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Resistance or Susceptibility of Eight Aubergine Cultivars to *Meloidogyne javanica*

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ABSTRACT

Variations were observed in resistance or susceptibility among eight aubergine cultivars to *Meloidogyne javanica*. Brinjal Jamak was the only cultivar found to be moderately resistant. Two cultivars namely Brinjal Shilpa and Singh Nath 666 appeared moderately susceptible. Five cultivars *viz*. Round Black, Short Purple, Brinjal PPL, Global Brinjal PPL and Namyal Ratchburi behaved as susceptible. All the cultivars behaved differently regarding formation of galls, egg masses, number of eggs per egg mass and reproductive factor. Maximum galls, egg masses, eggs per egg mass and reproductive factors were observed on Round Black followed by Global Brinjal PPL and the minimum were recorded on cultivar Brinjal Jamak. Similarly, significant effects of *M. javanica* were observed on growth parameters of these cultivars. The reductions in moderately resistant cultivar were significantly lower as compared to the moderately susceptible and susceptible cultivars. The maximum reductions in shoot and root lengths and shoot weight were recorded in case of Round Black followed by Global Brinjal PPL. On the other hand, the minimum reductions in these parameters were found in Brinjal Jamak. Similarly, the infection of *M. javanica* caused an increase in root weights of all the cultivars. The increase in root weight was the minimum in cultivar Brinjal Jamak while it was the maximum in case of Round Black followed by Global Brinjal PPL. Regression analysis showed positive and significant relationships between number of galls and reductions in shoot and root lengths and weights. As the plants of moderately resistant cultivar Brinjal Jamak suffered less damage and suppressed nematode infection considerably and therefore, recommended for cultivation in root-knot nematode infested fields to abate yield losses and repress the nematode from further multiplication.

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Authors' Contribution
MTAK and MS designed the study, executed experimental work, analyzed the data and prepared the manuscript. TM helped in designing the study and supervised the experimental work.

Key words
Resistance, Infection, Reproduction, Susceptibility, Eggplant, Root-knot nematode.

INTRODUCTION

Among solanaceous vegetables, aubergine commonly known as eggplant and brinjal, is an important and widely cultivated vegetable in central, southern and south-east Asia, and in a number of African countries (Hazra *et al*., 2003). It is tropical and subtropical in origin. Most of its varieties are perennial in nature. It is extensively grown in Indo-Pak subcontinent and also popular in other countries (Shammugavelu, 1989). Aubergine has very good nutritive value (Nonneck, 1989). It is also widely cultivated in Pakistan and the area under its cultivation was 8325 hectares with 82999 tons of production during 2014-15. In Punjab, the area under aubergine cultivation was 4452 hectares which produced 54159 tons of aubergine. Many biotic factors have been found to affect the successful production of aubergine including insect pests (Javed *et al*., 2017a, b; Iftikhar *et al*., 2018; Kassi *et al*., 2018, 2019a, b; Nabeel *et al*., 2018; Aslam *et al*., 2019a), viruses (Ashfaq *et al*., 2017), fungi (Fateh *et al*., 2017), bacteria (Aslam *et al*., 2017a, 2019b) and particularly nematodes (Kayani *et al*., 2017, 2018; Kayani and Mukhtar, 2018; Mukhtar *et al*., 2017a).

Among nematodes, root-knot nematodes of the genus *Meloidogyne* are considered by far the most damaging pest of eggplant (Hussain *et al*., 2016). There are more than 100 species of root-knot nematodes but *Meloidogyne javanica* is one of the most important nematodes associated with low production of aubergine in Pakistan (Tariq-Khan *et al*., 2017). Root-knot nematodes are ranked at the top among the five major plant pathogens and the first among the ten most important genera of plant parasitic nematodes in the world (Mukhtar *et al*., 2017b; 2018). They have wide geographic distribution, large host range and high destructive potential. They have been reported to be implicated with other plant pathogens like *Ralstonia solanacearum* and result in disease complexes and aggravation of wilt diseases (Aslam *et al*., 2017b). In Pakistan, *M. incognita* and *M. javanica* have been found one of the most dominant root-knot species and rampant in the vegetable-producing areas of Pakistan and considerably reduces growth and yield (Kayani *et al*., 2018). Overall yield losses of 50 to 80% have been reported to be caused by root-knot nematodes in vegetables and 23% yield losses due to root-knot nematodes have been estimated on eggplant (Sasser, 1979). Root-knot nematodes have become a serious threat to the profitable cultivation of aubergine in the country. The yield losses by root-knot

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nematodes are mainly caused due to buildup of inoculum of the nematode and repeated cultivation of same cultivars in the same land every year (Hussain and Mukhtar, 2019).

The disease is commonly controlled by using chemicals which are being discouraged due to health hazards coupled with its use. The use of resistant cultivars is a feasible alternative and can be employed as an important component in integrated disease management programs (Khan *et al*., 2017; Mukhtar, 2018; Rahoo *et al*., 2017, 2018a, b, 2019). Development of resistant varieties is the only possible and feasible way of managing this disease. Breeding for resistance requires suitable sources of resistance. For this process, the suitable sources of resistance are necessary and there is scanty information about the resistance to this nematode in available aubergine germplasm in Pakistan. Therefore, the objective of the present study was to assess the degree of resistance among the available aubergine germplasm against this nematode pest.

MATERIALS AND METHODS

Aubergine germplasm

Eight aubergine cultivars collected from Federal Seed Certification and Registration Department, Islamabad were used in the screening assay. The cultivars comprised of Brinjal Shilpa, Singh Nath 666, Round Black, Short Purple, Brinjal Jamak, Brinjal PPL, Global Brinjal PPL and Namyal Ratchburi.

Raising of nursery

The nurseries of eight aubergine cultivars were raised separately in sterilized potting mixture in germination trays in the greenhouse. The daily temperature of the greenhouse ranged 25-27°C. The trays were watered when required.

Assessment of resistance to M. javanica *in aubergine germplasm*

The screening of aubergine cultivars for resistance or susceptibility to *M. javanica* was done in polythene bags measuring 12.75×10.15 cm. The bags were filled with sterilized soil containing 3:1:1 sand, silt and compost, respectively. Three week old seedlings were transferred individually to polythene bags. There were five replications for each treatment. One week after transplantation, the plants of each cultivar were inoculated with 2000 freshly hatched second stage juveniles of *M. javanica*. The plants of each cultivar which were not inoculated with juveniles served as control of that cultivar. The bags were arranged randomly in a glasshouse at a temperature of 25°C and watered as per requirement. The degree of resistance or susceptibility was assessed employing the rating scale reported by Taylor and Sasser (1978).

Data recording

Forty nine days after inoculation, the plants of all the cultivars were gently uprooted from their respective pots and the data were recorded regarding shoot and root lengths and weights, number of galls, egg masses, eggs per egg mass and reproductive factor. Percentage decreases or increases over control in growth variables were calculated.

Galls and egg masses were counted under a stereomicroscope at a magnification of 35×. After counting egg masses on the roots, eggs were extracted from the roots (Hussey and Barker, 1973) and counted. The nematodes were also extracted from soil of each pot using Whitehead and Hemming tray method (Whitehead and Hemming, 1965). The eggs and nematodes extracted from soil formed the final nematodes population. The reproduction factors were calculated by dividing the final nematode populations by the initial ones.

Table I.- Effect of *Meloidogyne javanica* on infection parameters of aubergine cultivars.

Cultivar	No. of galls	No. of egg masses	Eggs per egg mass	Reproductive factor	Response
Brinjal Shilpa	25.4±3.21	22.4±3.91	215.8±9.11	2.41±0.33	Moderately susceptible
Singh Nath 666	28.2±2.69	24.2±3.85	220.2±8.89	2.66±0.38	Moderately susceptible
Round Black	83.6±4.12	78.6±5.13	249.6±10.34	9.71±0.83	Susceptible
Short Purple	56.4±3.73	50.0±4.17	236.0±9.44	5.90±0.85	Susceptible
Brinjal Jamak	9.2±1.85	7.6±1.88	170.8±11.32	0.65±0.26	Moderately resistant
Brinjal PPL	65.2±3.85	59.6±4.86	242.4±10.86	7.21±0.91	Susceptible
Global Brinjal PPL	73.8±4.11	66.2±5.21	248.4±15.31	8.21±0.81	Susceptible
Namyal Ratchburi	43.0±3.34	38.4±3.94	230.2±13.68	4.37±0.92	Susceptible

Values (±SE) are means of five replicates.

Statistical analysis

Completely Randomized Design was used in the experiment. All the data were subjected to Analysis of Variance using statistical software Genstat 12th edition. Means were compared by Fisher's Protected Least Significant Difference Test. A significance level of $p \leq 0.05$ was used in statistical analyses. The linear relationships between number of galls as independent variable (x) and growth parameters as dependent variables (y) were calculated in Microsoft Excel 2007. Standard errors of means were also calculated in Microsoft Excel 2007.

RESULTS

Variations were observed in resistance or susceptibility among eight tested aubergine cultivars and no high levels of resistance or susceptibility was found. Brinjal Jamak was the only cultivar found to be moderately resistant. Two cultivars namely Brinjal Shilpa and Singh Nath 666 appeared moderately susceptible. Five cultivars *viz*. Round Black, Short Purple, Brinjal PPL, Global Brinjal PPL and Namyal Ratchburi behaved as susceptible (Table I).

All the cultivars behaved differently regarding formation of galls, egg masses, number of eggs per egg mass and reproductive factor. Maximum galls, egg masses, eggs per egg mass and reproductive factors were observed on Round Black followed by Global Brinjal PPL and the minimum were recorded on cultivar Brinjal Jamak as shown in Table I.

The analysis of variance showed highly significant effects of *M. javanica* on growth parameters of these cultivars. The nematode resulted in significant reductions in growth variables of all the cultivars over their controls. The reductions in moderately resistant cultivar were significantly lower as compared to the moderately susceptible and susceptible cultivars. The maximum reductions in shoot and root lengths and shoot weight were recorded in case of Round Black followed by Global Brinjal PPL. On the other hand, the minimum reductions in these parameters were found in Brinjal Jamak. Similarly, the infection of *M. javanica* caused an increase in root weights of all the cultivars. The increase in root weight was the minimum in cultivar Brinjal Jamak while it was the maximum in case of Round Black followed by Global Brinjal PPL (Table II). Regression analysis showed positive and significant relationships between number of galls and reductions in shoot and root lengths and weights and are shown by regression equations and trend lines in Figure 1.

Table II.- Effect of *Meloidogyne javanica* on growth parameters of aubergine cultivars.

Cultivar	Shoot length	Root length	Shoot weight	Root weight
Brinjal Shilpa	0.9±0.04	1.2±0.13	2.8±0.21	1.2±0.14
Singh Nath 666	1.1±0.07	1.3±0.15	3.5±0.25	1.3±0.12
Round Black	4.9±0.76	3.9±0.36	8.2±0.83	7.3±0.73
Short Purple	2.8±0.28	2.8±0.32	5.5±0.64	3.6±0.45
Brinjal Jamak	0.3±0.04	0.1±0.07	0.9±0.05	0.6±0.09
Brinjal PPL	3.3±0.28	3.4±0.42	5.8±0.46	4.3±0.35
Global Brinjal PPL	3.4±0.32	3.8±0.45	7.2±0.83	5.2±0.68
Namyal Ratchburi	1.8±0.18	2.4±0.31	4.9±0.64	2.7±0.39

Values (±SE) are means of five replicates.

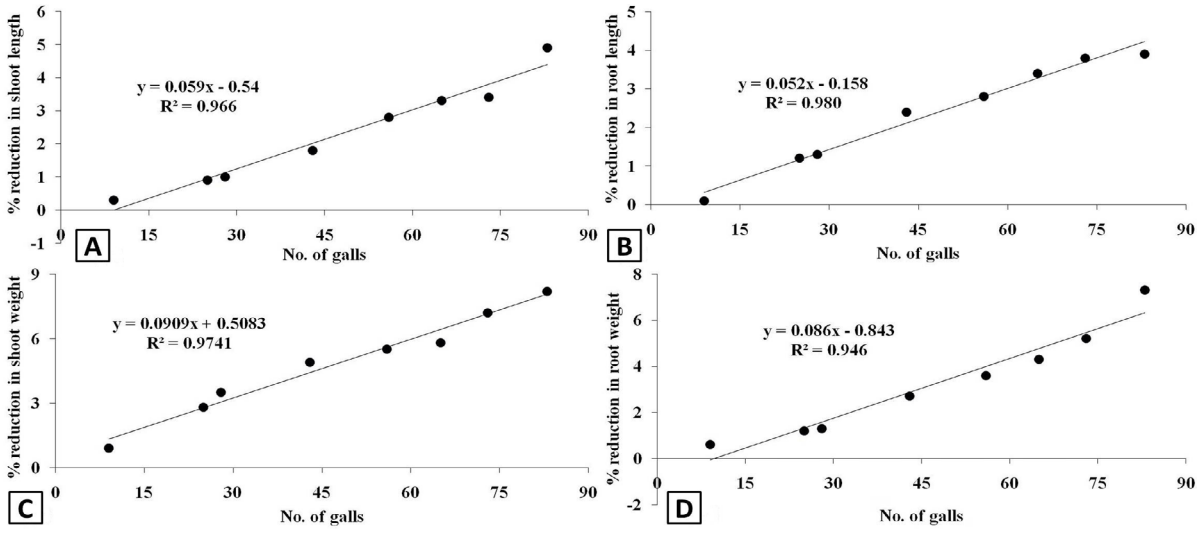

Fig. 1. Relationship between number of galls and % reduction in shoot length (A), root length (B), shoot weight (C) and root weight (D).

DISCUSSION

In the present study, differences were observed in the response of eight aubergine cultivars to *M. javanica* on the basis of gall formation on their roots. The cultivars also showed variations in reductions in growth parameters as a result of nematode infection. The moderately resistant cultivar suffered less damage by the nematode as compared to moderately susceptible and susceptible cultivars. The reductions in growth parameters are attributable to root injury due to penetration and/or feeding by nematodes leading to impairment of the efficiency of root systems to absorb water. The induction of galls in the roots and giant cells in the stellar region by *Meloidogyne* spp. extensively disrupt xylem tissues and greatly retard absorption and upward movement of water and nutrients. The infection also greatly reduces permeability of roots to water. The infection in plant roots by *Meloidogyne* spp. induces formation of nurse cells and regulates greater translocation of photosynthates towards infected root tissue while other parts (foliage) experience shortage (Di Vito *et al*., 2004; Wyss, 2002). Due to inadequate supply of water, nutrients, photosynthates and energy, growth and developments of leaf tissue and its constituents especially chlorophyll pigments are adversely affected (Khan and Khan, 1997). The poor growth of foliage subsequently leads to decreased production.

It was also noticed in the current study that the nematode produced lesser galls and egg masses on the roots of moderately resistant cultivar as compared to moderately susceptible and susceptible ones. The nematode reproduced at slower rate on moderately resistant cultivar while the rate of nematode reproduction was higher on susceptible cultivars. This was due to the fact that moderately susceptible and susceptible cultivars allowed the maximum juveniles to penetrate the roots and complete their life cycles successfully. On the other hand, lesser number of juveniles led to maturity in case of moderately resistant cultivar as it allowed only a limited number of juveniles of *M. javanica* to enter the roots which is evident by the number of galls and egg masses on its roots.

Differences in multiplication rates between resistant and susceptible cultivars might be in part, due to genetic factors in the host which confer susceptibility or resistance as well as genetic differences between nematode populations (Griffin, 1982; Jacquet *et al*., 2005; Castagnone- Sereno, 2006). Various stages in the life cycle of the nematode could be affected by host differences. The juveniles in a resistant plant are either incapable of penetrating the roots or their death may result ensuing penetration, or they fail to develop or females cannot reproduce. The differences in the susceptibility to *M. javanica* in aubergine cultivars are due to differences in their genetic makeup which can be explained in terms of number of galls.

CONCLUSIONS

In the present study, significant differences in growth reductions and increase in nematode infections were observed between the moderately resistant and susceptible aubergine cultivars. The plants of moderately resistant cultivar Brinjal Jamak suffered less damage and suppressed nematode infection considerably and therefore, recommended for cultivation in root-knot nematode infested fields to abate yield losses and repress the nematode from further multiplication.

Statement of conflict of interest

The authors declare no conflict of interest.

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