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Assessment of plant mediated interaction between root knot nematode and sucking insects in tomato

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Abstract
A field experiment was conducted for two consecutive years to assess the effect of infestation of root knot nematode on population of aphid and whitefly infesting tomato plants under three different nutrient regimes. The whole experiment was laid out in split plot design, with three main plots of different levels of fertilizer regimes *i.e.* recommended doses of fertilizer, 75% of the recommended dose and 50% of the recommended dose and four sub plots of different levels of pest infestation *i.e.* only root knot nematode, only insects, both root knot nematode and insects and the plot in which plants were subjected to no pest infestation. Population of root-knot nematode *i.e.* J_2 per 200cc of soil, female root knot nematode and egg mass per 5 g of root were recorded at 30, 60 and 90 DAT. Aphid and whitefly population were observed on weekly interval. The study revealed that both below ground and above ground population were lower in plants infested by both as compared to the plants subjected to sole infestation of these pests. The observation taken for yield of tomato were comparatively higher in the plots with no pest infestation and were the lowest in the plants subjected to infestation by both root knot nematode and sucking insects. The interaction of main plot and sub plot treatments had significantly influenced population of root knot nematode and sucking insects as well as yield of tomato plants.

Keywords: Tomato, root knot nematode, whitefly, aphid, population, fertilizer

1. Introduction
Among the various vegetable crops, family solanaceae forms an important group, which includes tomato (*Solanum lycopersicum* Linn.) along with other essential vegetables of our daily diet. Tomato is a popular and versatile food ranking third in the world's vegetable production, next to potato and sweet potato and placing itself at the first place among the processing crops. It has been reported to be attacked by about forty one insect pests from the time of planting till harvest [11]. At initial stage of crop development plants are majorly affected by sucking pests, among them aphid (*Aphis gossypii*) and white fly (*Bemisia tabaci*) are the major important and causing severe losses under favorable weather condition. Belowground part of tomato is severely affected by root knot nematode (*Meloidogyne* spp. Chitwood) causing yield loss upto 46.2% [3]. The feeding of RKN results in restriction of xylem and phloem vessels by formation of giant cells, breaking the host resistance mechanism and increasing susceptibility to pest attack [3].
In the field, plants also are exposed to both belowground and above ground consumers. Root feeders can significantly alter interactions between plants and aboveground herbivores [10]. Root feeding nematodes also can influence aboveground insects via their effects on the shared host plant [2, 9]. This awareness of plant-mediated above belowground interactions has brought a new level of complexity to the field of plant-insect ecology [13, 1, 14].
The RKN and sucking insects especially aphid and whitefly have an immense effect on physiological conditions of the Tomato plant hence producing indirect effects on each other which is plant mediated. Different levels of the nutrient regimes may affect insect-nematode interaction as nutrients have a profound effect on the primary and secondary metabolites present in the plant.
Keeping nutrient stress as an indicator the present study has been conducted to find out the effect of insect- nematode interaction on their population dynamics and yield of tomato plant.

2. Materials and Methods

2.1 Location of study

The field experiments were carried out at the Central Research Farm of Bidhan Chandra Krishi Viswavidyalaya, Gayeshpur, Nadia, West Bengal (Geographical location- Latitude 23°N, Longitude 89°E, Altitude 9.75m msl).

2.2 Treatment details

The experiment was laid out in a split plot design using tomato variety, "Heemshikhar".

The field was first divided into two parts:

1. Field with the mesh (40 mesh)
2. Field without the mesh

These two parts were further split into three main treatments:

A_1- Recommended dose of fertilizer (120:100:100).

A_2- 75% of recommended dose of fertilizer.

A_3- 50% of recommended dose of fertilizer.

These main plots were again sub divided into sub-plots where four treatments with five replications were adopted:

B_1-Only root knot nematode is allowed in the plot.

B_2-Only insects were allowed in the plot.

B_3-Both root knot nematodes and insects were allowed in the plot.

B_4- No pests were allowed to infest the crop.

2.3 Experimental practices

The plot size of 1.5 m by 1.5 m (2.25m^2) with row to row distance of 60 cm and plant to plant distance 50 cm was used. The plots with only root knot nematode attack and no pest attack were kept within the mesh to avoid insect attack.

The nursery bed was sterilized by drenching with 4% formaldehyde at 15 days prior to sowing of tomato seeds to get the seedlings free from nematodes and other plant pathogens. Sterilization of the main field soil was done with 4% formalin, one month before transplanting tomato seedlings in the plots where either no pests was allowed or only insects were allowed to infest the crop. The sterilization process was carried out along with the FYM so as to prevent the infestation of the nematodes and other plant pathogens. The soil was drenched with 4%Formaldehyde and then covered with polythene sheet for 7 days. After 7 days the soil was pulverized and kept open to remove the toxic gases of formaldehyde. The plants under control and the plants which were subjected to insect attack were grown in pots with a diameter of 25cm. Recommended package of practices were adopted to raise the crop and irrigation was given as and when required.

2.4 Method of observations

Population of aphid and whitefly were recorded at an interval of 7 days. Pest counts were made from one each of upper, middle and lower leaves of 5 randomly selected tagged plants per plot [12].

Population of nematode *i.e.* J_2 per 200cc of soil, female root knot nematode and egg mass per 5 g of root were recorded at 30, 60 and 90 DAT. Root Knot Juveniles (J_2) of *Meloidogyne* spp. per 200 cc of soil was measured by sieving and decanting technique given by [6] followed by Baermann's funnel technique which was earlier mentioned in [5]. Two grams of root samples were collected from four randomly selected tomato plants in each plot. Roots were then cleaned in tap water, cut into pieces of 2-3 cm and stained by NaOCl-acid Fuchsin method [4]. Stained root samples were then observed under stereoscopic binocular microscope to count the population of female RKN. Estimation of nematode egg mass per 5 g root was done by using modified method of [7].

Yield of matured fruit was estimated from each and every plot and expressed in Kg/ha.

2. 5. Statistical analysis

Data analysis was done using Real Statistics' Split –plot Anova data analysis tool of Excel.

3. Results and discussion

3.1 Aphid (*Aphis gossypii* Glover and *Myzus persicae* Sulzer)

Aphid population was observed from 3rd standard week for the 1st year (Table 1) and 4th standard week for the 2nd year (Table 2). For both of the year population reached peak during 8th standard week and then the population declined gradually. Interaction effect of different dose of fertilizer and types of pest infestation was found significant in aphid population per leaf for each year. Different doses of fertilizer had no significant effect on aphid population. Significantly maximum number of aphid population per leaf was obtained in treatment combination of A_1B_2 *i.e.* only insects with recommended dose of fertilizer (120:100:100) and A_1B_3 treatment combination resulted the significantly lowest aphid population per leaf compare to the other treatments for both of the year (Table 1 and Table 2).

Table 1: Aphid population per leaf of tomato crop recorded during the experiment (1st year)

Treatments	Standard weeks of observations									Mean weekly population
	3rd	4th	5th	6th	7th	8th	9th	10th	11th	
A_1B_2- Only insects with rec. dose of fertilizer	0.16 (0.81)	0.28 (0.88)	0.62 (1.06)	2.87 (1.84)	3.99 (2.12)	9.54 (3.17)	5.44 (2.44)	1.00 (1.22)	0.28 (0.88)	2.69 (1.79)
A_2B_2- Only insects with 75% of rec. dose of fertilizer	0.20 (0.84)	0.19 (0.83)	1.25 (1.32)	2.70 (1.79)	4.21 (2.17)	5.65 (2.48)	3.73 (2.06)	0.88 (1.17)	0.23 (0.85)	2.12 (1.62)
A_3B_2 -Only insects 50% of with rec. dose of fertilizer	0.06 (0.75)	0.16 (0.81)	0.83 (1.15)	0.25 (0.87)	3.60 (2.02)	8.94 (3.07)	1.97 (1.57)	0.82 (1.15)	0.21 (0.84)	1.87 (1.54)
A_1B_3- Both RKN and insects with rec. dose of fertilizer	0.09 (0.77)	0.15 (0.81)	0.80 (1.14)	1.97 (1.57)	2.95 (1.86)	4.75 (2.29)	2.40 (1.70)	0.73 (1.11)	0.14 (0.80)	1.55 (1.43)
A_2B_3- Both RKN and insects with 75% of rec. dose of fertilizer	0.12 (0.79)	0.13 (0.79)	0.58 (1.04)	3.90 (2.10)	3.09 (1.89)	5.31 (2.41)	2.82 (1.82)	0.91 (1.19)	0.15 (0.81)	1.89 (1.55)
A_3B_3 -Both RKN and insects 50% rec. dose of fertilizer	0.10 (0.77)	0.09 (0.77)	0.48 (0.99)	3.15 (1.91)	2.68 (1.78)	8.21 (2.95)	2.13 (1.62)	1.12 (1.27)	0.10 (0.77)	2.00 (1.58)
Mean	0.12 (0.79)	0.16 (0.81)	0.76 (1.12)	2.47 (1.72)	3.42 (1.98)	7.07 (2.75)	3.08 (1.89)	0.91 (1.19)	0.19 (0.83)	-
									SEm±	CD (5%)

A factor		NS	0.87	3.44
B factor		S	0.02	0.05
AXB factor		S	0.88	2.60
BXA factor		S	0.03	0.08

Table 2: Aphid population per leaf of tomato crop recorded during the experiment (2nd year)

Treatments	Standard weeks of observations								Mean weekly population	
	3rd	4th	5th	6th	7th	8th	9th	10th	11th	
A_1B_2- Only insects with rec. dose of fertilizer	0.00	0.27 (0.87)	0.85 (1.16)	2.83 (1.78)	3.71 (2.04)	9.18 (3.06)	5.33 (2.41)	0.97 (1.21)	0.25 (0.86)	1.67 (1.47)
A_2B_2- Only insects with 75% of rec. dose of fertilizer	0.00	0.18 (0.82)	0.88 (1.17)	2.82 (1.82)	3.80 (2.07)	5.97 (2.51)	3.86 (2.08)	0.76 (1.12)	0.21 (0.84)	1.32 (1.35)
A_3B_2 -Only insects 50% of with rec. dose of fertilizer	0.00	0.14 (0.80)	0.82 (1.15)	0.23 (0.85)	3.34 (1.95)	8.75 (3.04)	2.02 (1.58)	0.78 (1.13)	0.20 (0.84)	1.16 (0.29)
A_1B_3- Both RKN and insects with rec. dose of fertilizer	0.00	0.13 (0.79)	0.79 (1.13)	2.05 (1.59)	2.77 (1.80)	4.70 (2.28)	2.34 (1.68)	0.67 (1.08)	0.13 (0.80)	0.97 (1.21)
A_2B_3- Both RKN and insects with 75% of rec. dose of fertilizer	0.00	0.11 (0.78)	0.56 (1.02)	3.67 (2.03)	2.91 (1.84)	5.28 (2.38)	3.05 (1.88)	0.88 (1.18)	0.14 (0.80)	1.19 (1.30)
A_3B_3 -Both RKN and insects 50% rec. dose of fertilizer	0.00	0.08 (0.76)	0.46 (0.98)	3.10 (1.89)	2.57 (1.75)	8.23 (2.95)	2.17 (1.63)	1.05 (1.24)	0.11 (0.78)	1.27 (1.33)
Mean	0.00	0.15 (0.81)	0.73 (1.11)	2.45 (1.72)	3.18 (1.92)	7.02 (2.74)	3.13 (1.91)	0.85 (1.16)	0.17 (0.82)	-
									SEm±	CD (5%)
A factor								NS	0.55	2.15
B factor								S	0.01	0.02
AXB factor								S	0.55	1.63
BXA factor								S	0.01	0.04

3.2 Whitefly (*Bemisia tabaci* Gennadius)

In the first year whitefly population was observed first at 5th standard week and population reached at its peak during 6th and 7th standard week and then the population declined gradually (Table 3). The second year population data showed the same trend (Table 4). Regarding the interaction effect of different doses and types of pest infestation it was found that the number of whitefly per leaf was influenced significantly by the said interaction effect and the highest number of whitefly per leaf was obtained in treatment combination A_1B_2 *i.e.* only insects with recommended dose of fertilizer for both each year. Lowest value of 0.97 (1.21) number of whitefly per leaf was recorded for treatment combination A_2B_2 *i.e.* Only insects with 75% of rec. dose of fertilizer for first year and 0.37(0.93) number of whitefly per leaf was observed for treatment combination A_3B_2 *i.e.* Only insects with 50% of rec. dose of fertilizer for second year.

Table 3: Whitefly population per leaf taken during the experiment (1st year)

Treatments	Standard weeks of observations					Mean
	5th	6th	7th	8th	9th	
A_1B_2- Only insects with rec. dose of fertilizer	0.26 (0.87)	3.34 (1.96)	3.15 (1.91)	1.47 (1.40)	0.71 (1.10)	1.79 (1.51)
A_2B_2- Only insects with 75% of rec. dose of fertilizer	0.18 (0.82)	1.82 (1.52)	2.10 (1.61)	1.27 (1.33)	0.43 (0.96)	0.97 (1.21)
A_3B_2 -Only insects with 50% of rec. dose of fertilizer	0.15 (0.81)	1.50 (1.41)	2.53 (1.74)	0.85 (1.16)	0.27 (0.88)	1.06 (1.25)
A_1B_3- Both RKN and insects with rec. dose of fertilizer	0.21 (0.84)	3.25 (1.94)	2.28 (1.67)	1.01 (1.23)	0.42 (0.96)	1.43 (1.39)
A_2B_3- Both RKN and insects with 75% of rec. dose of fertilizer	0.13 (0.79)	3.43 (1.98)	3.54 (2.01)	0.90 (1.18)	0.52 (1.01)	1.70 (1.48)
A_3B_3 -Both RKN and insects with 50% rec. dose of fertilizer	0.14 (0.80)	1.62 (1.46)	2.83 (1.82)	0.69 (1.09)	0.29 (0.89)	1.11 (1.27)
Mean	0.18 (0.82)	2.49 (1.73)	2.74 (1.80)	1.03 (1.24)	0.44 (0.97)	-
					SEm±	CD (5%)
A factor				NS	0.58	2.29
B factor				S	0.01	0.03
AXB factor				S	0.58	1.73
BXA factor				S	0.02	0.06

Table 4: Whitefly population per leaf taken during the experiment (2nd year)

Treatments	Standard weeks of observations					Mean
	5th	6th	7th	8th	9th	
A_1B_2- Only insects with rec. dose of fertilizer	0.25 (0.87)	3.71 (2.05)	3.00 (1.86)	1.55 (1.43)	0.76 (1.12)	0.66 (1.08)
A_2B_2- Only insects with 75% of rec. dose of fertilizer	0.19 (0.83)	1.97 (1.57)	2.32 (1.67)	1.35 (1.35)	0.47 (0.98)	0.45 (0.97)
A_3B_2 -Only insects with 50% of rec. dose of fertilizer	0.13 (0.79)	1.38 (1.36)	2.53 (1.73)	0.83 (1.15)	0.29 (0.89)	0.37 (0.93)
A_1B_3- Both RKN and insects with rec. dose of fertilizer	0.22 (0.85)	3.60 (2.02)	2.28 (1.67)	1.22 (1.30)	0.46 (0.98)	0.56 (1.03)
A_2B_3- Both RKN and insects with 75% of rec. dose of fertilizer	0.12 (0.79)	3.87 (2.07)	3.43 (1.98)	1.02 (1.22)	0.58 (1.04)	0.64 (1.07)
A_3B_3 -Both RKN and insects with 50% rec. dose of fertilizer	0.13 (0.79)	2.00 (1.57)	2.88 (1.84)	0.67 (1.08)	0.30 (0.89)	0.43 (0.96)
Mean	0.17 (0.82)	2.76 (1.81)	2.74 (1.80)	1.11 (1.27)	0.48 (0.99)	-

			SEm±	CD (5%)
A factor		NS	0.22	0.88
B factor		S	0.00	0.01
AXB factor		S	0.22	0.67
BXA factor		S	0.01	0.02

3.3 Root-knot nematodes (*Meloidogyne* spp.)

The interaction effect of different doses of fertilizer and types of pest infestation on J_2 per 200 cc of soil depicted in Table 5 and Table 6. For both of the year it was found that highest value of J_2 per 200 cc of soil was recorded from treatment combination A_1B_1 *i.e.* only RKN with rec. dose of fertilizers followed by A_2B_1 *i.e.* only RKN with 75% of rec. dose of fertilizers. However lowest value of J_2 per 200 cc of soil was obtained from A_3B_1 *i.e.* only RKN with 50% of rec. dose of fertilizers. The mentioned interaction was found to significantly influence the J_2 population in soil.

Population of female RKN per 5 g of root was found statistically non-significant in different doses of fertilizer as well as different types of pest infestation but their interaction effect was observed to significantly influence female RKN population in root. The maximum value of female RKN per 5 g of root was obtained in treatment combination A_1B_1 i.e. Only RKN with rec. dose of fertilizers whereas the minimum value of female RKN per 5 g of root was for A_3B_1 *i.e.* only RKN with 50% of rec. dose of fertilizers for 1st year and 2nd year (Table 7 and Table 8).

The different doses of fertilizer and different types of pest infestation was found non-significant incase of population of egg mass per 5 g of root but the interaction effect had direct influence on egg mass population in root. Significantly higher number of egg mass per 5 g of root was recorded in treatment combination of A_1B_1 *i.e.* only RKN with rec. dose of fertilizers followed by A_2B_3 and A_1B_3 and the lowest in A_3B_3 *i.e.* both RKN and insects with 50% of rec. dose of fertilizers (Table 9 and Table 10).

Table 5: Population of root- knot Nematode, J_2 per 200cc of soil at different developmental stages of tomato (1st year)

Treatments	J2 /200cc of soil			
	30 DAT	60DAT	90DAT	mean
A_1B_1-Only RKN with rec. dose of fertilizers	426.80	425.20	451.30	434.43
A_2B_1- Only RKN with 75% of rec. dose of fertilizers	388.00	403.80	414.50	402.10
A_3B_1- Only RKN with 50% of rec. dose of fertilizers	231.60	222.80	248.34	234.25
A_1B_3- Both RKN and Insects with rec. dose of fertilizers	232.20	248.00	267.80	249.33
A_2B_3-Both RKN and Insects With 75% of rec. dose of fertilizers	295.20	298.80	328.28	307.43
A_3B_3- Both RKN and insects with 50% of rec. dose of fertilizers	308.20	337.40	340.10	328.57
mean	313.67	322.67	341.72	
			SEm±	CD (5%)
A factor		NS	141.37	554.31
B factor		S	3.32	9.87
AXB factor		S	141.26	419.70
BXA factor		S	5.75	16.52

Table 6: Population of root- knot Nematode, J_2 per 200cc of soil at different developmental stages of tomato (2nd year)

Treatments	J2 /200cc of soil			
	30 DAT	60DAT	90DAT	mean
A_1B_1-Only RKN with rec. dose of fertilizers	432.40	441.00	462.16	445.19
A_2B_1- Only RKN with 75% of rec. dose of fertilizers	391.20	414.00	415.10	406.77
A_3B_1- Only RKN with 50% of rec. dose of fertilizers	229.70	219.00	251.74	233.48
A_1B_3- Both RKN and Insects with rec. dose of fertilizers	231.70	248.46	261.74	247.30
A_2B_3-Both RKN and Insects With 75% of rec. dose of fertilizers	291.70	300.38	335.44	309.17
A_3B_3- Both RKN and insects with 50% of rec. dose of fertilizers	316.60	338.40	347.04	334.01
mean	315.55	326.79	345.54	-
			SEm±	CD (5%)
A factor		NS	142.60	559.92
B factor		S	3.52	10.45
AXB factor		S	142.70	423.98
BXA factor		S	6.09	17.48

Table 7: Population of root- knot Nematode, Female RKN per 5 g of root at different developmental stages of tomato (1st year)

Treatments	Female RKN/5 g of root			
	30 DAT	60 DAT	90 DAT	mean
A_1B_1-Only RKN with rec. dose of fertilizers	31.40	52.60	62.20	48.73
A_2B_1- Only RKN with 75% of rec. dose of fertilizers	12.80	26.60	29.20	22.87
A_3B_1- Only RKN with 50% of rec. dose of fertilizers	16.00	18.60	18.40	17.67
A_1B_3- Both RKN and Insects with rec. dose of fertilizers	21.20	27.20	38.00	28.80
A_2B_3-Both RKN and Insects With 75% of rec. dose of fertilizers	15.80	45.20	61.80	40.93
A_3B_3- Both RKN and insects with 50% of rec. dose of fertilizers	17.40	14.40	25.60	19.13
mean	19.10	30.77	39.20	
			SEm±	CD (5%)

A factor		NS	13.02	51.12
B factor		NS	2.65	7.88
AXB factor		S	13.61	40.45
BXA factor		S	4.59	13.18

Table 8: Population of root- knot Nematode, Female RKN per 5 g of root at different developmental stages of tomato (2nd year)

Treatments	Female RKN/5 g of root			
	30 DAT	60 DAT	90 DAT	mean
A_1B_1-Only RKN with rec. dose of fertilizers	30.60	53.40	66.20	50.06
A_2B_1- Only RKN with 75% of rec. dose of fertilizers	13.40	27.00	32.40	24.26
A_3B_1- Only RKN with 50% of rec. dose of fertilizers	15.20	18.40	20.20	17.93
A_1B_3- Both RKN and Insects with rec. dose of fertilizers	20.80	27.00	37.60	28.46
A_2B_3-Both RKN and Insects With 75% of rec. dose of fertilizers	15.20	48.20	64.80	42.73
A_3B_3- Both RKN and insects with 50% of rec. dose of fertilizers	15.80	15.00	23.80	18.20
mean	18.50	31.50	40.83	-
			SEm±	CD (5%)
A factor		NS	13.29	52.18
B factor		NS	2.88	8.54
AXB factor		S	13.97	41.51
BXA factor		S	4.98	14.30

Table 9: Population of root- knot Nematode, Egg mass RKN per 5 g of root at different developmental stages of tomato (1st year)

Treatments	Egg mass of RKN/5 g root			
	30 DAT	60DAT	90DAT	mean
A_1B_1-Only RKN with rec. dose of fertilizers	20.60	52.60	61.60	44.93
A_2B_1- Only RKN with 75% of rec. dose of fertilizers	12.40	27.00	34.00	24.47
A_3B_1- Only RKN with 50% of rec. dose of fertilizers	20.80	19.40	27.00	22.40
A_1B_3- Both RKN and Insects with rec. dose of fertilizers	18.60	27.20	37.20	27.67
A_2B_3-Both RKN and Insects With 75% of rec. dose of fertilizers	18.40	41.40	62.80	40.87
A_3B_3- Both RKN and insects with 50% of rec. dose of fertilizers	15.60	13.00	17.80	15.47
mean	17.73	30.10	40.07	
			SEm±	CD (5%)
A factor		NS	12.92	50.71
B factor		NS	2.88	8.56
AXB factor		S	13.62	40.46
BXA factor		S	4.99	14.32

Table 10: Population of root- knot Nematode, Egg mass RKN per 5 g of root at different developmental stages of tomato (2nd year)

Treatments	Egg mass of RKN/5 g root			
	30 DAT	60DAT	90DAT	mean
A_1B_1-Only RKN with rec. dose of fertilizers	22.40	55.00	63.80	47.07
A_2B_1- Only RKN with 75% of rec. dose of fertilizers	19.20	30.00	35.20	28.13
A_3B_1- Only RKN with 50% of rec. dose of fertilizers	17.40	21.40	25.60	21.47
A_1B_3- Both RKN and Insects with rec. dose of fertilizers	17.80	28.40	38.40	28.20
A_2B_3-Both RKN and Insects With 75% of rec. dose of fertilizers	17.20	45.20	64.60	42.33
A_3B_3- Both RKN and insects with 50% of rec. dose of fertilizers	12.60	13.40	18.60	14.87
mean	17.77	32.23	61.55	
			SEm±	CD (5%)
A factor		NS	13.31	52.25
B factor		NS	2.99	8.87
AXB factor		S	14.04	41.72
BXA factor		S	5.17	14.85

Table 11: Yield of the tomato plants in different nutrient regimes under different treatments (1st year)

Treatments	Yield at different doses of fertilizer (Kg/ha)		
	Recomended Doses of Fertilizer A_1	75% of Recc Doses of Fertilizer A_2	50% of Recc Doses of Fertilizer A_3
B_1-Only RKN	27990	26100	17900
B_2-Only Insects	24800	24790	24650
B_3-Both RKN and Insects	20570	25010	16550
B_4-No RKN & insects	32000	32570	28120
		SEm±	CD (5%)
A factor	S	698.37	2277.51
B factor	S	683.83	1961.32
AXB factor	S	1240.91	3559.13
BXA factor	S	1184.42	3351.72

Table 12: Yield of the tomato plants in different nutrient regimes under different treatments (2nd year)

Treatments	Yield at different doses of fertilizer (Kg/ha)		
	recomended doses of fertilizer A_1	75% of recc doses of fertilizer A_2	50% of recc doses of fertilizer A_3
B_1-Only RKN	26510	25750	18200
B_2-Only Insects	24920	24480	24094
B_3-Both RKN and Insects	19740	24610	16840
B_4-No RKN & insects	32610	33776	28540
		SEm±	CD (5%)
A factor	NS	2156.16	7031.64
B factor	S	1303.33	3738.17
AXB factor	NS	2910.51	8347.80
BXA factor	NS	2257.44	6388.18

3.4 Yield (Kg/ha)

Irrespective of the nutrient regimes Yield of plots with no pest attack had shown the maximum yield. At recommended dose & 50% dose of fertilizer minimum yield was observed for the plots infested with both RKN & insects but at 75% doses of fertilizer minimum yield was for the plots infested with only insects for both of the year (Table 11 and Table 12).

The interaction of different dose of fertilizer and types of pest infestation had pronounced effect on yield of tomato plant for the first year but the mentioned effect was found non-significant for the second year. Higher value was obtained from treatment combination of A_2B_4 *i.e*. no pest attack with 75% of rec. Dose of fertilizer and the lowest value was recorded from A_3B_3 *i.e*. both RKN and insects with 50% of rec. dose of fertilizers for both of the year.

4. Conclusion

It can be concluded that the sucking of the plant sap by the nematodes and phloem feeding by the insects played a major role in their co inhabitation and affected the population of each other as well as yield of tomato plant. Despite adequate availability of nutrients under recommended dose of fertilizer, plants infested by both root knot nematodes and sucking pests the population of these pests were lower as compared to the plants subjected to sole infestation of these pests. This could have happened due to plant mediated interaction between these two spatially separated organisms.

Both below ground and above ground feeder population was recorded to reduce due to nutrient stress condition at 75% and 50% recommended dose of fertilizer. Regarding the yield component, it was recorded to be maximum in the plot without RKN and insect infestation and plants infested by both nematode and insects exhibited significantly lesser yield.

The interaction of different doses of fertilizer and types of pest infestation had statistically significant effect on below ground and above ground population and yield of tomato plants.

Root-feeding nematodes can positively or negatively affect shoot herbivorous insects, and *vice versa*. As herbivore often elicits systemic changes in plant traits, indirect interactions via induced plant responses may be a pervasive feature structuring herbivore communities.

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