e}	79.7	38.5	118.2^{d}	16.2	7.5	23.7^{e}	7.0^{d}	135^{d}
	(38.32)	(45.45)	(41.64)	(50.18)	(57.45)	(52.72)	(56.68)	(63.59)	(59.13)	(41.66)	(46)
LSD (p = 0.050)			6.14			16.95			3.69	0.85	17.24
LSD (p = 0.01)			8.73			24.11			5.24	1.21	24.56

Values in parenthesis are percentage increase/decrease over control. Means not followed by same letters are significantly different according to Duncans Multiple Range Test (DMRT)

Table 2: Interactive effect of *Meloidogyne incognita* and *Fusarium solani* on nematode multiplication in tomato

Treatment	No. of galls/plant	No. of egg-masses/plant	No. of females/plant	Nematodes/500 g soil	Reproduction factor
Control	0.0^{e}	0.0^{e}	0.0^{e}	0.0^{d}	0.0^{d}
N	130.5^{a}	110.6^{a}	240.0^{a}	4580.0^{a}	4.58^{a}
F	0.0^{e}	0.0^{e}	0.0^{e}	0.0^{d}	0.0^{d}
N+F	65.6^{d} (49.73)	47.5^{d} (57.05)	115.6^{d} (51.83)	2870.2^{c} (37.33)	2.87^{c}
F+n_{10}	94.6^{b} (27.5)	75.7^{b} (31.55)	155.5^{b} (35.2)	3340.5^{b} (27.06)	3.34^{b}
N+f_{10}	78.2^{c} (40.07)	62.4^{c} (43.58)	130.3^{c} (45.7)	3010.6^{c} (34.26)	3.01^{c}
LSD(p = 0.050	7.74	6.3	13.6	284.6	0.28
LSD(p = 0.01)	11	8.97	19.35	404.81	0.40

Values in parenthesis are percentage increase/decrease over nematode inoculated treatment. Means not followed by same letters are significantly different according to Duncans Multiple Range Test (DMRT)

that reduction of various plant growth parameters, number of galls, number of egg masses, number of females and final nematode population was significantly higher in the treatments were nematode was inoculated prior to fungus viz., N+F and N+f_{10} as compared to treatments were fungus was inoculated prior to nematode viz., F+n_{10}. The synergistic effects of *M. incognita* and *F. solani* on tomato plants were consistently greater than the effect of either pathogen alone. This may be due to the reason that *M. incognita* predisposes tomato plants to *F. solani* and enhanced the severity of disease (Jonathan and Rajendran, 1998; Akhtar *et al*., 2007). Furthermore, nematodes cause injury on root surface, weakening the root tissue by causing rotting or lesions, thereby making host plant more prone to fungal attack (Senthamarai *et al*., 2008). Statistical analysis of the data shows that reduction in various plant growth parameters due to simultaneous inoculation of both the test pathogens was at par with those of the sequential inoculation of the treatments in which nematode preceded the fungus inoculation (N+f_{10}). In comparison to un-inoculated control (C) significant reduction was observed in the number and weight of tomato fruits on individual, simultaneous and sequential inoculation of *M. incognita* and *F. solani*. The highest reduction in tomato yield (50%) was observed on simultaneous inoculation of both the pathogens, followed by treatments were nematode preceded the fungus viz. N+f_{10} c (41.66%). However, the least reduction in tomato yield (11.66%) was observed on individual inoculation of *F. solani*. The results of the present study support the earlier findings of Tiwari (1998), Walia and Gupta (1986) and Latha (1997), who studied the various growth parameters of *Vigna mungo*, cowpea and black gram, respectively.

Table 2 shows the effect of individual, simultaneous and sequential inoculation of test pathogens on nematode multiplication. The maximum final nematode population of 4580 per 500 g soil was recorded in treatments with nematode alone, followed by treatments were fungus preceded the nematode (3340.5) and treatments where nematode preceded the fungus (3010.6). The minimum final nematode population per 500 g soil was found in treatments with simultaneous inoculation of both the pathogen (2870.2). The reproduction factor of various treatments signifies that lowest reproduction of *M. incognita* occurs in treatments in which both the pathogens were inoculated simultaneously. Among the sequential inoculations the higher nematode population and reproduction factor was observed in treatments in which fungus preceded the nematode inoculation. These results are in contradiction with those of Anwar and Khan (2002) and Bagawati *et al*. (2007), who observed the lower nematode population and reproduction factor in the treatments where fungus preceded the nematode inoculation.

Galls were present on roots of all seedlings which received larvae of *M. incognita*. However, inoculation of nematodes alone resulted in highest number of galls than the treatments in which pathogens were inoculated simultaneously and sequentially. Significant reduction of 49.73% in root galling was observed on simultaneous inoculation of both the pathogens, whereas on sequential inoculation of *F. solani* prior and after ten days of *M. incognita* a reduction of 27.5 and 40.07% was observed in root galling, respectively. The reduction in number of root galls and final nematode population in treatments where fungus was also present along with nematodes suggests that *F. solani* is inhibitory to nematode multiplication (Pathak *et al*., 1999; Pathak and Keshari, 2004).

CONCLUSION

The present study concludes that root-knot nematode *Meloidogyne incognita* and root-rot fungus *Fusarium solani* cause significant reduction in various plant growth parameters as well as on tomato yield. In view of the aggressiveness of these pathogens and by taking into account the medicinal and consumptive value of tomato, the management practices for the control of these pathogens should be stressed. Especially in areas where environmental conditions and tomato culture practices may favor the development of these pathogens.

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