Damage threshold of *Meloidogyne arenaria* to common bean influenced by dates of planting

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Abstract

Effect of root-knot nematode *Meloidogyne arenaria* was studied on common dry bean plants under natural infestation in the field at two different seasons of planting. In the first season, bean was grown in Autumn, 2012 while, the second season in early Spring, 2013. For the first season, the relation between nematode initial population density and bean yield was significantly negative ($r = -0.6$). A significant reduction in bean yield ($P = 0.05$) was obtained when nematode density was more than 100 J_2/200 g soil. While, damage threshold level (DT); nematode density at which yield begin to decrease; was estimated by 3 J_2/200 g soil. For the second season, no significant relation ($P = 0.05$) between nematode population density and bean yield was found ($r = 0.33$). DT was estimated as 22 J_2/200 g soil. Total protein and nitrogen element decreased in seeds of infected plants compared with those of healthy ones.

Keywords: Common dry bean, root-knot nematode, damage threshold, dates of planting

Common dry bean (French bean) *Phaseolus vulgaris* L., has now become one of the most important and widely grown crops in the world, since it was domesticated from a wild-growing vine distributed in some tropical regions of America (Gepts & Debouck, 1991). Dry beans are nutritious; they contain good levels of carbohydrates and protein. They have no cholesterol and are excellent source of iron, potassium, selenium, molybdenum, thiamine, vitamin B6 and folic acid. So, U.S. Department of Agriculture considered bean to be both a vegetable and a protein source (Long *et al*., 2010). Dry bean is mostly grown in all districts of Egypt, during two seasons Spring and Autumn, when the temperature is most suitable for its growth and yield. Based on reports by the Egyptian Ministry of Agriculture in 2011 dry bean is grown on more than 11000 ha annually (Anonymous, 2011). Various pathogenic nematodes have negative effects on common bean production in many parts of the world as well as in Egypt. Among them, the root-knot nematodes (*Meloidogyne* spp.) are the most important and destructive nematodes which attack bean crops and feed on roots causing root galls, the visible symptom of infection (Sikora & Greco, 1990). The loss in bean yield due to root-knot nematodes was correlated with the nematode population density in soil. A significant growth reduction was observed in soil infested with *M. javanica* at one egg/g of soil and it was 82% at 10 eggs/g soil in a glasshouse (Sharma, 1981). While, reduction in bean pods was 16.7% at 2 J_2/g soil in field experiment (Korayem *et al*., 2008). Therefore, many growers have applied some chemical treatments for controlling these nematode pathogens. Application of these chemicals is mostly based on bad ecological and economical information. The use of nematode threshold levels in nematode management programs, avoided crude use of nematicides that polluted the environment. The nematode threshold levels, that is damage threshold (the nematode density at which the yield begin to decrease) and economic threshold (the nematode density at which cost of the yield loss equals the cost of nematode control) have important roles in the decision-making process and development of management strategies. The objectives of this study were to study i) relationship of root-knot nematode *Meloidogyne arenaria* and yield of common bean and estimating damage threshold under two dates of planting and ii) the effect of nematode infection on the chemical composition of seeds.

Materials and Methods

Two experiments were conducted during 2012 and 2013 seasons in sandy soil naturally infested with *Meloidogyne arenaria* at Nobaria region, Bohaira Governorate, Egypt. The first experiment was carried out in Autumn, 2012 and the second experiment was done in early Spring, 2013.

Relationship between *M. arenaria* population density and yield of common bean: The site of the two experiments was divided into square microplots 50x50 cm each, then one hundred microplots were randomly selected to estimate the initial nematode population density (Pi) per each microplot directly before planting. Nematodes were extracted from soil by the sieving method (Christie & Perry, 1951). Then three seeds of common bean cv., Giza-3 were planted in each microplot. Plants were thinned to one plant per micro plot about 12 days after seed germination. Planting of bean seeds was done on 21-9-2012 for the first experiment and harvesting was on 6-12-2012, while it was done on 15-2-2013 for the second experiment and harvesting on 16-5-2013. The sites were irrigated by sprinkler system according to need and fertilized with 2.5 g N/plant in the form of urea (46% N). At harvest pods of each plant were removed by hand, air-dried and weighed.

Mineral elements determination: N, P and K contents in seeds were determined using a mixture of the sulfuric and percloric acids digestion methods (Cottenie *et al*., 1982).

Total protein and carbohydrates determination: The protein content in seed was determined according to A.O.A.C. (1990), while total carbohydrates were determined according to Dubois *et al*., (1956).

Statistical analysis: Initial nematode population densities were based on the nematode population per root system (Taylor & Sasser, 1978). Then data were subjected to analysis of variance and significant differences determined at P = 0.05. Also yield of pods (g/plant) was plotted against nematode densities (log x+1) to depict both linear and polynomial regression lines (Log nematode-yield lines), then nematode damage threshold (DT) was estimated from quadratic curve, as the point at which yield begin to decrease compared to the point at zero nematode. Temperature data were obtained from Central Laboratory of Agricultural Climate, Ministry of Agriculture, Giza, Egypt (Table 1).

Table 1. Maximum and minimum temperature (°C) during growing seasons 2012-2013.

Date	Temperature °C		
	Maximum	Minimum	Average
September, 2012	33.5	21.5	27.5
October	30.3	19.2	24.7
November	25.5	17.5	21.5
December	23.5	12.5	18.0
January, 2013	17.7	8.1	12.9
February	18.3	10.3	14.3
March	21.8	11.8	16.8
April	22.7	13.9	18.3
May	29.0	18.0	23.5

Results

Relationship between nematodes and bean yield: Relation between different nematode initial population densities (Pi) and pod yield of bean (Table 2 and Fig. 1) significant reduction at (P = 0.05) in pod yield was found when the nematode initial population density was more than 100 J_2 /200 g soil. Reduction in yield was 15.5% and 19.5% at 120 and 170 J_2/200g soil initial population density averages, respectively. At 20 and 70 nematode population averages, no significant reduction in pod yield occurred. Depicting the log nematode-yield lines as linear and quadratic regressions, indicated that there was a negative and significant relation (r = -0.6) between nematodes and pod yield. Damage threshold (DT) was estimated from quadratic regression by 3 J_2/200 g soil.

Table 2. Yield of common bean *Phaseolus vulgaris* in relation to different initial population density (Pi) of *M. arenaria* in Autumn, 2012.

Group No.	Pi range	Average of Pi	Pod yield g/plant	Reduction %
1	0	0	65.1	-
2	1-50	20	64.9	0.3
3	51-100	70	62.3	4.3
4	101-150	120	55.0	15.5
5	151-200	170	52.4	19.5
LSD (0.05)			7.1	

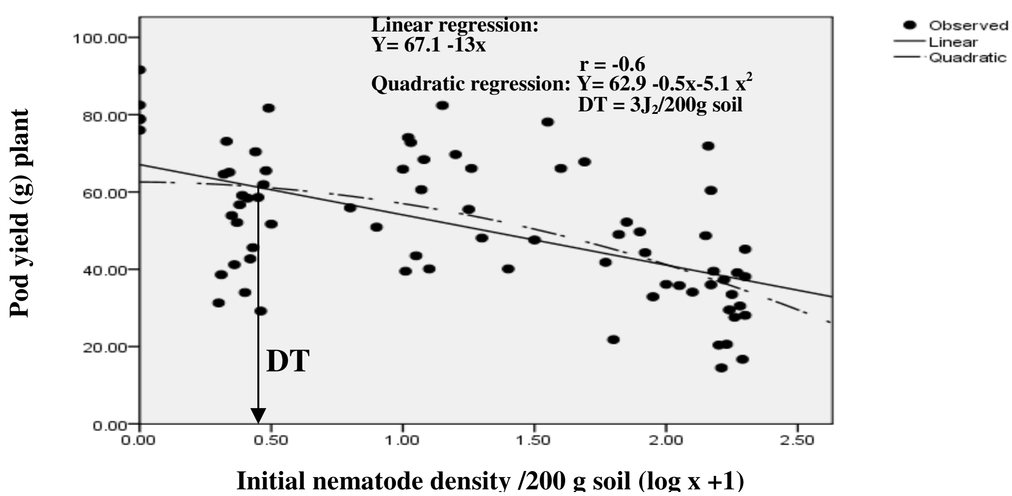

Fig. 1. Relationship between initial *M. arenaria* population density and pod yield of common dry bean grown in Autumn, 2012.

Effect of nematodes on pod yield was not significant, at range of nematode population from 1-300 J_2/200 g soil (Table 3). When depicting this relation as regression lines, correlation between nematodes and pod yield was also insignificant but negative (Fig. 2), namely the yield of pods decreased with increasing nematode population. The yield began to decrease (DT) at 22 J_2/200 g soil.

Table 3. Yield of common bean in relation to different initial population density (Pi) of *M. arenaria* at early Spring, 2013.

Group No.	Pi range	Average (Pi)	Pod yield g/ plant	Reduction %
1	Zero	Zero	47.6	-
2	1-75	50	48.0	-
3	76-150	125	47.1	1.7
4	151-225	200	46.5	2.3
5	226-300	275	45.5	4.4
LSD = 0.05			ns	

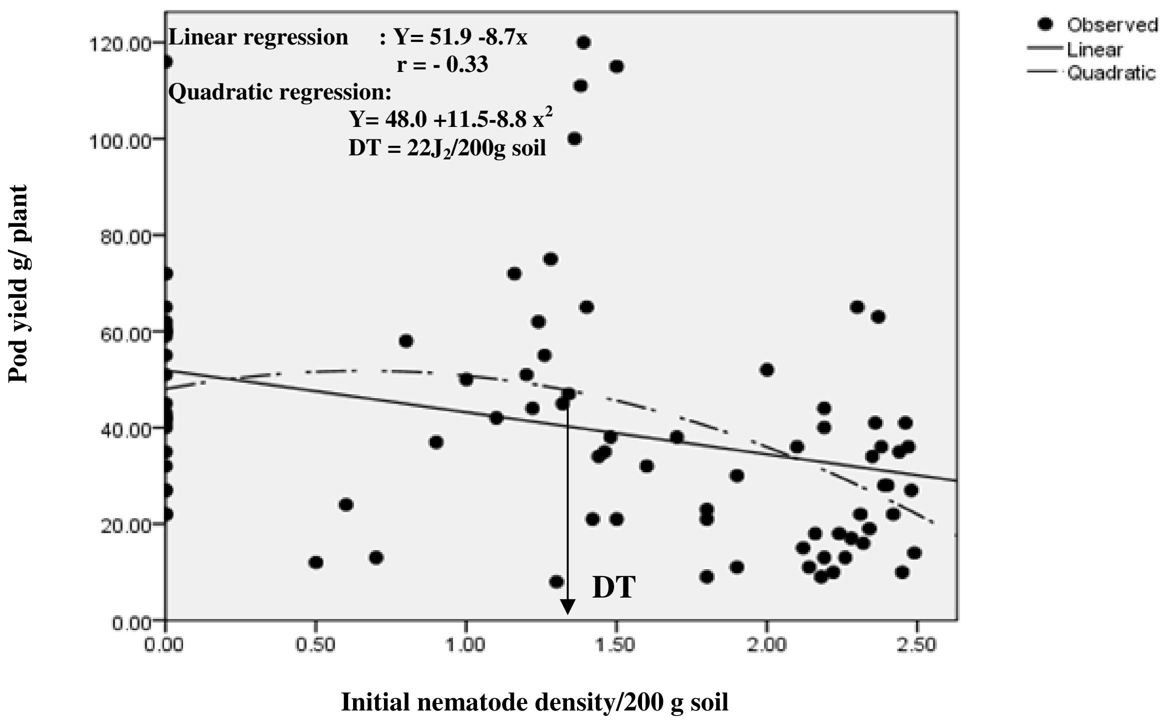

Fig. 2. Relationship between initial *M. arenaria* population density and pod yield of common dry bean grown in early Spring, 2013.

Effect of nematodes on the chemical composition of seeds: Total protein, carbohydrates, N, P and K contents (%) in seeds of nematode-infected and non-infected plants results presented in Table (4). Data indicated that total protein and nitrogen element decreased in seed of infected plants compared with those in healthy plants, either in Autumn or Spring. Phosphorus, potassium and total carbohydrates decreased in seeds of the infected plants, when bean was grown in Autumn, while they increased in both infected and non-infected plants, when bean was grown in early Spring (Table 4).

Table 4. Effect of nematode infection on some chemical components of bean seeds grown in Autumn and early Spring.

Chemical components (%)	Autumn, 2012				Early Spring, 2013			
	Infected	Non-infected	Reduction (%)	Average	Infected	Non-infected	Reduction (%)	Average
Nitrogen	3.0	3.3	9.1	3.15	2.90	3.08	5.80	2.99
Phosphorus	0.32	0.35	8.6	0.34	0.37	0.35	-	0.36
Potassium	1.71	1.87	8.6	1.79	2.1	2.00	-	2.05
Total protein	18.75	20.63	9.1	19.7	18.1	19.25	5.97	18.7
Total carbohydrates	58.5	58.9	0.68	58.7	66.3	64.9	-	65.6

Discussion

Results of our study demonstrated that common bean plants were severely damaged by the root-knot nematode, *Meloidogyne arenaria*. This damage was greatly influenced by season of planting (temperature degrees prevalent during bean growing). Loss in yield caused by nematodes were significant when bean grown in Autumn, 2012 while, non-significant when bean was grown in early Spring, 2013. Insignificant effects of nematodes on yield of bean grown in the early Spring may be due to the low temperature prevalent during early stages of bean grown (February-March) as temperature averages were 14.3 °C and 16.8 °C, respectively. This low temperature reduced nematode activity and their ability to attack plants and to reproduce (de Guiran & Ritter, 1979; van Gundy, 1985; Evans & Perry, 2009). In addition, at low temperature (less than 20 °C) nematode life cycle be delayed and it may take more than two months (Korayem & Romaşcu, 1983), hence bean plants reach maturity before emergence of the first nematode generation which cause dramatic damage to hosts (Korayem *et al*., 2012).

Data also showed that nitrogen and protein contents decreased in seeds of the infected plants compared with healthy ones either bean was grown in Autumn or in early Spring. Similar results were obtained by Di Vito *et al*., (1996), who found that protein in sunflower seeds was reduced by *M. incognita*. Total carbohydrates were also affected by nematode infection, but did not show a constant trend, as they slightly decreased in seeds when plants were grown in Autumn, but increased when plants were grown in early Spring. Increasing of carbohydrates either in infected plants or in non-infected ones, when bean was grown at early Spring may be due to low temperature prevalent during this season (environmental stress), as effect of nematodes on bean yield was not significant under these low temperature.

Our study indicated that *M. arenaria* infect bean plants and caused a significant loss in yield when bean grown in a suitable condition for nematodes activity. Therefore control of this nematode in the proper time was very important in preventing yield losses. Planting bean at unsuitable temperatures for nematodes development (less than 20 ^{o}C) may be a good solution for minimizing loss in bean yield.

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(Accepted: October 14, 2014)