Research Article

Soybean Genotypes Response to Root-Gall Nematode

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Abstract | Twenty local and imported soybean (*Glycine max*) genotypes were evaluated for susceptibility to root-gall nematode (RGN), *Meloidogyne incognita* race 2, under greenhouse conditions. Significant differences among the genotypes resistance degrees were achieved. Substantial variations existed among the soybean genetic resources with regard to the evaluated parameters. According to reduction percentage in reproduction factor (RPRF), the tested genotypes were ranked as resistant or susceptible to challenge nematode genus. The genotypes viz., G22, G111(100% RF) were found to be highly resistant (HR), genotypes ranked as resistant (R) viz., C97, H2, CV1, Clark, A7 (99.97, 99.96, 98.73, 98.29 and 97.06% RF, respectively), moderately resistant (MR) category was achieved by seven genotypes (G21, CV2, Carford, Katler, G35, C11 and AG in which RF values varied between 76.01-91.72%). Two genetic resources (Tano and A10) reacted as low resistant (LR) their RF were 65.22 and 72.20%, successively. Susceptible (S) reaction was possessed by two genotypes (G82 and A11), also highly susceptible (HS) response was registered by the rest two genotypes, L2b3 and Holiday which were the most suitable one that recorded the highest rates of reproduction 17.26, 23.23 and used as susceptible standard. In general, growth of the tested genotypes was negative to nematode infection. Results obtained in the present study could be used for the planning of crop rotation systems as well as the identification of resistance sources for breeding purposes.

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Introduction

Soybean (*Glycine max* L.) is one of the greatest important crops in oil production; also, it is a good source of protein for humans and farm animals throughout the world. Recently, the global production of soybean has been increased (reached to two thousand and ten million tons). However, its consumtion has increased rapidly as compared with its production (Ibiam *et al*., 2014; Jiao *et al*., 2015; Lima *et al*., 2017).

In Egypt, soybean was cultivated on about 32,000 feddans. It is considered a source of oil as well as protein; Egypt imports more than 90% of its vegetable oil requirement (FAO, 2017). Thus, increase in local soybean cultivation area could lead to minimize its current imports and reduce depletion of hard currency required for other needs. One of many factors that has potential to expand or increase the size of soybean domestic production is the research into soybean varieties adapted to Egyptian conditions including resistance to root-gall nematode (RGN).

Soybean could be infected by various pathogens, including the plant parasitic nematodes (PPN). They are serious pathogens of soybean throughout the world and cause huge yield losses. More than one hundred nematode species belonging to 50 genera have been documented in association with *Glycine max*. Among nematode genera capable of infecting soybeans throughout the world and cause yield losses in many fields, are the root-gall nematodes (*Meloidogyne* spp.), reniform nematodes (*Rotylenchulus* spp.), lesion nematodes (*Pratylenchus* spp.), and cyst nematodes (*Heterodera* spp.), which have been focused by many authors (Fourie *et al*., 2001; Wrather *et al*., 2003; Sikora *et al*., 2010; Li *et al*., 2016; Lima *et al*., 2017). *Meloidogyne* spp., are considered as one of the ten most dangerous genera of plant parasitic nematodes in the world. This dangerous pest causes colossal casualties in crop productivity (Jones et al., 2013). In addition, *Meloidogyne* spp., are the main causes of damage to soybean. In this genus more than 100 species are described, the major species are *M. arenaria*, *M. hapla*, *M. incognita* and *M. javanica*; the last two species are the major soybean-infesting species (Ferraz, 2001; Embrapa, 2011; Elling, 2013; Fourie *et al*., 2015).

In Egypt, *Meloidogyne incognita* and *M. arenaria* are previously reported as soybean pathogens as in many other African countries (Salem *et al*., 1994; Onkendi *et al*., 2014). RGN combating is extremely difficult and mainly is depending on chemical nematicides, the easiest method for controlling nematodes, but nowadays, due to their hazardous impacts, environmental concern and cost ineffectiveness, their applications have become restricted.

Genetic resistance (using resistant genotypes) is the most effective, environmentally sound and low-cost method of combating RGN. The recent accessibility and/or use of resistant germ plasms for nematode control is indicator for success of research efforts in determining and evaluating resistant germ plasms, introducing them into commercially acceptable crop selections, and implementing them into integrated nematode management protocols (Ferris, 1992). Therefore, using resistant cultivars is safer, durable and affordable tool in the long run as managing approach for different plant pathogens. Because, in most cases, genetic resistance either is not found or found at a low level, or resistance is lost due to genetic variability of attacking pathogens; hence, research for resistance against RGN is permanent and continuous tactic.

The concerning knowledge of soybean-germ plasm liability or sensitivity to RGN is vital to foretell the potential effect on soybean production and also the influence of each genotype on nematode populations with regarding to increasing or decreasing the damage of RGN on susceptible crops that may be cultivated after soybean. The aim of the present work was to evaluate some soybean genotypes for resistance to *M. incognita*, with the goal of identifying resistance in plants that might be used in crop rotation to reduce nematode damage and introduce the tolerant or resistant genotypes in new breeding program.

Materials and Methods

Populations of *Meloidogyne* spp., were isolated from North Sinai samples of egg plant-galled roots and identified as *M. incognita* according to Taylor *et al.* (1955). Its population was maintained in pure culture on roots of tomato cv. Super Strain B, grown in pots filled with sterilized soil and the plants were arranged in sterilized bench in greenhouse. After forming egg-masses and egg hatching, on previous inoculated tomato, another set of tomato and egg plant were planted in the same pots and seedlings were inoculated with RGN for continuous supply with fresh juveniles of *M. incognita* when needed in this study.

A pot experiment was carried out to investigate the susceptibility of 20 soybean genotypes to *M. incognita*. Two seeds of each 20 soybean genotypes (9 American, 6 Chinese and 5 Egyptian) were planted into 15 cm diameter earthen pots filled with sterilized mixture of soil (sand: clay = 3:1v/v). After germination, plantlets were thinned to one /pot. Seven-day-old plantlets were inoculated with ≈ 2000 freshly hatched second stage juveniles (J_2S) of *M. incognita* as nematode inoculum suspension, around the roots of each plantlet after making four holes in the soil (Ref). Each soybean genotype represented by 4 plants in the experiment served as replicates. Un-inoculated-four plants were used as check. Plants were randomly arranged in a complete block design (RCBD) on a bench in the greenhouse with average temperature of 24°C minimum and 35°C maximum; they were received the same horticultural practices and watered when needed.

Fifty days later, each plant was removed carefully from the pot to avoid root damage during uprooting from the pot. Each plant root system was washed to tap water stream to get rid of adhering substrates and soil particles. Afterwards, roots were dried with tissue paper, the plant growth criteria viz., root system mass and length, aerial parts fresh and dry masses plus height were recorded.

Counting nematodes in soil was accomplished by stirring the soil suspension, then pouring through set of sieves (60, 200 and 325µ aperture mesh), then quantitatively transferred the received suspension from the last sieve in measuring cups. The number of nematode juveniles (J_2S) in 1 milliliter water was counted, as an average of four washing times, and then the total number of J_2S in soil water extract/ each pot was calculated. Roots and all in roots were counted after staining by lactophenol acid fuchsin according to Franklin and Goodey (1959), then roots were washed and soaked in water to clarify the vision of stained roots. Fecundity (mean number of eggs/egg-mass) was estimated, after the eggs were extracted according to Hussey and Barker (1973). Relatively similar egg-masses (10) were transferred to 50 ml screw tap-tube containing NaOCl (0.5%) and shaked well in vortex mixer for three minutes. The suspension was passed through 25µ aperture-sieve, extracted eggs were rinsed under stream of water and eggs were then transferred to glass beaker and total number of eggs was calculated after counting in one ml of egg suspension four times using Hawksley counting slide. Number of total eggs per roots (TER) was counted as: average number of eggs per egg-mass x egg-masses/roots). The number of juveniles in soil + root population+ egg-masses+ whole number of eggs per roots was used to calculate final population (PF) and the reproduction factor (RF) was calculated following the equation: RF=Pf/Pi (2000 J_2 S) as in Oostenbrink (1966).

To identify the behavior of the tested soybean genotypes to RGN (host suitability) reproduction factor (RF) was calculated. This option was proposed by many researchers and has been found to be a reliable scale to identify RGN resistance for various plants (Oostenbrink, 1966; Fourie *et al*., 2006, 2012; Montasser *et al*., 2017). The tested soybean genotypes were ranked as susceptible or resistant to *M. incognita* according to Moura and Régis (1987). In this classification, the genotype with the highest RF is considered as the susceptible standard, then this genotype was compared with each of the others and the reduction percentage of the reproduction factor (RF) was calculated. Each genotype was rated as highly susceptible (0-25% RPRF), susceptible (26-50% RPRF), low resistance (51-75% RPRF), moderately resistant (76-95% RPRF), resistant (96-99% RPRF) or highly resistant (100% RPRF).

Results and Discussion

Data in Table 1 show that tested soybean genotypes reacted to *M. incognita* infection differently. It is surprising to find out two highly resistant (HR) soybean genotypes (G22 and G111) prohibited *M. incognita* from penetration into their roots. On the other hand, *M. incognita* failed to develop and multiply on 5 genotypes viz., CV97, H2, CV1, Clark, and A7, where the nematode final population per plant was less than its initial population 0.01, 0.01, 0.30, 0.40 and 0.68, respectively and considered as resistant (R). Seven genotypes were categorized as moderately resistant (MR), their reduction percentages in final population (RPRF) were 91.72, 90.03, 87.50, 87.06, 86.37, 85.43 and 76.01% for G21, CV2, Carford, Katler, G35, 11 and AG, successively. The lowest resistance (LR) was found in A 10 and Tano in which they allowed nematode to reproduce 6.46 and 8.08 times of initial inoculation. Susceptibility was observed at two levels; susceptible (S) as recorded by A11 and G82, their RPRF were 37.06 and 43.92 %, respectively. The highest susceptibility (HS) was confined to Holiday (the standard one) that possessed the highest reproduction rate (23.23) and L2b3 (17.26%). The maximum number of egg-masses (271.7) was formed on Holiday roots, while the lowest number of egg-masses (10) was recorded by CV1. Nematode fecundity (Number of eggs/egg-mass) were peaked in L2b3 (175.7) followed by G82 (147.7) and was sharply diminished in A 7, CV1 and Clark (35.0, 42.3 and 47.7, consequently).

Plant growth of tested soybean genotypes was negatively proportional with nematode infection in most cases, as the plant vigor was relativity suppressed as expressed in all estimated parameters Table 2. The length of shoot was highly reduced in C97 and slightly decreased in G82 (53 and 0.65%, respectively) as compared with healthy ones. No significant differences were found between shoot length values of healthy and infected ones in G21 and Holiday genotypes. Maximum root length reduction was found in Clark (31.48%) and minimum reduction (1.41%) was recorded in H2; most of genotypes showed insignificant differences between each other. Fresh shoot weight was sharply minimized in CV2, as it possessed the maximum reduction percentage (26.89%), while the lowest reduction was registered by G82 (1.18%). Root mass was extremely diminished in A10 and slightly decreased in A1. A few genotypes

Table 1: *Development and reproduction of Meloidogyne incognita on some soybean genotypes under greenhouse conditions.*

Source	Genotype name	No. galls/ roots	No. soil juveniles/ pot	No. individuals/ roots	No. egg-masses/roots	No. eggs/ egg-mass	No. total eggs/roots	Nematode final population	RPRF %	RF (Pf/Pi)	Host rank**
American (9)	AG	80.7 de	919.3 de	125.3 fg	71.0 ef	136.0 bc	10030.0 de	11145.7 d-f	76.01	5.57	MR
	A7	20.0 f	719.0 ef	28.3 i	17.0 h-j	35.0 h	602.3 f	1366.7 g	97.06	0.68	R
	A10	148.3 c	969.7 de	171.3 de	127.0 d	91.7 ef	11645.0 de	12913.0 de	72.20	6.46	LR
	A11	267.3 b	1872.3 b	285.7 ba	233.3 b	107.7 de	26846.7 bc	29238.0 bc	37.06	14.62	S
	Carford	106.3 d	158.7 i-h	133.7 ef	65.3 e-g	83.3 f	5450.7 ef	5808.3 e-g	87.50	2.90	MR
	Clark	23.7 f	200.0 g-j	35.3 i	11.3 ij	47.7 gh	547.3 f	794.0 g	98.29	0.40	R
	Holiday*	305.3 a	3846.7 a	322.3 a	271.6 a	154.7 b	42013.0 a	46452.7 a	Standard	23.23	H.S
	Katler	61.0 e	1021.7 c-e	113.0 f-h	47.0 f-i	103.0 ef	4831.0 b	6012.7 e-g	87.06	3.01	MR
	Tano	156.7 c	530.0 fg	175.0 de	121.3 d	126.0 cd	15330.0 d	16156.3 d	65.22	8.08	LR
Chinese (6)	CV1	14.3 f	129.3 ij	23.0 i	10.0 j	42.3 gh	429.3 f	591.7 g	98.73	0.30	R
	CV2	58.3 e	1100.0 cd	100.3 f-h	32.3 g-j	104.7 e	3398.0 ef	4630.7e-g	90.03	2.32	MR
	C11	58.0 e	1348.0 c	83.0 gh	49.3 f-h	107.3 de	5288.7	6769.0 e-g	85.43	3.38	MR
	C97	15.7 f	0.0 j	15.7 i	0.0 j	0.0 i	0.0 f	15.7 g	99.97	0.01	R
	H2	15.0 f	0.0 j	18.0 i	0.0 j	0.0 i	0.0 f	18.0 g	99.96	0.01	R
	L2 b3	238.0 b	490.0 f-h	250.7 bc	191.0 c	175.7 a	33581.7 b	34513.3 b	25.70	17.26	H.S
Egyptian (5)	G21	63.0	469.3 f-i	78.7 h	36.0 f-j	90.7 ef	3263.3 ef	3847.3 fg	91.72	1.92	MR
	G22	0.0 f	0.0 j	0.0 i	0.0 j	0.0 i	0.0 f	0.0 g	100.00	0.00	HR
	G35	158.3 c	190.3 g-j	183.0 d	95.3 de	61.3 g	5863.3 ef	6332.0 efg	86.37	3.17	MR
	G82	174.3 c	1875.7 b	240.0 c	161.0 c	147.7 b	23774.0	26050.7 c	43.92	13.03	S
	G111	0.0 f	0.0 j	0.0 i	0.0 j	0.0 i	0.0 f	0.0 g	100.00	0.00	HR

*Means followed by the same letter in the columns do not differ (Duncan's multiple range test, 5% probability), * Susceptible standard genotype; ** Moura and Régis (1987) scale of categorizing host resistances (in this classification, the genotype with the highest RF is used as the susceptible standard, then this genotype is compared with each of the others and the reduction percentage of the reproduction factor-RPRF- is calculated); {HS= highly susceptible (0 to 25% RPRF), S= susceptible (26 to 50% RPRF), LR= low resistant (51 to 75% RPRF), MR=moderately resistant (76 to 95% RPRF), R= resistant (96 to 99% RPRF) or HR=highly resistant (100% RPRF)}.*

showed similar values of growth criteria in infected and healthy ones, also in rare cases, the infection insignificantly promoted some growth parameters (Figure 1).

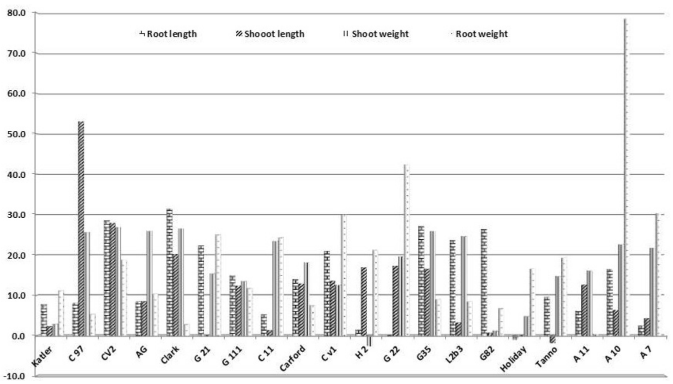

Figure 1: *Reduction in plant growth parameters of some soybean genotypes affect by M. incognita infection.*
The reduction percentage was calculated as: (Healthy-Infected)/ healthy×100.

In this research work some soybean genotypes were evaluated for their resistance to RGN *M. incognita*. The obtained data revealed that of the 20 genotypes, G22 and G111 were found to be highly resistance (HR); five genotypes viz., C97, H2, CV1, Clark and A7 were categorized as resistance (R). The genotypes that occupied the moderately resistance (MR) rank were: G21, CV2, Carford, Katler, G35, C11 and AG. Low resistance (LR) categories were possessed by Tano and A10. Susceptible (S) genotypes were G82 and A11, while the highly susceptible (HS) genotypes were Holiday and L2B3. The reduction will be achieved when a resistant genotype suppressed nematode from high multiplication. Usually reduction in reproduction was equal to 90% or more as compared to susceptible cultivars of the same plant species (Taylor and Sasser, 1978). Seven soybeans genotypes were found to be resistant against RGN nematode. These sources may possess unique and previously unidentified resistance genes that could be incorporated into new varieties with higher levels of resistance. This information will be useful to plant breeders who may plan to develop soybean germ plasms for introducing resistance genes towards RGN.

Plants possess different levels of resistance or susceptibility. Nematode infective juveniles can penetrate the roots, develop into mature females and form large number of eggs in highly susceptible plant, in contrast, the juveniles may succeed in penetration into the roots of resistant plants, but their development and maturity may completely fail according to their level of resistance, and consequently not allow the females to lay eggs or complete their reproduction cycle (Karssen and Moens, 2006).

Nematode reproduction may be failed or inhibited by resistant host plant as a result of stimulation aegis processes in response to nematode infection. On the contrary, losing resistance or tolerance in plant or both, transforms it into good host for nematode reproduction (Trudgill, 1991). Resistance that forestalls *Meloidogyne* spp. can involve pre or post infection procedures (Huang, 1985). Challenge before infection may occur at the root morphological exterior or within the rhizosphere soil adhering roots, rhizosphere, and accordingly severe nematode invasion do not occur. Root repellent or toxic secretions can also captivate or repulse root-gall nematode. After-infection, resistance processes can encompass physiological operations inside the roots which: (1) prevent nematode feeding; (2) avert the installation or induction of feeding loci, (3) holdup or restrict nematode flourishing or enhancement, and (4) inhibit reproduction (Trudgill, 1991).

Capability of root-gall nematode juvenile to invade the plant roots and initiate typical giant cells, including hypertrophy and hyperplasia, are easily visible as galls on root surface which only happen in susceptible host plants (Chen *et al*., 2004). In resistant host plants, the infective juvenile either do not enter, or die after entrance into the roots and fail to reach maturity or fail in reproduction process.

Table 2: *Effect of M. incognita infection on plant growth parameters of some soybean genotypes.*

Plant genotype	Length (cm)						Mass (g)					
	Shoot			Root			Shoot			Root		
	Infected	healthy	R%	Infected	healthy	R%	Infected	healthy	R%	Infected	healthy	R%
AG	50.33 f-k	55.00 d-g	8.48	25.33 j-m	27.67 h-k	8.43	11.43 j-q	15.43 b-h	25.92	7.20 j-l	8.03 i-l	10.37
A7	67.33 ab	70.33 a	4.27	26.33 j-l	27.00 i-l	2.47	12.00 j-q	15.33 b-i	21.74	12.67 c-f	18.17 b	30.28
A10	49.67 f-l	53.00 d-j	6.29	22.00 m-o	26.33 j-l	16.46	10.17 o-q	13.13d-o	22.59	2.83 n	13.20 cd	78.54
A11	41.67 m-o	47.67 g-m	12.59	20.67 o	22.00 m-o	6.06	13.40 e-n	15.97 b-f	16.08	22.77 a	22.83 a	0.29
Carford	52.00 e-j	59.67 c-e	12.85	26.67 j-l	31.00 d-h	13.98	13.10 e-o	16.00 b-e	18.13	11.07 d-h	11.97 c-g	7.52
Clark	52.67 e-j	66.00 f-j	20.20	24.67 k-n	36.00 bc	31.48	12.73 g-p	17.33 bc	26.54	10.27 f-i	10.57 e-h	2.84
Holiday	66.00 a-c	66.00 a-c	0.00	33.00 c-e	32.67 c-e	-1.02	14.60 c-j	15.33 b-i	4.78	10.57 e-h	12.67 c-f	16.75
Katler	42.33 m-o	43.33 k-o	2.31	31.7 d-f	34.3 b-d	7.77	11.27 l-q	11.60 k-q	2.87	7.17 j-l	8.07 i-l	11.16
Tanno	55.67 d-f	54.67 d-h	-1.83	28.33 f-k	31.33 d-g	9.57	12.17 i-q	14.27 c-l	14.72	11.17 d-h	13.83 c	19.28
CV1	57.33 d-f	66.33 a-c	13.57	21.33 no	27.00 i-l	20.99	11.87 j-q	13.57 e-m	12.53	6.07 lm	8.67 h-k	30.00
CV2	38.67 no	53.67 d-i	27.95	21.67 no	30.33 e-i	28.57	10.33 n-q	14.13 d-l	26.89	9.07 h-j	11.17 d-h	18.81
C11	26.00 p	26.33 p	1.27	24.00 l-o	25.33j-m	5.26	9.60 pq	12.53 h-p	23.40	6.63 kl	8.77 h-k	24.33
C97	25.33 p	54.00 d-h	53.09	30.33 e-i	33.00 c-e	8.08	9.20 q	12.37 i-q	25.61	4.17 mn	4.40 mn	5.30
H 2	37.67 o	45.33 j-n	16.91	23.33 l-o	23.67 l-o	1.41	13.17 d-o	12.83e-o	-2.60	10.50 e-i	13.33 cd	21.25
L2b3	50.67 f-k	52.33 e-j	3.18	28.00 g-k	36.7ab	23.64	11.93 j-q	15.83 b-g	24.63	8.70 h-k	9.50 h-k	8.42
G21	55.00 d-g	55.00 d-g	0.00	22.00 m-o	28.33 f-k	22.35	10.83 m-q	12.80 f-o	15.36	9.67 g-i	12.90 c-e	25.06
G22	60.67 b-d	73.33 a-c	17.27	26.67 j-l	26.67 j-l	0.00	14.50 c-j	18.03 b	19.59	9.60 g-j	16.67 b	42.40
G35	47.00 h-m	56.33 d-f	16.57	28.67 f-j	39.3 a	27.12	16.30 b-d	22.00 a	25.91	12.50 c-f	13.73 c	8.98
G82	50.67 f-k	51.00 f-j	0.65	26.00 j-l	35.33 bc	26.42	11.20 l-q	11.33 k-q	1.18	9.17 h-j	9.83 g-i	6.78
G111	40.33 m-o	46.00 i-n	12.32	21.00 o	24.67 k-n	14.86	11.57 j-q	13.37 d-k	13.47	12.47 c-f	14.13 c	11.79

Means followed by the same letter in the columns do not differ (Duncan's multiple range test, 5% probability), R%= Reduction percent.

It is thus possible to say that, the plant which is able to survive and develop well and offer considerable yield productivity under infection of nematode population around or exceeds the economic threshold, is categorized as tolerant host. Another definition of tolerant host supposed by Canto-Saenz (1985) is the professional host plant that suffers in achieving targeted growth or the reduction in its productivity or yield is found to be insignificant statistically. It is believed that nematode combating via employing the resistant germ plasm is a considerable approach. In the current study, reaction of the selected soybean genotypes to RGN was judged based on the reduction in nematode final population and rate of multiplication (RF).

It was noticed that the 20 tested genotypes significantly differed in their reaction to RGN infection. Around 80% of the tested soybean genotypes showed various degrees of resistance; 2 of them were HR, 5 were R, 7 MR and 2 were LR. RGN susceptible genotypes represented about 20% of all examined genetic resources (2 were HS and 2 were S). These results were supported by many studies (Acosta and Negron, 1982; Kirkpatrick and May, 1989; Davis *et al*., 1996; Fourie *et al*., 2006, 2015; Bruinsma and Antoniolli, 2015; Teixeira *et al*., 2017).

Plant growth parameters in majority of examined soybean germ plasm were reduced as a result of nematode infection. The differences between inoculated and untreated plant in growth criteria were varied; often were insignificant and in few cases, significant or equated. These results matched with pervious study by Ibiam *et al*. (2014) as they found no significant differences in root length of tested soybean varieties affected by RGN infection. Also, Stirling *et al*. (2006) did not observe diminishing in growth of soybean germplasms infected with RGN, but dry weights across the different inoculation treatments revealed that there were significant differences in biomass among soybean genotypes.

Hypothetically, depending on tally of knots (proportion of juvenile intrusion) on plant roots, if knots are countable, the reproduction caliber will dwindle similarly and consequent inhibition of nematode elaboration be getting depressed fecundity grade. Previous finding stated that, in general, root-gall indices were indicative of RGN-egg production, but the observed exceptions highlighted the value of obtaining both types of data (Davis *et al*., 1996). In our study the number of galls was not positively correlated with the final population or rate of nematode build-up, as observed in genotype AG that formed about 80 galls but its final population was 11145, while Carford possessed 106 galls, however, its FP was less than AG (5808). Neglected effect of number of juveniles penetrating roots was found on categorizing soybean genotypes resistance to RGN but using RF parameter has been documented (Teixeira *et al*., 2017). They found that juveniles penetration of *M. incognita* in the roots was not a good parameter to evaluate cultivar behavior. In the same context, finding of Bruinsma and Antoniolli (2015) confirmed that using gall index as evaluating criterion of resistance was weak because when using RF only or gall index plus RF factor as evaluation criteria, all resistant soybean genotypes become susceptible or sometimes tolerant, successively. The greater galls numbers, but with low RF or low gall numbers with high RF on soybean suggested the genetic independence of resistance from root galling and/or nematode reproduction (Li *et al*., 2016).

However, there are contradictory reports regarding differences between resistant and susceptible cultivars in rates of invasion by J_2S of RGN. This finding was supported by Fourie *et al*. (2006), as they reported less galls associated with more number of eggs/root of some soybean genotypes and the opposite was also observed. Earlier investigations reported that host status made no differences to rate of invasion (Fassuliotis *et al*., 1970; Reynolds *et al*., 1970; Griffin and Elgin, 1977). Different findings oppose above reports, mentioned by Sasser (1954) who noted that the roots of susceptible plants were attacked faster than resistant ones. In the same direction, it was reported that number of developing and mature nematodes inside resistant genotypes were less than in susceptible ones (Dropkin and Nelson, 1960). The other nematode populations, belonging to different genera, especially *Heterodera* and *Rotylenchulus* must be considered when selecting or developing soybean cultivars that were resistant to specific nematode before recommending them for cultivation in certain regions. This issue was stated by Davis *et al*. (1996), as they found that most of the cyst nematode-resistant soybean genotypes evaluated were susceptible to two species of *Meloidogyne*, nematode race must also be recognized.

This research manifestly displayed that, the chief constituent impacting on final count of nematode community is the number of produced eggs, so we advise to count eggs per roots in appraisement of the reaction of such genotypes toward RGN. The significance of this research is supplied from the viewpoint of the growers that appropriate environmental-safe tactics be undertaken for the control PPN.

Additionally, recognition and utilizing of defiance or for bearing varieties in governing RGN are quite feasible manners of reducing damages resulting from RGN. Employing of resistant germ plasm to control the reproduction of nematode is a low-cost approach for managing diseases caused by the nematodes. Using resistant genotypes with other approaches of nematode combating can transform the growers' perception from the idea of control to the idea of superintendence or management. Culturing of resistant or moderately resistant cultivars potentially aids in diminishing the injuries resulting from root-gall or other nematode diseases. Moreover, inspections of other genotypes (encompassing nondomestic or wild ones) are urgent to search for RGN-resistant genotypes and may present settlements to root-gall nematode which are more endemic in soybean in tropical and subtropical zones in order to endeavour for reducing losses and ensure food security.

Conclusions and Recommendations

The screening carried out in the present study has led to identification of useful sources of resistance to *M. incognito* race 2 in both local and imported soybean germplasms. This emphasized the need for introducing resistance into high yielding cultivars with good market potential. Besides, this investigation attained particular importance from its results; firstly, fecundity (produced eggs) was found to be basic element in evaluating the resistant soybean against *M. incognita*, secondly, guiding the growers to utilize resilience or resistive genotypes to diminish nematode damage and thirdly, aiding the researches in breeding programs to improve the low resistance degree of genotypes for managing root-gall nematode. It is recommended to soybean growers to avoid cultivating liable genotypes in the previously RGN-infested soils, estimating the susceptibility of targeted cultivar to other nematode communities, particularly that colonized in chosen soil for agriculture before transferring and it is also advisable that pre-planting soybean cultivars in field should be planted in rotation with hosts that are less susceptible or resistant if found. Thereupon, widely to utilize these resistant genetic resources. It is desirable to assemble all resistant forefingers comprising knots, egg-masses, total eggs, and rate of build-up to dependably evaluate nematode tolerance or resistance and to acknowledge or distinguish how they share, relatively to all pathogens attacking crop, in soybean yield damage level. Generally, the use of sustainable schemes can be useful to growers and must be checked for the entry of RGN into their fields.

Novelty Statement

Offer two highly resistant and five resistant soybean genotypes for producers against *Meloidogyne incognita.*

Author's Contribution

Ashraf Ismail Afia proposed the research idea, experiments design, brought the soybean seeds and accomplish the experiment, also share in all work steps. Ahmed Soliman Mohamed El-Nuby shared the first author in examination and following up the experiments, also writing the manuscript, doing the statistical analysis and interpretation of all obtained data. Dealing with journal for publishing.

Conflict of interest

The authors have declared no conflict of interest.

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