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Field Evaluation of Tomato Genotypes for Resistance to *Meloidogyne incognita*

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Abstract.- The effects of *Meloidogyne incognita* on growth of tomato genotypes and nematode reproduction were studied in the nematode infested field. The genotypes included were Riogrande, Round-41, Round-27, Round Small-127, PB-47, PB-28 and PB-8. Three week old seedlings were transplanted on raised strips in a randomized complete block design with three replications. At 60 days, plants were uprooted, washed and ranked for root galling and egg mass indices on a 0 to 5 scales. The plant growth responses i.e., foliage length, foliage weight, root length and root weight and nematode reproduction in term of number of galls per root system, gall index, egg masses, egg mass index, eggs per root system, eggs per gram of root and second stage juveniles per 100-cm^3 of soil were recorded. The field experiment revealed that *M. incognita* was able to induce root galling and reproduced on all the seven tomato genotypes. All the genotypes were found susceptible to *M. incognita* infection however, responses were variable. Tomato cv. PB-8 and PB-28 were susceptible with gall index of 4. While other five genotypes namely Round-41, Riogrande, Round-27, Round Small-127, and PB-47 were highly susceptible having gall indices of 5. The findings of this trial proved that there is no resistant cultivar for growers to recommend.

Key words: Tomato, field conditions, root knot nematode.

INTRODUCTION

Tomato (*Lycopersicon esculentum*) is the second most important vegetable crop next to potato (FAO, 2009). Present world production is about 100 million tons fresh fruit produced on 3.7 million hectares. Tomato production has been reported for 144 countries; the major five countries are China, United States, Italy, Turkey and India, whereas Pakistan ranks 35 in tomato yields ranking in the world (FAO, 2009).

Tomato production is tremendously reduced due to pests and pathogens, the major biological constraints to low yield in Pakistan. The diseases include bacterial wilt, early and late blight, leaf curl, tomato spotted wilt virus, leaf spot and powdery mildew, physiological disorders (blossom end rot, cracking, sunburn or scald), insect pests and other arthropods (spider mites, thrips, white flies, bollworm), nematodes and poor crop management especially lack of crop rotation practice opportunities due to small land holdings. The institutional constraints include lack of improved and pest resistant varieties, lack of storage facilities, shortage of inputs such as irrigation water, fertilizers (manure and inorganic fertilizers), and lack of transportation; and market price constraints.

Plant-parasitic nematodes particularly root-knot nematodes (*Meloidogyne* spp.) are a severe constraint causing major economic damage to agricultural vegetable production including tomato around the world (Anwar *et al.*, 2007; Williamson and Hussey, 1996). These are endoparasitic-migratory-vascular feeders animal where during feeding they induce the formation of “galls” as well as the development of “giant cells" on the roots of their hosts. These alterations grossly affect nutrient partitioning and water uptake in the host (Anwar and Van Gundy, 1993). Root knot nematode particularly *M. incognita* is widely distributed and ranked most destructive pathogen on vegetable crops including tomato in the world (Anwar *et al.*, 2007; Sasser, 1980; Jones *et al.*, 1991; Fourie and McDonald, 2000).

Damage to tomato crop due nematodes has been documented by various workers. Shahid *et al.*

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(2007) has reported 90 to 100% yield losses due to plant parasitic nematodes on vegetable crops in the major production area of the Punjab. The tomato yield losses ranging from 32 to 40% due to root knot nematode has been reported (Anwar and McKenry, 2012). The prevalence of two root knot species including *M. incognita* (68%), *M. javanica* (9%) and in combination of *M. incognita +M. javanica* have been found in 53% of the tomato growing area of Sargodha during our nematode survey conducted by the senior author (Kamran *et al.*, 2010).

Several control strategies, such as host plant resistance, rotation with non-host crops, sanitation, destruction of residual crop roots, and discriminating use of nematicides, have been reported to effectively keep the root knot nematode population below damaging level (Barker and Koenning, 1998). However, the use of nematode resistant varieties remains the most viable option, particularly in Pakistan for growers with limited input resources. The purpose of this study was to determine: (i) the ability of *M. incognita* to reproduce on tomato genotypes and (ii) the effects of nematode reproduction on tomato plant growth.

MATERIALS AND METHODS

Plant materials

Seven tomato genotypes including PB-8, PB-28, PB-47, Round-27, Round-41, Round Small-127 and Riogrande, were evaluated in the field against known level of root knot nematode. The experimental field had 57J2 per cm^3 of soil. The soil was sandy loam (sand 56.25, silt 28.5%, and clay 15.3%).

Experimental procedure

The trial was conducted at the Experimental Farm of Continuing Education and Extension Department, University of Agriculture, Faisalabad. Based on our survey results (Anwar *et al*., 2007) the field used was known to be highly infested with *M. incognita*. Three week old seedlings of tomato genotypes were transplanted on raised strips. Transplants were spaced 30-cm apart in the row and 60-cm between rows with 5 plants per row. There were two rows for each block of replication. Trails were laid out in a randomized complete block design with three replications. Weeds were manually removed.

Data collection

Nematode densities were determined before planting and at the final harvest, 8-week after transplanting. A sample consisted of five soil cores (2.5 cm dia. x 30 cm deep) was taken from each row. Soil cores were mixed thoroughly and a 100-cm^3 sub sample was used for nematode extraction on sieving-cum-modified Baermann funnel technique (Thistlethwayte, 1970).

At final harvest, five plants from each replication were uprooted and roots washed gently to remove soil. Then the root systems of the plants were stained with Phloxine B (Holbrook *et al*., 1983) and rated for root galling and egg mass indices on a 0 to 5 scale (Queensberry *et al.*, 1989) where 0 is no galls/egg masses; 1 is 1-2 galls/egg masses; 2 is 3-10 galls/egg masses; 3 is 11-30 galls/ egg masses; 4 is 31-100 galls/egg masses and 5 is > 100 galls/egg masses per root system. The plant growth responses *viz*., foliage length (cm), foliage weight (g), root length (cm) and root weight (g) and nematode reproduction parameters *viz.*, number of galls per root system, gall index, egg masses, egg mass index, eggs per root system, eggs per gram of root, root knot nematode juveniles per 100 cm^3 of soil and nematode reproduction factor were also recorded.

Data analysis

Data were analyzed by ANOVA and mean comparisons were made using Duncan's multiple range (DMR) test at probability levels of (P=0.05).

RESULTS AND DISCUSSION

Meloidogyne incognita developed and reproduced at all seven tomato genotypes including Round-41, Riogrande, Round-27, PB-28 and PB-8 at initial inoculum level (Pi=57 J_2/100-cm^3). These seven tomato genotypes can be classified into three groups based on their response to nematode infection. *Meloidogyne incognita* was able to induce root galling on the roots of all the tomato genotypes but at differential rates, which might be due to genetic make-up differences among the geotypes

Table I.- Reproduction of *Meloidogyne incognita* on seven tomato genotypes in nematode infested field.

Tomato genotypes	Root galls	Egg masses	Indices[1]		Number of eggs per root		Rate of reproduction[2]
			Gall	Egg mass	system	Gram^{-1}	
Round-41	133 a[3]	104 a	5	5	22310 a	1127 b	18.75 a
Riogrande	126 b	95 b	5	4	20220 b	1126 b	15.84 b
Round-27	120 c	89 c	5	4	19250 bc	1222 ab	13.38 c
Round small-127	112 d	80 d	5	4	18800 c	1300 a	10.42 d
PB-47	105 e	77 de	5	4	17200 d	1260 a	9.263 e
PB-28	84 f	74 e	4	4	16080 e	1241 ab	7.871 f
PB-8	72 g	55 f	4	4	12680 f	998.7 c	6.199 g

[1] Gall and egg mass indices: 0-5 scale; where 0 = no galls or egg masses, 1 = 1-2 galls or egg masses; 2 = 3-10 galls or egg masses; 3 = 11-30 galls or egg masses; 4 = 31-100 galls or egg masses, and 5 = > 100 galls or egg masses per root system (Quesenberry *et al*., 1989).

[2] Rate of reproduction = Pf/Pi (Final Population/Initial Population)

[3] Means with in a column sharing the same letter are not significantly different from each other at $P = 0.05$ according to Duncan Multiple Range Test.

(Jacquet *et al.,* 2005). Group one included two tomato cultivars, Round-41 and Riogrande, which supported highest ($P = 0.05$) number of galls, egg masses, eggs, indices and rate of reproduction [Pf/Pi]. Round-27, Round Small-127, PB-47 three tomato genotypes exhibited intermediate response, and other two including PB-28 and PB-8 had revealed lowest of nematode infection (Table I).

Barker and Olthoe (1976) provided a thorough discussion of the terminology and schemes used to designate a host as good or poor for a given nematode species. Oostenbrink's reproductive factor (Pf/Pi) provides a basic measurement of the nematode's reproductive capabilities (Oostenbrink, 1966). Seinhorst (1967) used the equilibrium density (E) and maximum rate of reproduction to determine host status. Quantitative characterization of relationships in this manner provides fundamental models for predicting nematode reproduction.

High root gall and egg mass indices (4 to 5) for all seven tomato genotypes rendered them good host of *M. incognita*. Root galling indices have been used to assess host status of annual and perennial crops to root-knot nematodes (Marull *et al.,* 1994; Stirling and Cirami, 1998; Zhou *et al.,* 2000). However, root galling is not a satisfactory indicator of the durability of root-knot nematode resistance (McClure *et al.,* 1974; Hussey and Boerma, 1981; Reed and Schneider, 1992; Zhou *et al.,* 2000; Anwar and McKenry, 2002). In this experiment, we used egg mass number and number of eggs per root system as well as per gram of root and reproduction rate to evaluate tomato genotypes against infection by *M. incognita*. These three parameters are better indicators of nematode reproduction than root galling (Luzzi *et al.,* 1987; Hirunsalee *et al.,* 1995; Jenkins *et al.,* 1995; Ornat *et al.,* 2001; Anwar and McKenry, 2007). Plants are good hosts if values of rate of reproduction (Pf/Pi) are higher, poor hosts if Pf/Pi are low, which are influenced by environmental conditions for any plant and nematode combination (Seinhorst, 1967; Oostenbrink, 1966).

High values of reproduction rates for *M. incognita* confirmed that all seven tomato genotypes tested were good host for *M. incognita*. The reproduction rates on tomato genotypes are comparable to *M. incognita* reproduction on susceptible soybean (Nardacci and Barker, 1979) and to observed reproduction rates for endoparasitic and ectoparasitic nematodes reproducing on good hosts (Seinhorst, 1967).

Significant differences ($P = 0.05$) were visible among tomato genotypes in decline of top and root growth, and increase of J2 population in *M. incognita* infested soils at harvest after 60 days of transplantation (Table II). The extent of reduction in plant growth of tomato genotypes inflicted by nematodes was directly proportionate to increase in reproduction potential of *M. incognita* on specific tomato cultivar. Tomato cultivar Round-41and Riogrande supported significantly ($P = 0.5$) greater

Table II.- Plant growth of tomato genotypes and population build-up of *Meloidogyne incognita* in nematode infested field.

Tomato genotypes	Plant growth parameters[1]					J2 soil population/ 100-cm^3
	Plant length (cm)		Plant Fresh weight (g)		Weight of whole plant (g)	
	Shoot	Root	Foliage	Root		
Round-41	25.73 g	15.60 f	50.73 d	19.80 a	70.53 d	1069 a
Riogrande	28.30 f	17.70 e	55.57 c	17.97 b	73.53 c	902 b
Round-27	30.77 e	19.83 d	58.63 c	15.80 c	74.43 c	762 c
Round small-127	33.80 d	21.13 c	62.77 bc	14.47 d	77.23 bc	594 d
PB-47	35.97 c	20.77 c	66.73 ab	13.67 de	80.40 abc	528 e
PB-28	38.13 b	23.73 b	69.83 ab	12.97 e	82.80 ab	448 f
PB-8	41.40 a	26.60 a	73.63 a	12.70 e	86.33 a	353 g

[1] Means with in a column sharing the same letter are not significantly different from each other at $P = 0.05$ according to Duncan Multiple Range Test.

number of J2 and were able to cause more plant growth reduction compared to that of all other five tomato cultivars. Both nematode population and damaged inflected to plant growth was intermediate on three tomato genotypes including Round-27, Round Small-127, and PB-47. There was significantly ($P = 0.05$) low nematode population coupled with less plant growth reduction than that of other five tomato cultivars.

Plant growth reduction in tomato genotypes might be due to sever root galling and arrested root system by nematode infection. The ability of galled roots lead to modification in absorption of water and nutrient from soil and their translocation to foliage resulting in foliage chlorosis and stunting of vegetative growth (Bala, 1984). The arrested root system could not be able to fully explore the soil for water and nutrients (Clark *et al.*, 2003).

The occurrence of variation in susceptibility among seven tomato genotypes to *M. incognita* might be due to genetic differences (Brow *et al.*, 1997; Ehlers *et al.*, 2002; Jacquet *et al.*, 2005). The highly susceptible genotypes supported greatest number of juveniles penetrated and completed their development to maturity as shown by high gall numbers and egg masses present while in susceptible cultivar limited numbers of juveniles were able to penetrate, develop to maturity and lay egg masses.

This investigation on the reaction of commercially available tomato genotypes to *M. incognita* provides evidence that they are susceptible to nematodes in the infected field. The compatible reaction of all the seven tomato genotypes to *M. incognita* infection indicated that they lack resistant genes so genotypes were unable to stop the penetration, development, and reproduction. This suggests that we need to transfer resistant genes to our tomato genotypes from germplasmto avoid the infection by nematodes, which is essential for the management of root knot nematodes. This also warrants that growers must practice rotation with poor-nematode-host like cereals to avoid the losses.

REFERENCES

ANWAR, S.A. AND MCKENRY, M.V., 2002. Penetration and development of *Meloidogyne arenaria* on two grape rootstocks. *J. Nematol.*, **34**: 143-145.

ANWAR, S.A. AND MCKENRY, M.V., 2007. Variability in reproduction of four populations of *Meloidogyne incognita* on six cultivars of cotton. *J. Nematol.*, **39**: 105–110.

ANWAR, S.A. AND VAN GUNDY, S.D., 1993. Effect of *Meloidogyne incognita* on root and shoot growth parameters of susceptible and resistant varieties of tomato. *Afro-Asian J. Nematol*., **3**: 152-160.

ANWAR, S.A. AND. MCKENRY, M.V., 2012. Incidence and population density of plant-parasitic nematodes infecting vegetable crops and associated yield losses. *Pak. J. Zool*., **44**: 327-333**.**

ANWAR, S.A., ZIA, A., HUSSAIN, M. AND KAMRAN, M., 2007. Host suitability of selected plants to *Meloidogyne incognita* in the Punjab, Pakistan. *Int. J. Nematol.*, **17**: 144-150.

BALA, G., 1984. Occurrence of plant parasitic nematodes associated with crops of agricultural importance in Trinidad. *Nematropica*, **14**: 37-45.

BARKER, K.R. AND KOENNING, S.R., 1998. Developing sustainable system for nematode management. *Ann.*

Rev. Phytopathol., **36**: 165-205.

BARKER, K.R. AND OLTHOE, T.H.A., 1976. Relationships between nematode population densities and crop responses. *Annu. Rev.Phytopathol*. **14**: 327-352.

BROW, C.R., MOJTAHEDI, H., SANTO, G.S. AND WILLIAMSON, V.M., 1997. The effect of the *Mi* gene in tomato on reproductive factors of *Meloidogyne chitwoodi* and *M.* h*apla*. *J. Nematol*., **29**: 416-419.

CLARK, L.J., WHALLEY, W.R. AND BARRACLOUGH, P.B., 2003. How do roots penetrate strong soil? *Plant Soil*, **255**: 93-104.

EHLERS, J.D., MATTHEWS, W.C., HALL, A.E. AND ROBERTS, P.A., 2002. Breeding and evaluation of cowpeas with high levels of broad-based resistance to root-knot nematodes. In: *Challenges and opportunities for enhancing sustainable cowpea production* (eds. C.A. Fatokun, S.A. Tarawali, B.B. Singh, P.M. Kormawa, and M. Tamo). Proc. of the world cowpea Conf. III held at the Inter. Inst. of Tropical Agric. (IITA), Nigeria, Ibadan, pp. 41–51.

FAO, 2009. Faostat database collection http://apps.fao.org/page/collection.

FOURIE, H. AND MCDONALD, A.H., 2000. Nematodes. ARCLNR Leaflet. *Crop Prot. Ser*., **18**: 4-8.

HIRUNSALEE, A., BARKER, K.R. AND BEUTE, M.K., 1995. Infection, reproduction potential, and root galling by root-knot nematode species and concomitant populations on peanut and tobacco. *J. Nematol*., **27**: 172-177.

HOLBROOK, C.C., KNAUFT, D.A. AND DICKSON, D.W., 1983. A technique for screening peanut for resistance to *Meloidogyne incognita*. *Pl. Dis.*, **57**: 957-958.

HUSSEY, R.S. AND BOERMA, H.R., 1981. A greenhouse screening procedure for root-knot nematode resistance in soybean. *Crop Sci*., **21**: 794-796.

JACQUET, M., BONGIOVANNI, M., MARTINEZ, M., VERSCHAVE, P., WAJNBERG, E. AND CASTAGNONE-SERENO, P., 2005. Variation in resistance to the root-knot nematode *Meloidogyne incognita* in tomato genotypes bearing the *Mi* gene. *Pl. Pathol.*, **54**: 93-99.

JENKINS, J.N., GREECH, R.G., TANG, B., LAWRENCE, G.W. AND MCCARTY, J.C., 1995. Cotton resistance to root-knot nematode: II. Post penetration development. *Crop Sci*., **35**: 369-373.

JONES, J.B., JONES, J.P., STALL, R.E. AND ZITTER, T.A., 1991. *Compendium of Tomato Diseases*. *Am. Phytopathol. Soc*., St. Paul, MN.

KAMRAN, M., ANWAR, S.A., JAVED, N., KHAN, S. A. AND SAHI, G.M., 2010. Incidence of root-knot nematodes on tomato in Sargodha, Punjab, Pakistan. *Pak. J. Nematol*., **28**: 253-262.

LUZZI, B.M., BOERMA, H.R. AND HUSSY, R.S., 1987. Resistance to three species of root knot nematode in soybean. *Crop Sci*., **27**: 258-262.

MARULL, J., PINOCHET, J., FELIPE, A. AND CENIS, L., 1994. Resistance verification in *Prunus* selections to mixtures of thirteen *Meloidogyne* isolates and resistance mechanisms of a peach-almond hybrid to *M. javanica*. *Fund. appl. Nematol.*, **17**: 85-92.

McCLURE, M.A., ELLIS, K.C. AND NIGH, E.L., 1974. Resistance of cotton to the root-knot nematode, *Meloidogne incognita*. *J. Nematol.*, **6**: 17-20.

NARDACCI, J.F. AND BARKER, K.R., 1979. The influence of temperature on *Meloidogyne incognita*on soybean. *J. Nematol.*, **11**: 62-70.

ORNAT, C., VERDEJO-LUCAS, S. AND SORRIBAS, F.J., 2001. A population of *Meloidogyne javanica* in Spain virulent to the *Mi* resistance gene in tomato. *Pl. Dis.*, **85**: 271-276.

OOSTENBR1NK, M., 1966. Major characteristics of the relation between nematodes and plants. *Mede Landbouwhogesch, Wageningen*, **66**: 1-46.

QUESENBERRY, K.H., BALTENSPERGER, D.D., DUNN, R.A., WILCOX, C.J. AND HARDY, S.R., 1989. Selection for tolerance to root-knot nematodes in red clover. *Crop. Sci.*, **29**: 62-65.

REED, S.M. AND SCHNEIDER, S. M., 1992. Evaluation of *Nicotiana otophora* as a source of resistance to *Meloidogyne incognita* Race 4 for tobacco. *J. Nematol*., **24**: 253-256.

SASSER, J.N., 1980. Root-knot nematode: A global menace to crop production. *Pl. Dis.*, **64**: 36-41.

SEINHORST, J.W., 1967. The relationships between population increase and population density in plant parasitic nematodes. III. Definition of the terms host, host status and resistance. IV. The influence of external conditions on the regulation of population density. *Nematologica*, **13**: 429.

SHAHID, M., REHMAN, A.U., KHAN, A.U. AND MAHMOOD, A., 2007. Geographical distribution and infestation of plant parasitic nematodes on vegetables and fruits in the Punjab province of Pakistan. *Pak. J. Nematol*., **25**: 59-67.

STIRLING, G.R. AND CIRAMI, R.M., 1998. Resistance and tolerance of grape rootstocks to South Australian populations of root-knot nematode. *Aust. J. exp. Agric. Husband.*, **24**: 277-282.

THISTLETHWAYTE, B., 1970. Reproduction of *Pratylenchus penetrans* (Nematode: Tylenchida). *J. Nematol.*, **2**: 101-105.

WILLIAMSON, V.M. AND HUSSEY, R.S., 1996. Nematode pathogenesis and resistance in plants. *Pl. Cell*, **8**: 1735-1745.

ZHOU, E., WHEELER, T.A. AND STARR, J.L., 2000. Root galling and reproduction of *Meloidogyne incognita* isolates from Texas on resistant cotton genotypes. *Suppl. J. Nematol*., **32**: 513-518.

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