EFFECT OF SALINITY AND ROOT-KNOT NEMATODE ON GROWTH OF EGGPLANT (*SOLANUM MELONGENA* L.)

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Abstract

Effects of salinity, root-knot nematode infection and their combination have been studied on eggplant (*Solanum melongena* L.). The morphological changes were recorded after 15, 30 and 45 days of inoculation of nematodes. In salinity treatments, plants were irrigated with 0.1 % of NaCl. The overall growth was reduced with the duration of time under all treatments. Extreme reduction in shoot height and total biomass was recorded under combination of both salinity and root-knot infection, followed by salinity and least reduction was found in root-knot infection.

Introduction

Plant parasitic nematodes particularly root knot nematodes (*Meloidogyne* spp.) have considerable importance and their devastating effects on crops have major economic and social impacts (Perry and Maurice, 2006). They are obligate parasites of roots, tubers and corms of thousands of plant species, resulting in adverse effects on the quality and quantity of crops yield (Perry *et al*., 2009 and Abid and Maqbool, 1990). Karssen and Moens (2006) and Abid and Maqbool (1991) reported that root-knot nematode (RKN) infection primarily impairs water and nutrient uptake and translocation by the root system, resulting in yellowing of leaves, stunted growth and low-yield.

Soil salinization is one of the major problems for agricultural crop production in arid and semi-arid regions of the world (Ghassemi *et al.,* 1995; Hillel, 2000). Water deficit or osmotic effects are probably the major physiological mechanisms for growth reduction as both stresses lower the soil water potential (Hu and Schmidhalter, 2005). The salt in the soil solution cause osmotic stress resulting reduction of leaf growth and to a lesser extent root growth, and decrease stomatal conductance (Munns, 1993). Salinity acts like drought on plants and preventing roots from performing their osmotic activity where water and nutrients move from an area of low concentration into an area of high concentration. Because of the higher salt levels in the soil, water and nutrient cannot absorb by the plant roots. It is well documented that seed germination and seedling growth under saline conditions are critical for establishment of plant population (Ashraf and Khanum, 1997; Noreen *et al*., 2007; Sabir and Ashraf, 2007, Saeed and Ahmad, 2009; Saeed and Ahmad, 2013 a & b; Saeed *et al*., 2014). The aim of the present study is to elucidate the effects of salinity and root-knot nematode on growth of eggplant.

Materials and Methods

Preparation of root-knot nematode inoculums: Roots of Okra infected with root-knot nematode *(Meloidogyne javanica*) were collected from Malir (Karachi, Pakistan). Eggs of root-knot nematodes extracted using the modified technique of McClure *et al*. (1973). The egg suspension was poured on a cotton-wool filter and incubated at 28 ± 2 °C to obtain freshly hatched juveniles.

Experimental design: Four sets of treatments were maintained. One set with control (without nematode and salinity), second set was treated with 0.1 % NaCl (without nematode), third set was treated with RKN (without salinity) and forth with combination of 0.1% NaCl and RKN.

Plant growth experiment: Seedlings of eggplant were grown and maintained in large earthen pots (diameter, 24 cm) containing 5 kg of sterilized soil fertilizer mixture (2:1) in each. One month after germination, two seedlings were transplanted in each plastic pot containing 240 g sterilized soil fertilizer mixture (2:1). Five days after transplantation of the seedlings, approximately 2000 freshly hatched J_2 were introduced into four holes made around the roots of each plant. Saline water was irrigated (25 % water holding capacity) in each pot of salinity and combined treatment sets. Each treatment was replicated three times. The pots were placed in complete randomized manner on screen house bench. Pots were irrigated daily with tap water. Growth parameters includes, root, shoot length, root weight, plant fresh and dry weight were recorded after 15, 30 and 45 days of nematode inoculation.

Nematode Penetration Test: For nematode penetration test, plants were uprooted after 15 days of nematode inoculation. Roots from each treatment were collected, washed, dried, weighted and cut into small pieces. One g sample wrapped in muslin cloth and dipped in 0.25 % boiling acid fuchsin stain for 3 to 5 minutes. Roots were allowed to cool in the stain and washed under tap water to remove excess stain and put in destain (1:1 glycerol: water with few drops of lactic acid). Roots were macerated in an electric grinder for 30 seconds; the macerate was suspended in 50 ml water. Number of J_2, J_3, J_4 and females were counted with the help of microscope and number of nematodes/g roots was calculated (Bridge *et al*., 1982).

Data Analysis: Statistical analysis of the data was performed through COSTAT, a computer based program. Analyses were includes, factorial analysis of variance (FANOVA), Least Significant Difference (LSD), Duncan's Multiple Range Test (DMRT) to compare the means for each treatment (Gomez and Gomez, 1984).

Results

After performing ANOVA on data set obtaining results showed that the number of leaves, shoot length, plant fresh and dry weight was significantly reduced among days except root length (Table 2). Leaves were reduced after 15, 30 and 45 days of salinity and combined treatment as compared to control. Number of leaves was not affected in root-knot nematode infection (Table 1). Shoot length increased in all treatment as compared to control (Table 1). Root length increased in salinity and root-knot treatments as compared to control after 15 days while reduced after 30 days. Root length comparatively decreased was recorded under combined treatment as compared to control whereas increased under salinity and root-knot treatments after 15 days. However, it was increased after 45 days in the all treatments (Table 1). Weight of infected roots with RKN was greater than all treatments and reduction was observed in combined treatment of salinity and RKN (Fig. 1). Increased plant fresh weight was noted under salinity as compared to control whereas sharp decline was observed after 45 days. Plant dry weight was reduced as the exposure time of treatments increased (Table 1). Plant fresh and dry weight was increased in root-knot inoculated plants as compared to control. Combined treatment of root-knot and salinity showed cumulative response (Table 1). Number of J_2 was increased when treated with salinity as compared to untreated (Root-knot) but number of J_3 and J_4 were reduced due to salinity (Fig. 2).

Duncan's multiple range test also carried out with same data, showed significant difference was presents between the number of leaves, shoot length, plant fresh and dry weight in 30 and 45 days experiment (Table 2). While in 15 days observations showed number of leaves, shoot length, root length, plant fresh and dry weight increased in salinity and root-knot treatment as compared to control while reducing in combined treatment. Significant relation observed among days i.e. 15, 30 and 45 days except root length (Table 2).

Comparison of control with all treatments appeared as significantly in number of leaves and plant fresh weight while shoot length, root length and plant dry weight showed non-significant relation between control and treatments (Table 2). Plant treated with salinity and combined treatment showed significant difference as compared to control in number of leaves (Table 2).

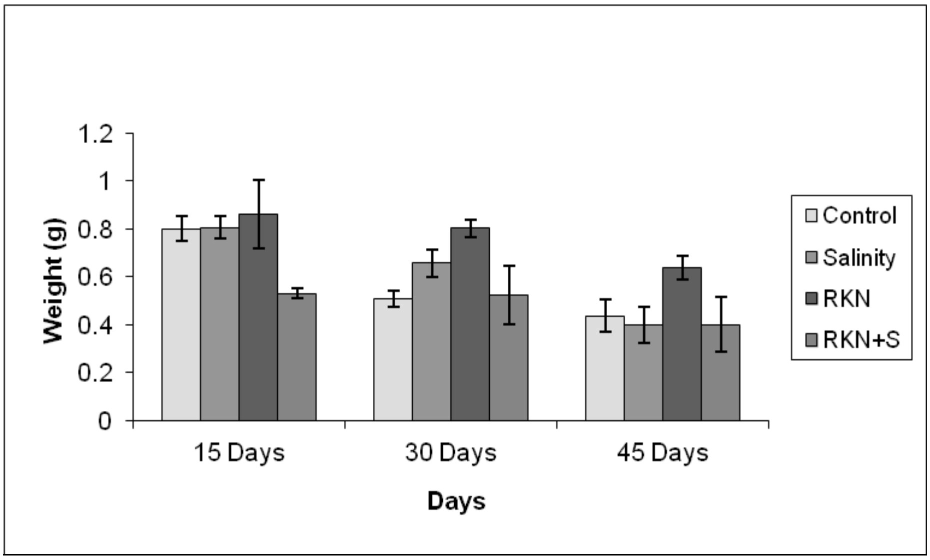

Fig. 1. Effect of salinity and RKN on root fresh weight ($LSD_{0.05}$ of days and treatment 0.113 and 0.13)

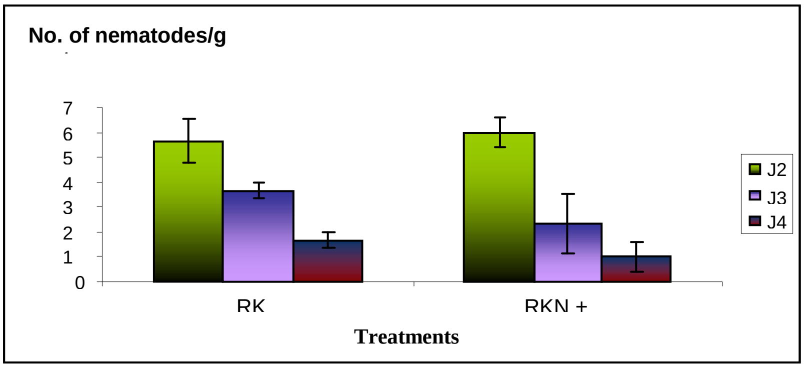

Fig. 2. Effect of salinity on nematode development in root system of eggplant.

Table 1. Effect of salinity and root-knot nematode on growth of eggplant after 15, 30 and 45 days.

Treatment	Number of leaves	Shoot length (cm)	Root length (cm)	Plant fresh weight (g)	Plant dry weight (g)
			15 Days		
Control	5±0.577	6.8±0.435	16.1±2.17	1.183±0.064	0.108±0.004
Salinity	4.333±0.333	6.9±0.723	17.166±0.796	1.2±0.052	0.09±0.013
RKN	5±0	6.933±0.674	17.7±1.252	1.250±0.208	0.119±0.021
RKN+ S	3.666±0.333	5.866±0.783	15.533±0.94	0.787±0.057	0.08±0.004
			30 Days		
Control	3.666±0.333	4.3±0.351	18.75±2.664	0.700±0.036	0.09±0.009
Salinity	2.666±0.333	5.1±0.115	16.266±1.121	0.924±0.074	0.165±0.047
RKN	4.333±0.333	4.933±0.185	16.533±0.856	1.073±0.073	0.147±0.027
RKN+ S	2.666±0.333	4.933±0.266	15.483±2.821	0.779±0.179	0.121±0.035
			45 Days		
Control	4±0.577	4.933±0.268	15.533±3.224	0.606±0.086	0.064±0.064
Salinity	2.333±0.333	5.316±0.462	19.883±2.319	0.549±0.101	0.044±0.011
RKN	4.666±1.201	5.833±0.466	19.283±0.596	0.905±0.076	0.093±0.021
RKN+ S	2.666±0.333	5.816±0.158	18.133±4.736	0.592±0.131	0.043±0.016

*Each value is an average of three replicates, Mean±S.E, RKN = Root-knot nematode, S = Salinity

Table 2. ANOVA and DMRT table of different growth parameters against salinity, nematode and days, treatments and their interaction observed in eggplant.

Days	Numbers of leaves	Shoot length	Root length	Plant fresh weight	Plant dry weight
15 Days	4.5a	6.625a	16.625a	1.105a	0.09b
30 Days	3.33b	4.816b	16.758a	0.869b	0.14a
45 Days	3.41b	5.475b	18.208a	0.663c	0.07b
F value	6.777	15.748	0.583	16.821	9.549
P value	0.004**	0.000***	.565ns	0.000***	0.000***
$LSD_{0.05}$	0.729	0.673	3.355	0.157	0.032
df = 2					
TREATMENTS					
Control	4.222a	5.34a	16.794a	0.83b	0.087a
Salinity	3.111b	5.77a	17.772a	0.891b	0.103a
RKN	4.666a	5.9a	17.838a	1.076a	0.125a
RKN+S	3b	5.53a	16.383a	0.719b	0.102a
F value	8.135	0.858	0.296	5.75	1.481
P value	0.0007***	0.47ns	.827ns	0.004**	0.244ns
$LSD_{0.05}$ df = 3	0.842	0.777	0.05	0.181	0.036

Note: *df* = degree of freedom and ns = non-significant

Discussion

In the present study, morphological changes were observed in different treatments like salinity and root-knot. The results suggested general decrease in plant weight due to combined effect of root-knot and salinity. Endogali and Ferris (1981) also reported stunted plant growth of tomato grown under salinity and nematode treatment. They have also observed reduction in egg hatching of nematode under saline condition.

The present study revealed that fresh and dry biomass of the plant was decreased while comparatively increase was noted in roots of infected (root-knot) plants. Similar results have been reported by Ahmed *et al.* (2009) in mungbean plants infected with *M. javanica*. Only root weight showed increase in root-knot infected plants which were due to the formation of galls or giants cells (Pinkerton and Simpson, 1986; Abid *et al*., 1992 and Hussain *et al*., 2013).

Reduction in plant height and stunted growth was recorded in present study under root-infected plants. Abbasi *et al*. (2008) reported that plants infected by root-knot reduced their heights. They further explained the reason for reduction was possibly due to the formation of root galling and giant cells provide a nutrient sink on which the nematode feeds.

It is in general observation that limitation of nutrient elements in the plant is probably the first effect by the nematode and change the physiology and metabolism of the host. Length of the time to infection is another factor which increases the severity of the infection. Melakeberhan *et al.* (1987) have been observed the increase in infection in French bean.

It is also recorded in a recent investigation that percent germination and heights of the plant reduced due to salinity. Similar results were obtained by Heuer *et al*., 1986; Saeed *et al*., 2014) while examined salinity tolerance of eggplant. According to study of Qureshi *et al*. (1990), this decrease in plant height may be due to physiological drought under salinity. Akinic *et al*. (2004) reported negative effect of increasing salinity (0, 50, 100, and 150 mM NaCl) on plant growth and development of fruits of eggplant. They have reported three varieties of eggplant (*S. melongena* 'Kemer', 'Pala', and 'Aydin Siyahi') response differentially under salinity treatment at different stages. High salinity may inhibit root and shoot elongation due to slowing down the water uptake by the plant (Werner and Finkelstein 1995).

Greater reduction in growth parameter (shoot height, fresh and dry biomass) was found under combined treatments of salinity and root-knot than their individual treatments (either salinity or root-knot alone). Reduction in growth parameters was more prominent at early stages as compared to later stages of plant growth. Present study revealed that over all plant growth was reduced under the saline conditions. Similar results were found in cherry tomato and okra under salinity has been observed by Saeed and Ahmed (2013a & b respectively).

Conclusions

It is concluded that salinity and root-knot nematodes infect the plant growth. After combination of both seems greater reduction on growth of eggplant due to the formation of knot on root and osmotic potential developed due to salinity that's why plant could not receive water and minerals from soil. Presence of salinity in soil shows reduction in development of nematode juveniles. A study on development of nematode in salty soil is necessary for understanding of the impact of this condition on survival of nematode.

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