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Dynamic role of studies on Interaction between *Meloidogyne javanica* and *Rhizoctonia solani* on tomato

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Abstract
Tomato (*Solanum lycopersicum* L.) is one of the major vegetable crops widely grown in almost every country in the world. The crop is prone to attack of various pathogens from early sowing of crop till maturity and amongst various soil borne diseases, root rot disease complex of tomato considered as the most devastating disease complex in Haryana. Fungus is an essential component of the interacting system of a fungus-nematode complex disease and plays an important role in the disease etiology. The present study was conducted under screen house conditions to know the effect of concomitant occurrence of *Rhizoctonia solani* and *Meloidogyne javanica* on root rot disease complex in tomato. Seeds of tomato cv. Hisar Arun (Selection 7) were inoculated with the nematode or fungus individually or simultaneously in various combinations and it was found that that maximum pre emergence plant mortality (30per cent), post emergence plant mortality (53.3 per cent) and 83.3 per cent disease incidence occurred when *M. javanica* (1000 J_2/kg soil) was inoculated one week prior to *R. solani* (1000mg/kg soil) followed by occurrence of 63.3 per cent disease incidence when *R. solani* and *M. javanica* were inoculated simultaneously. The severity of disease incidence was enhanced when inoculation of *M. javanica* preceded *R. solani* confirming that interaction of both the pathogens require consideration for management strategies.

Keywords: *Meloidogyne javanica*, pre-and post-emergence mortality, *Rhizoctonia solani*, tomato

Introduction
Tomato (*Solanum lycopersicum* L.) is one of the major vegetable crops grown widely in almost every country in the world and considered as "protective food" as it is rich source of vitamin K and C, minerals, organic acids and potassium. Tomato is a native of Andean regions of South America. India ranks second in the area and production of tomato after China. The estimated production of tomato in India is about 19.759 Lakh MT with productivity of 25.04 MT/ha and Haryana contributed 7.53 Lakh MT with productivity of 21.54 MT/ha. (www.indiastat.com, 2017-18). The crop suffers from vagary of diseases *i.e.* fungal, bacterial, nematode and viral diseases and among them, root-rot disease complex caused by concomitant occurrence of *R. solani* and *M. javanica* has been key problem which reduces yield and production greatly throughout the world yield loss ranging from 10 to 80% due to root-rot complex has been reported (Hadwan and Khara, 1992) [6]. It has been noted that *Meloidogyne* species alone cause 90-100% losses in yield in tomato crop (Shahid *et al*., 2007; Olabiyi, 2008) [10, 9]. *Rhizoctonia solani* causes pre-emergence and post-emergence plant mortality in seedlings, black lesions in root and stem rot. Root rot complex caused by *Rhizoctonia solani* and *Meloidogyne javanica* is considered as destructive disease of nursery as well as transplanted crop of tomato.
The present study was carried out to study the role of concomitant occurrence of *R. solani* and *M. javanica* on root rot disease complex of tomato with the aim to device management strategies.

Materials and Methods
The present study was carried out in Department of Plant Pathology, Chaudhary Charan Singh Haryana Agricultural University, Hisar during 2018-19.

Variety/cultivar used in experiment: The experiment was conducted on most popular variety Hisar Arun (Selection 7).

Isolation of pathogen: The diseased tomato seedlings with infection on collar region and roots were collected from tomato field of Department of Vegetable Science, CCS HAU, Hisar.

Infected seedlings were showing rotting and dark brown discoloration on collar region. The diseased portion was cut into small pieces and then the bits were surface sterilized with 0.1% mercuric chloride solution for about 30 seconds followed by washing several times with sterilized distilled water. The surface sterilized pieces were aseptically transferred on sterilized potato dextrose agar (PDA) medium in Petri plates and placed in incubator at 25±2 ^{0}C for seven days. The pure culture of *R. solani* was purified by hyphal tip method (Brown, 1924) [3] and maintained on PDA medium for further studies. Identification of fungus pathogen was done on the basis of the morphological characters, branching and colony characters.

Nematode culturing: Tomato plants showing galling were collected from CCS HAU, Hisar farm. The soil adhered was removed by washing the plant galled roots under tap water. The species of *Meloidogyne javanica* showing lateral lines was identified under microscope by cutting perineal patterns of the adult female. Lateral lines and high dorsal arc were visible in the *Meloidogyne javanica* which was multiplied on tomato crop and egg masses were collected from roots by using forceps. The collected egg masses were transferred to double fold tissue paper put on moulded pieces of aluminium wire net which was placed in Petri plates. Egg masses were submerged in plates by adding sufficient amount of water. The water containing J_2 larvae was collected next day and hatched J_2 larvae were used as pathogen inoculum for the present study.

Screen house experiment: Earthen pots of 15 cm diameter were filled with sterilized sandy loam soil (autoclaved at 22 psi for 2 h). The inocula were added @ 1000 mg of *Rhizoctonia solani* /kg soil and @ 1000 J_2 of *M. javanica* / kg soil. The inocula were mixed thoroughly upto 5 cm depth of the pot and tomato seeds tomato cv. Hisar Arun (Selection 7) were sown @10seeds/pot with treatments as presented as in Table 1. The different treatments used were inoculation of *R. solani* (1000 mg/kg soil), inoculation of *M. javanica* (1000 J_2/kg soil), *R. solani* (1000 mg/kg soil and *M. javanica* (1000 J_2/kg soil) inoculated simultaneously, *M. javanica* (1000 J_2/kg soil) inoculated one week prior to *R. solani* (1000 mg/kg soil), *R. solani* (1000 mg/kg soil) inoculated one week prior to *M. javanica* (1000 J_2/kg soil). The control pots without any pathogen inoculum were also maintained to compare the seeds germination. Each treatment was replicated three times and the experiment was laid out in a completely randomized design (CRD). The observations were recorded on per cent pre-emergence and post-emergence mortality (30 DAS) and calculated using the formula.

$$\text{Per cent Plant Mortality} = 100 - \frac{\text{Plants stand in inoculated treatment}}{\text{Plants stand in uninoculated control}} \times 100$$

Experimental data was analyzed by using OPSTAT software (https://www.hau.ac.in/page/o-p-stat).Critical differences (C.D.) were calculated at 5 per cent probability.

Results and Discussion

The experimental results on effect of *R. solani* and *M. javanica* inoculated individually or simultaneously in various combinations on tomato cv. Hisar Arun (Selection 7) are presented in Table-2. The inoculation of *M. javanica* (1000 J_2/kg soil) one week prior to *R. solani* (1000 mg/kg soil) resulted higher percentage of pre emergence (30%), post emergence (53.3%) and total mortality (83.3%) while it was lower when *R. solani* was inoculated one week prior to *M. javanica* with pre emergence (20%), post emergence (33.3%) and total mortality (53.3%). Total mortality of 63.3 per cent was observed when both *R. solani* and *M. javanica* were inoculated simultaneously as compared to total mortality of 43.3 per cent when *R. solani* inoculated alone (Fig.1).

The severity of disease incidence increased when *M. javanica* inoculated one week prior to *R. solani* suggesting that *M. javanica* predisposed the roots for further infection by *R. solani.* Disease incidence (*M. javanica* inoculated one week prior to *R. solani*) was found greater than the sum of the independent effects of *M. javanica* and *R. solani* indicating synergistic interaction in causing root rot disease complex in tomato. The reason for low infection when *R. solani* inoculated alone might be due to delay in the entry or due to absence of nutrient rich cells which were responsible for attracting the fungus to galled tissues (Kumar and Haseeb, 2009) [8]. There might be some physio-chemical changes in the host tissues leading to some chemical changes in root exudates containing amino acids, sugar and other carbohydrates that stimulated the growth of fungus. In other words, the nematode infected cells are easily attacked by fungus than uninfected cells (Abdel-Momen and Star, 1998) [1]. Experimental findings of interaction effects of these pathogens are in agreement of the results of Goswami *et al.* (2005) [5] Al-Hazmi and Al-Nadary (2015) [2] Gogoi *et al.* (2017) [4] who found greater damage due to prior invasion of *M. incognita* to roots, making them vulnerable for further fungal infection.

Table 1: Treatments for screen house experiment

Treatment	Description
T1	*Rhizoctonia solani*
T2	*Meloidogyne javanica*
T3	*R. solani* and *M. javanica*
T4	*M. javanica* inoculated one week prior to *R. solani*
T5	*R. solani* inoculated one week prior to *M. javanica*
T5	No inoculum

Table 2: Effect of concomitant occurrence of *R. solani* and *M. javanica* on root rot disease complex of tomato cv. Hisar Arun (Selection 7) under screen house conditions

Pathogen	* Per cent Disease Incidence		Total mortality (%)
	[1]PEM (%)	[2]POEM (%)	
Rhizoctonia solani (F)	16.7 (23.9)	26.7 (31.0)	43.4
Meloidogyne javanica (N)	0.0 (4.05)	0.0 (4.05)	0.0
R. solani and *M. javanica* inoculated simultaneously (F + N)	23.3 (28.8)	40.0 (39.2)	63.3
M. javanica inoculated one week prior to *R. solani* (N → F)	30.0 (33.2)	53.3 (47.0)	83.3
R. solani inoculated one week prior to *M. javanica* (F → N)	20.0 (26.6)	33.3 (35.2)	53.3
Check (No inoculum)	0.0 (4.05)	0.0 (4.05)	0.0
CD at 5%	(4.45)	(4.51)	-

*(Mean of 3 replications)
Figures in parenthesis are angular transformed values
[1]PEM = Pre-emergence mortality
[2]POEM = Post-emergence mortality

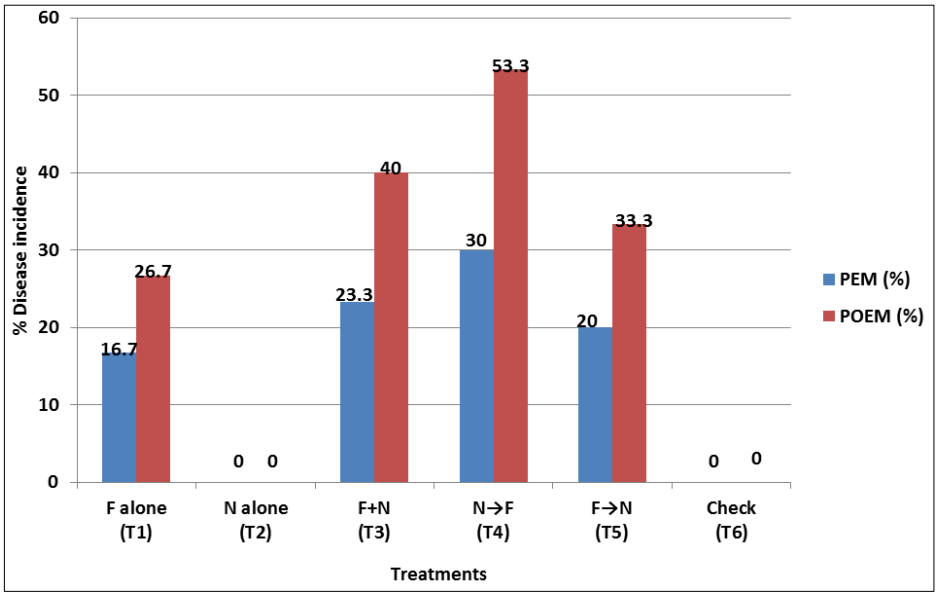

Fig 1: Interaction effect of sequential inoculation of *Meloidogyne javanica* and *Rhizoctonia solani* on root rot disease complex of tomato

Conclusion

Inoculation of *M. javanica* one week prior to *R. solani* caused greater disease incidence followed by when both *R. solani* and *M. javanica* were inoculated simultaneously indicating synergistic relationship between the pathogens. *M. incognita* acts as incitant for the entry of *R. solani* and predisposed the roots for further infection by *R. solani.* Hence, it is imperative that interaction of both the pathogens require consideration for management strategies.

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