Bangladesh J. Sugarcane, 29 : 48-55

July, 2007

Effect of NPK and Nematode Inoculum on Root-knot Disease Incidence and Some Yield Parameters Contributing to Yield of Sugarcane and Recovery of Sugar

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ABSTRACT

An experiment was conducted to find out the effect of different NPK combinations and nematode inoculum on root-knot disease incidence and yield of sugarcane. The number of galls and female root-knot nematodes ranged from 1.3-5.0 and 1.4-5.4 respectively per gram of roots under different combinations of NPK. Significantly higher number of galls and mature females of root-knot nematodes were found in plant fertilized with N alone as compared to all other treatments. The treatments K alone and P+K gave the least population (1.4 nos./g root) of nematodes. Non- inoculated canes gave significantly higher numbers of leaves, roots, tillers, millable canes, length of internodes, weight of canes and recovery of sugar than those of inoculated canes under different N, P and K treatments. Nematode inoculated infected canes showed comparatively low sugar recovery of 6.85% than the non- inoculated healthy canes which showed 8.44% recovery of sugar. Besides, number of roots, length of internode, and height of cane and girth of cane showed significant negative correlation with the galling incidence under different fertilizer treatments. On the other hand, length of roots, girth of cane, weight of millable canes and number of millable canes also showed significant negative correlations with number of female rootknot nematodes.

Key words : Effect, NPK, root-knot, sugarcane.

INTRODUCTION

Fertilizers may affect nematodes in various ways. Sometimes attack is avoided either in part or totally because the activity of the pest is not properly synchronized with the vulnerable stages of the host. Fertilizers may also induce tolerance through hypersensitivity reactions causing necrotic lesions or in the formation of suberized cells. Non-preference response to a host by a parasite due to substances that deter or repel it , may also be evident. Antibiosis may occur due to the inappropriate quality of food, wrong or unbalanced proportion of nutrients, unpalatable food, sticky hairs or other morphological impediments, excess of fibre or harmful toxins that interfere with growth and reproduction (Jones, 1976).

Inorganic fertilizers have been in use for over one century with great benefit in increased plant growth and better crop quality (Lyon *et al.*,1952). Nitrogenous fertilizer is essential for vegetative growth of plant, while phosphatic fertilizer aids in the development of reproductive structures and potassic fertilizer gives strength and stiffness to the plant. Since plant nutrition and growth are altered by these elements, the rates of reproduction and development of plant parasitic nematodes may also be influenced (Mountain,1965). Nitrogenous fertilizers normally stimulate plant growth and increase indirectly some plant parasitic nematodes. But this depends on the form of nitrogen and the rate of application which may also directly affect soil nematodes.

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Mukhopadhyaya and Prasad (1968) observed increased numbers of *Meloidogyne incognita* with application of N and decrease with K whereas, Lall and Das (1959) reported that fertilization of the soil with muriate of potash seemed to reduce *M. incognita* infestation in vegetables belonging to *Solanaceae, Leguminosae*, and *Malvaceae*. Gupta and Mukhopadhyaya (1971) reported that N favours greatly the formation of *M. javanica* galls with corresponding increase in dry weight of root of tomato. They found no significant increase in the number of galls in different P treatments though significant increase in dry weight of root and shoot were obtained. They also noted that increased level of K brought down significantly the number of nematodes galls probably due to the limitation of nematodes reproduction; galls were smaller in size and the dry weight of shoots increased significantly. NPK interaction was predominant for dry weight of shoot and number of galls. Ichinohe (1972) found that *Aphelenchus besseyi* caused a greater rate of infection in rice paddies due to excessive nitrogenous fertilizers.

With the above background, to find out the effect of NPK and nematode inoculum on root-knot and yield of sugarcane this experiment was undertaken.

MATERIALS AND METHODS

A pot experiment was conducted to find out the effect of NPK and nematode inoculum on root-knot development, plant growth and yield parameters of sugarcane during 1999-2000 and 2000-2001. The soil was sterilized with formalin (40% formaldehyde) @ 30 ml formalin dissolved in 1000 ml water for per cubic feet of soil. The treated soil was covered with polythene sheets and kept for 72 hours. Then the polythene sheets were removed and the soil was spread in thin layer on the pucca floor for 7 days. Earthen pots were used. Each pot was filled with 12 kg sterilized and dried soil. An earthen plate was placed below each pot to retain excess fluids. Urea, TSP and MP @ 280, 180 and 120 kg/ha were applied as recommended for sugarcane (Ali *et al*., 1989). Urea, TSP and MP were applied for N, P and K respectively in different combinations viz. N, P, K, NP, NK, PK and NPK. Entire amount of TSP was applied at planting. One third of urea and one third of MP were applied as first top dressing after 20 days of planting. The rest two third of urea and MP were applied in two splits as top dressing after 45 days and 90 days of the first application of urea and MP. The experiment was conducted in a split plot design with four replications. Eight fertilizer treatments were tested in sub-plots and the nematode inocula were tested in whole plots. Three sets each of 32 plots (40 cm dia) were used in the experiment. All the three sets of pots were filled with sterilized soil and one month old settling of the sugarcane variety Isd 16 was transplanted in each pot. The pots with settling were watered regularly for normal growth of the cane. When the plants were established, the soil of the pot around the base of the plant was loosened with the help of a "Nirani" from time to time. Weeding and mulching were done every alternate fortnight up to harvest of the plants. To enhance the growth and root development, the settlings were fertilized in three instalments as cited earlier. Each pot received 3.5 g urea, 2.25 g TSP and 1.5 g MP at the rate of 280, 180 and 120 kg/ha of urea, TSP and MP, respectively as recommended by Ali *et al.*(1989).

After 45 days of transplanting, a set of 32 pots (four for each treatment) were inoculated with 20 eggmasses collected from tomato roots and brinjal roots previously inoculated with single eggmass of root-knot nematode. These 32 pots were used for recording data on galling incidence and population of root-knot nematodes. Another set of 32 pots (four for each treatment) was similarly inoculated to record data on different growth and yield parameters. Another set of 32 pots (four for each treatment) was used as control (without inoculum). Data were collected on tiller number, number of galls and eggmass, population of nematodes, number and length of leaves per plant, number of millable canes, growth of cane, height of cane, length of internode, weight of millable canes, weight and length of root and recovery of sugar.

RESULTS AND DISCUSSION

Significantly higher number of galls and mature females of root-knot nematodes were found in plant fertilized with N alone as compared to other treatments (Table 1). The differences in number of root-galls under the treatments P alone, K alone, N+P, N+K, P+K, N+P+K and control were not significant. Similarly the differences among the treatments P alone, N+P, N+K, N+P+K and control regarding population of nematodes were not significant. The treatments K alone and P+K gave the least population (1.4 nos./g root) of nematodes. These findings confirm the results obtained by Mukhopadhyaya and Prasad (1968) who observed that number of *Meloidogyne incognita* was increased with application of N and decreased with K. Lall and Das (1959) reported that fertilization of the soil with muriate of potash seemed to reduce *M. incognita* infestation in vegetables belonging to *Solanaceae, Leguminosae* and *Malvaceae*. Gupta and Mukhopadhyaya (1971) reported that N favours greatly the formation of *M. javanica* gall with corresponding increase in dry weight of root of tomato. They also noted that increased level of K brought down significantly the number of nematode galls due to the limitation of nematode production and galls were smaller in size. Tandon (1973) reported that addition of N to tobacco caused an increase in galling of plants by *M. incognita*. Similar results in support of this experiment were narrated by Fayad and Sweelam (1989) that in a pot experiment, tomato plants were inoculated with *Meloidogyne javanica* and then given various applications of super phosphate and organic fertilizers. Application of TSP as a source of phosphorus together with cattle manure reduced nematode populations and increased the nutrient uptake and tomato growth. Singh and Sitaramaiah (1971) observed that application of sawdust at the rate of 2,200 1bs/acre, three weeks before planting followed by inorganic nitrogenous fertilizers with P and K at the time of planting, effectively reduced the population of *Meloidogyne javanica* on okra and increased the yields many fold. Fertilizers may affect nematodes in various ways. Sometimes attack is avoided (escape) either in part or totally because the activity of the pest is not properly synchronized with the vulnerable stages of the host. Fertilizers may also induce tolerance through hypersensitivity reactions causing necrotic lesions or in the formation of suberized cell. Non-preference response to a host by a parasite due to substances that deter or repel it may also be evident. Antibiosis may occur due to the inappropriate quality of food, wrong or unbalanced preparation of nutrients, unpalatable food, sticky hairs or other morphological impediments excess of fibre or harmful toxins that interfere with growth and reproduction (Painter, 1951,1958 and Jones, 1976).

Table 1. Number of root galls and population of mature females of *Meloidogyne spp.* in roots of sugarcane grown in soils fertilized with NPK in different combinations.

Treatments	Number of galls/ g root	Population of female nematodes /g root
N = Urea 280 kg/ha	5.0 a	5.4 a
P = TSP 180 kg /ha	2.5 b	2.6 bc
K = MP 120 kg / ha	1.3 b	1.4 c
N + P	3.4 b	3.4 b
N +K	1.9 b	2.1 bc
P + K	1.3 b	1.4 c
N + P + K	1.6 b	1.9 bc
Control(without fertilizer)	1.5 b	1.7 bc

Values are averages of 16 observations and those within the same column with a common letter (s) do not differ significantly (P= 0.05) by DMRT.

The NPK fertilizers had significant effects on almost all yield components of sugarcane. Specifically the combined effect of NPK fertilizers significantly increased the yield of sugarcane

(Table 2 and 3). These results had the conformity with that of Lyon *et al.* (1952) who reported that inorganic fertilizers have been in use for over one century with great benefit in increased plant growth and better crop quality . Nitrogenous fertilizer is essential for vegetative growth of plant, while phosphate fertilizer aids in the development of reproductive structures (flowers and fruits) and potash fertilizer gives strength and stiffness to the plant. Other citations similar to this experimental results are given. Sugarcane cv. Co 419 was grown continuously from 1971 at Mandhya, Karnataka on red sandy loam soil with no fertilizer application, 250 kg N ha^{-1} annually as urea or ammonium sulphate or each N treatment plus 100 kg P_2O_5 and 125 kg K_2O t ha^{-1} annually. Cane yield in 1971 was 63 t ha^{-1} without fertilizers and was similar 152 -164 t ha^{-1} from N alone and N+P+K. In 1988 gave cane yields of 130-136 t ha^{-1}, yield from N alone was 30-34 t ha^{-1} and N+P+K gave cane yields of 130-136 t ha^{-1} (Rabindra *et al.*,1993). Alvarez *et al.* (1991) reported that the NPK factorial experiments were conducted on dark red latosols in various sugar plantations in the state of Sao Paulo, Brazil with the amounts of nutrients applied 0,90 and 180 kgha^{-1} of N ; 0,80 and 160 kgha^{-1} of P_2O_5 and 0,100 and 200 kg ha^{-1} of K_2O. It has been observed that yield increased due to NPK was directly related to the maximum economic yield.

Table 2. Effect of NPK and nematode inoculum on leaf and root growth of sugarcane during the first crop year (1999 – 2000).

Treatments	No. of leaves/ plant	Length/leaf (cm)	No. of roots/clump	Lenght of roots /clump (m)	Weight of air dried roots/ clump (g)
Fertilizer (kg/ha)					
N = Urea 280	6.8 abc	113.1 a	79.5 a	8.39 ab	23.00 bc
P = TSP 180	6.2 bc	141.1 ab	82.6 a	7.83 ab	24.63 bc
K = MP 120	7.6 ab	115.7 ab	72.8 a	7.59 ab	18.00 c
N + P	7.3 abc	115.8 ab	82.0 a	8.78 ab	31.25 ab
N +K	6.7 abc	110.6 abc	93.8 a	9.23 a	30.50 ab
P + K	6.9 abc	107.6 bc	80.9 a	6.84 ab	20.00 c
N + P + K	7.9 a	121.9 a	85.8 a	9.42 a	33.75 a
Control (without fertilizer)	6.0 c	99.9 c	70.0a	5.43 b	4.88 d
Category of canes					
Inoculated	6.2 b	111.2 a	72.3 b	6.72 b	18.88 b
Noninoculated	7.7 a	113.5 a	89.5 a	9.16 a	27.63 a

Values are the averages of 8 observations in case of NPK and 32 observations in case of category of canes and those within the same column with a common letter (s) do not differ significantly (P = 0.05) by DMRT.

Non-inoculated canes gave significantly higher number of leaves, roots, length of internode, weight of canes, recovery of sugar, number of tillers and number of millable canes than those of inoculated canes under different N, P and K treatments (Table 2 and 3). Nematode inoculated infected canes showed comparatively low sugar recovery of 6.85% than the non-inoculated healthy canes which showed 8.44% recovery of sugar (Table 3).

Besides, number of roots, length of internode, height of cane, girth of cane and number of tillers showed significant negative correlation with the galling incidence under different fertilizers treatments (Table 4). On the other hand, girth of cane, number of millable canes and height of cane also showed significant negative correlations with number of female root-knot nematodes (Table 5). All these effects on growth and yield parameters of sugarcane as observed in our study might have resulted from nemic infection and change in metabolic activities of plant due to nematodes (Islam *et al.*,1994). Similar results were reported by various workers regarding heavy galling of the roots and significantly reduced growth of sugarcane by root-knot nematodes (Salawu, 1985). Novaretti (1982) carried out studies under controlled conditions, comparing a check plot without nematodes to plots infested with three different initial levels of *Meloidogyne javanica*. Reduction up to 54% in the dry weight of roots and 45% in the yield, occurred in inoculated plants compared to healthy plants. Choudhury (1981) reported that the crop loss due to root–knot nematodes has been estimated to vary 10-15% resulting in substantial yield loss. The result of the present study also corroborated with the work of Salawu (1987). Working with *Meloidogyne incognita* and *Heterodera sacchari* Salawu (1987) observed that increase in the population of two nematodes in the rhizosphere caused severe damage to the roots of sugarcane which in turn was responsible for the reduction of top growth of the plants. *M. incognita* caused heavy galling of roots and significantly reduced the plant growth in the sugarcane variety Co 396. Similarly Oteifa (1952) reported a correlation between the increase in number of *Meloidogyne incognita* on the plant and reduction of plant growth. It was suggested by Oteifa (1952) that nematode damage was correlated with available K and that the nematodes thus caused marked injury to plants with insufficient available K. Addition of this element might reduce the damage. Oteifa (1953) further concluded that the use of K fertilizers in nematode infested soil would increase plant growth provided the soil was deficient in K. Significant reduction in growth of sugarcane was evident as a result of additive effects of both the red rot and root- knot disease complex (Salawu, 1988). Similar results were observed in case of other crop also. There was continuous reduction in length and weight of shoot of gram crop with the increase in the initial inoculum level of *Meloidogyne javanica*. The length of gram root was significantly reduced by inoculating 100 nematodes. Thousand or more larvae were required to cause appreciable damage in root weight (Srivastava *et at.*, 1974). The results of the present study also support the results reported by Sivakumar and Meerzainuddin (1973) who observed that the yield loss due the nematode, *Rotylenchulus reniformis* on okra ranged from 2.7% in pots under N and P to 26.84 % under 'no fertilizer'. Differences in yield due to the nematode, irrespective of the fertilizer treatments were highly significant, while the interaction of fertilizer × nematodes was not significant. The reniform nematode caused maximum reduction in yield in poor soils not supplemented with fertilizers. The yield reduction due to nematode varied with the nutrients supplied, but had no relation to the final nematode population .Similar result was observed by Fayad and Sweelom (1989) that application of triple super phosphate as a source of phosphorus together with cattle manure reduced nematode population and thus increased the nutrient uptake and tomato growth.

Table 3. Effect of NPK and nematode inoculum on height, girth and length of internode of cane, tillers, millable canes (MC) and recovery of sugar during the first crop year (1999 – 2000).

Treatments	Height /cane (cm)	Girth/cane (cm)	Length /internode (cm)	Tillers /clump (Nos.)	MC/clump (Nos.)	Weight of MC/clump (kg)	Recovery of sugar (%)
Fertilizer (kg/ha)							
N = Urea 280	137.5 a	2.00 a	8.31 cd	2.3 a	2.6 a	1.10 ab	7.67 a
P = TSP 180	134.2 ab	1.88 a	8.64 bcd	1.4 b	1.9 ab	0.89 abc	8.07 a
K = MP 120	141.0 a	1.78 a	9.51abc	1.8 ab	2.5 a	1.01 ab	7.28 a
N + P	145.3 a	1.85 a	9.07 abcd	1.8 ab	2.1 a	0.92 abc	7.48 a
N +K	133.8 ab	1.85 a	9.92 a	2.4 a	1.9 ab	1.00 ab	7.68 a
P + K	143.3a	1.90 a	9.65 ab	1.3 b	1.9 ab	0.77 bc	7.86 a
N+P + K	149.4 a	2.00 a	10.19 a	2.3 a	2.5 a	1.42 a	7.75 a
No fertilizer	99.2 b	1.81 a	8.10 d	1.1 b	1.1 b	0.46 c	7.36 a
Category of canes							
Inoculated	124.7 b	1.84 a	8.69 b	1.6 b	1.7 a	0.74 b	6.85 b
Non-inoculated	146.3 a	1.92 a	9.66 a	2.0 a	2.4a	1.14 a	8.44 a

Values are the averages of 8 observations in case of NPK and 32 observations in case of category of canes and those within the same column with a common letter (s) do not differ significantly (P = 0.05) by DMRT.

Table 4. Correlations between galling incidence and yield components of sugarcane under K, N+K & no fertilizer treatments during 1999-2000 and P & N+P +K treatments during 2000-2001.

Parameters	1999-2000			2000-2001	
	K	N+K	No fertilizer	P	N+P +K
	r-value	r-value	r-value	r-value	r-value
NL x NG	-0.0822	-0.8195	-0.4405	-0.4714	-0.5771
LL x NG	-0.0166	-0.6031	-0.4023	-0.075	-0.0964
NR x NG	-0.9885*	-0.2543	-0.026	-0.3352	0.7652
LR x NG	-0.7582	-0.5983	-0.1796	-0.664	0.2130
WR x NG	-0.8465	-0.9163	-0.6794	-0.6558	0.8555
HC x NG	-0.59	-0.8634	-0.9515*	-0.7737	-0.7230
GC x NG	-0.363	-0.9966**	-0.3699	-0.9034	-0.4035
LI x NG	-0.5257	-0.3189	-0.2229	-0.059	-0.9587*
NT x NG	-0.1302	-0.9439	-0.6794	-0.9623*	-0.3887
NM x NG	-0.3184	-0.8540	-0.1022	-0.5774	-0.2748
WM xNG	-0.1648	-0.1580	-0.2851	-0.5041	-0.3015
RS x NG	-0.0659	-0.2623	-0.0825	-0.2298	-0.6063

* = Significant at 5% level
** = Significant at 1% level

NL = No. of leaves / plant
LL = Length /leaf
NR = No. of roots / clump
LR = Length of roots / clump
WR = Wt. of air dried roots / clump
HC = Height / cane
GC = Girth / cane
LI = Length / internode
NT = No. of tillers / clump
NM = No. of millable canes / clump
WM = Wt. of millable canes /clump
RS = Recovery of sugar
NG = No. of galls / g root.

Table 5. Correlations between female root-knot nematodes and yield components of sugarcane under P, N, N+P and no fertilizer treatments in the first crop year (1999-2000) and second crop year (2000-2001).

Parameters	1999-2000		2000-2001	
	r-value		r-value	
	P	No fertilizer	N	N+P
NL x RN	-0.7873	-0.2650	-0.6471	0.0747
LL x RN	-0.7066	-0.6293	-0.8836	-0.6823
NR x RN	-0.7440	-0.1796	-0.4172	0.5523
LR x RN	-0.9804*	-0.3394	-0.9445	-0.7065
WR x RN	-0.3453	-0.6647	-0.4529	0.3274
HC x RN	-0.3033	-0.9689*	-0.5909	-0.9091
GC x RN	-0.3449	-0.1738	-0.9720*	-0.0371
LI x RN	-0.0865	-0.2435	-0.5814	-0.9162
NT x RN	-0.3506	-0.5101	-0.09	-0.8461
NM x RN	-0.7103	-0.1391	-0.5913	-0.9798*
WM x RN	-0.8048	-0.4796	-0.9894*	-0.6767
RS x RN	-0.4791	-0.086	-0.9267	-0.2888

* = Significant at 5% level

NL = No. of leaves / plant
LL = Length / leaf
NR = No. of roots / clump
LR = Length of roots / clump
WR = Wt. of air dried roots / clump
HC = Height / cane
GC = Girth / cane
LI = Length / internode
NT = No. of tillers / clump
NM = No. of millable canes / clump
WM = Wt. of millable canes / clump
RS = Recovery of sugar
RN = No. of female root-knot nematodes / g root.

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