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Eco-friendly management of sugarcane nematode, *Pratylenchus zae graham*

J Jayakumar**Abstract**

Field experiments were conducted at Sugarcane Research Station, during 2017-2018 and 2018-2019 to find out the field efficacy of ecofriendly management of lesion nematode, *Pratylenchus zae* Graham in sugarcane. The experiment was laid out in randomized block design with ten treatments replicated three times. The initial nematode population was assessed prior to planting by analyzing soil samples. Soil samples were collected on 90,180,270, and 360 days after planting of the cane. The soil samples were processed and analyzed for nematode population. The tiller count was taken up on 90 days after planting. Cane samples were collected on 10th month and analyzed the juice for commercial cane sugar percentage. The pooled analysis of the two years, main and ratoon crop data revealed significant reduction in the population of lesion nematode, *Pratylenchus zae* in sugarcane plants treated with the combined application of press-mud 25t/ha, FYM 12.5t/ha, poultry manure 1t/ha, sunhemp intercropping, neem cake 2t/ha, mulching with cane trash 5 t/ha and biocontrol agents of *pseudomonas fluorescens* + *Trichoderma viridie*. Significant reduction in nematode population was observed upto harvest of the crop. The above treatment also significantly enhanced the cane yield. The treatment viz., T₁ to T₇, Carbofuran @ 1kg a.i/ha and neem cake 2t/ha resulted 78.33, 77.15 and 75.45 percent reduction in lesion nematode population over control. The above treatments also enhanced the no. of millable cane/ha, cane yield, sugar yield, commercial cane sugar and benefit cost ratio. The cost benefit ratio worked out for the treatments viz T₁ to T₇, Carbofuran @ 1kg a.i/ha and neem cake 2t/ha resulted 1:2.76, 1:2.61 and 1:2.58 respectively.

Keywords: Sugarcane nematode, biocontrol agent, management**Introduction**

Sugarcane is cultivated under varied conditions ranging from the tropics to the sub-tropics. At present 48 genera and 275 species of nematodes have been associated with sugarcane from 36 countries. Species of five genera viz., *Pratylenchus* spp, *Hoplolaimus* spp, *Helicotylenchus* spp, *Tylenchorhynchus* spp and *Meloidogyne* spp were listed as the major parasitic nematode. All these nematode have a wide distribution and are common in sugarcane cultivated areas in India ^[1]. Plant parasitic nematodes are one of the important biotic constraints in sugarcane production in subtropical and tropical regions of the world. It is estimated that nematodes cause an average annual yield loss of 15.3% in sugarcane ^[2]. Among the 20 life sustaining crops of the world, highest monetary loss due to nematodes is reported in sugarcane. In India nematodes are reported to cause about 10-40% yield loss in sugarcane. More than 200 species of nematodes have been reported to infest sugarcane. In India five genera viz., *Pratylenchus* sp., *Meloidogyne* sp., *Hoplolaimus* sp., *Tylenchorhynchus* sp. and *Helicotylenchus* sp. were widely prevalent in sugarcane ecosystem. Tamil Nadu has shown the association of *Helicotylenchus*, *Pratylenchus*, *Hoplolaimus*, *Tylenchorhynchus* and *Meloidogyne* spp in sugarcane crop ^[1] (Mehta, 1992). Of these, Lesion nematode *Pratylenchus* spp is the most predominant and economically important genera. Regarding the studies conducted so far shown the efficacy of organic amendments viz., press-mud and oil cakes are effective against the management of sugarcane nematodes ^[3, 4]. Further beneficial effect of intercropping for the management of nematode was also reported by (Naganathan *et al.*, (1988) and Prasad *et al.*, (1992) ^[5, 6] and in particular marigold or sunhemp or dhaicha coupled with application of either press-mud (25t/ha) or neem cake (2t/ha) is found to be very effective for the management of sugarcane nematodes. The lesion nematode, *Pratylenchus zae* are migratory endoparasites are responsible for injuries owing to its invasion of the cortical parenchyma of roots, producing yellowing-chlorosis occurring in patches spread out all over the field and causing serious economic losses.

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Long duration of one year followed by 2-3 ratoons with little disturbance of soil facilitate the build up of high nematode population in just 2-3 crop cycles which results in yield decline in subsequent crops. Further, mono-cropping of sugarcane to meet the cane demands of increasing number of sugar factories makes phyto-nematodes as a constraint to sustainable sugarcane production in many parts of India.

Studies conducted at Sugarcane Research Station, Sirugamani has shown the frequent association of *Pratylenchus* spp with the sugarcane crop. Studies conducted so far has shown the efficacy of organic amendments viz., press-mud and oil cakes for the management of sugarcane nematodes [1]. Intercropping sugarcane with either marigold or sunhemp or dhaicha coupled with application of either press-mud (25t/ha) or neem cake (2t/ha) is found to be very effective for the management of sugarcane nematodes [7]. Considering the above facts involve an attempt was made to evaluate the available eco-friendly management strategies against lesion nematode, *Pratylenchus zae* in sugarcane.

Materials and Methods

At Sugarcane Research Station, during 2017-2018 in an sick plot field condition infested with lesion nematode *P. zae* sugarcane plant crop was raised and it was subsequently ratooned during 2018-19 in which the proposed ten treatments in randomized block design. Initial population load of lesion nematodes in the experimental site was assessed by taking the pre plant soil samples in which mean population was 398 nematodes /250g soil. Seeds of the sunhemp intercrop were sown at a distance of 20 cm along the sides of the sugarcane setts. The intercrops were allowed to grow with the sugarcane crop and were incorporated in the respective plots at 60 days after sowing. The amendments viz., press-mud 25.0t/ha, farm yard manure 1.0t/ha, *Trichoderma viride* @ 1.25 kg/ha + *Pseudomonas fluorescens* @ 1.25 kg/ha, neem cake @2.0t/ha, mulching with cane trash @5t/ha and Carbofuran @1 kg a.i/ha were applied at the same time as the intercrops were incorporated.

Soil and root samples were collected at 90, 180, 270 and 360 days after planting for assessing the lesion nematode population load in the soil. Nematodes were extracted from soil samples by Cobbs decanting and sieving method [8] followed by modified Baermann's funnel method [9] for extraction of vermiform stages of males and second stage juveniles. Observations on the germination percentage and number of tillers per ha was recorded 30 and 90 days after planting respectively. The quality parameters viz., sugar yield and commercial cane sugar (CCS%) were estimated [10] at tenth month and cane yield was recorded. The data recorded were statistically analyzed. Finally the two year data were pooled and analyzed.

Results and Discussion

The statistical analysis of the first year study revealed significant reduction in the population of lesion nematode *Pratylenchus zae* in plots treated with the combined application of press-mud (25t/ha), FYM (12.5t/ha), poultry manure (1t/ha), sunhemp intercropping, neem cake (2t/ha), mulching with cane trash (5 t/ha) and *Pseudomonas fluorescens* (1.25 kg/ha) + *Trichoderma viride* (1.25 kg/ha). The above treatments resulted in reduction in lesion nematode population by 77.21 percent respectively over control. The above treatment was comparable with carbofuran used @ 1 kg a.i/ha which resulted in 76.03 percent in reduction in lesion

nematode population over control. The treatments were also enhanced the number of millable cane, commercial cane sugar per cent cane yield and sugar yield. The data are furnished in the Table 1 and 2.

The results of the first ratoon crop study revealed significant reduction in the population of lesion nematode, *Pratylenchus zae* in sugarcane plants treated with the combined application of press-mud (25t/ha), FYM (12.5t/ha), poultry manure (1t/ha), sunhemp intercropping, neem cake (2t/ha), mulching with cane trash (5 t/ha) and *Pseudomonas fluorescens* + *Trichoderma viride* each @ 1.25kg/ha. Significant reduction in nematode population was observed upto harvest of the crop. The above treatment also significantly enhanced the cane yield. The combined treatment viz., T₁ to T₇, Carbofuran @ 1kg a.i/ha and neem cake 2t/ha resulted in 79.46, 78.28 and 76.58 per cent reduction in lesion nematode population over control. The above treatments also enhanced the no. of millable cane/ha, cane yield, sugar yield, commercial cane sugar and cost benefit ratio (Table 3 and 4).

The pooled analysis of the two years, main and ratoon crop data revealed significant reduction in the population of lesion nematode, *Pratylenchus zae* in sugarcane plants treated with the combined application of press-mud (25t/ha), FYM (12.5t/ha), poultry manure (1t/ha), sunhemp intercropping, neem cake (2t/ha), mulching with cane trash (5t/ha) and biocontrol agents of *Pseudomonas fluorescens* + *Trichoderma viride* @ 1.25 kg/ha each. Significant reduction in nematode population was observed upto harvest of the crop. The above treatment also significantly enhanced the cane yield. The combined treatment viz., T₁ to T₇, Carbofuran @ 1kg a.i/ha and neem cake 2t/ha resulted in 78.33, 77.15 and 75.45 per cent reduction in lesion nematode population over control. The above treatments also enhanced the no. of millable cane/ha, cane yield, sugar yield, commercial cane sugar and cost benefit ratio (Table 5 and 6). The cost benefit ratio treatments viz T₁ to T₇, Carbofuran @ 1kg a.i/ha and neem cake (2t/ha) was 1:2.76, 1:2.61 and 1:2.58 respectively. Such effective reduction in nematode soil population and subsequent increase in yield parameters of sugar cane crop under field conditions supports the view that the eco-friendly use of intercropping and organic amendments can be effective in management of the lesion nematode in sugarcane. As observed in the present study, Jonathan *et al.*, 1991 [11] showed that the effect of organic amendments on the control of sugarcane nematodes and found that neem cake @ 2 t/ha and press-mud @ 25t/ha were most effective in reducing the population of *Meloidogyne incognita*, *Pratylenchus coffeae* and *Helicotylenchus dihystra*. Combined application of press-mud 1t/ha, farm yard manure 12.5 t/ha, poultry manure 1t/ha and *Trichoderma viride* 1.25 kg/ha + *Pseudomonas fluorescens* 1.25 kg/ha caused significant reduction in population of lesion nematode population in soil and significant increase in cane yield, cane sugar per cent and sugar yield [12]. Addition of organic amendments such as farm yard manure, oil cakes, green manure and press-mud etc. encourages the multiplication of nematode antagonistic microbes which inturn checks the plant parasitic nematodes. Jayakumar 2019 [13] reported that Maximum and significant reduction in lesion nematode in soil was observed in plots with incorporated with combination of all the treatments compared to the untreated control. Significant increase in the cane yield, commercial cane sugar percentage and sugar yield of canes was noted as compared to untreated check. The

addition of organic amendments acts in several ways against the plant parasitic nematodes. Organic acid such as formic, acetic propionic and butyric acids are released in soil during microbial decomposition or organic amendments. Ammonia and hydrogen sulphide gases are also released in soil during decomposition. These organic acids and gases are toxic to nematodes. Nematode antagonistic microbes multiply rapidly due to addition of organic matter. Organic amendments improve soil conditions and helps the plants to grow. The organic matter also provides nutrition for the crop plants. The intercropping and incorporation also add 10 to 12 tonne biomass/ha which helps to improve the physico-chemical properties of soil [14]. Among seven nematicides tested, carbofuran 3G was found most effective to enhance the plant growth and significantly reduced the *P. zae* population in soil [15]. The intercropping and incorporation also add 10 to 12 tonne biomass/ha which helped to improve the physico-chemical properties of soil [16]. Application of five oilcakes viz, groundnut, sesame, cotton seed and coconut significantly increased yield and quality of sugarcane. Application of *Pseudomonas fluorescens* (PF1) at 2.5 kg/ha significantly reduced the population of *Pratylenchus zae* and enhanced the

number of millable cane, commercial cane sugar, cane yield and sugar yield [17]. Population of *P. zae* in soil and roots was significantly suppressed by all the treatment as reported by Mehta and Sundararaj (1996) [18]. They further reported that organic amendments like neem, neem cake, FYM pressmud and *Calotropis* were effective against *P. zae* and carbofuran 3G was found at par. However, Haider and Askary (2011) [19] reported maximum reduction of plant parasitic nematodes including *P. zae* on sugarcane in Bihar state and growth was higher in *Brassica campestris* followed *Ocimum sanctum* in field. Haider and Dutta (2004) [20] reported integration of press-mud @ 200 q/ha with carbofuran 3G @ 1 kg a.i/ha at planting time resulted minimum nematode population and increased growth, yield, juice quality and CCS%. Further, significant press-mud alone could reduce *P. zae* population by 19% and increased yield by 16% sugarcane. Jonathan *et al.* (1999) [7] also observed in significant reduction in spiral nematode infestation in sugarcane plants intercropped and incorporated with either marigold (*Tagetes erecta*) or daincha (*Sesbania aculeata*) coupled with the application of either press-mud (25 t/ha) or neem cake (2 t/ha) and this treatments also enhanced the yield and quality of canes.

Table 1: Ecofriendly management of sugarcane nematode – Main crop

Treatments	Initial nematode population	Nematode population 90DAP	Nematode population 180 DAP	Nematode population 270 DAP	Nematode population 360 DAP	Per cent nematode reduction over control
T ₁ – Press-mud @ 25t/ha	396.3	252.6	275.3	290.0	302.0	64.97
T ₂ – Farm Yard Manure @ 12.5 t/ha	391.0	264.6	283.3	299.3	311.6	61.47
T ₃ – Poultry manure @ 1t/ha	399.6	244.6	262.0	278.6	287.3	67.10
T ₄ – <i>T. v</i> @ 1.25 kg/ha + <i>P. f</i> @ 1.25 kg/ha	375.6	235.0	254.3	269.6	276.3	66.59
T ₅ – Sunhemp intercropping	415.6	283.0	313.3	328.0	339.3	58.00
T ₆ – Neem cake @ 2t/ha	429.6	173.3	211.6	227.0	238.0	74.33
T ₇ – Mulching with cane trash @ 5t/ha	388.3	276.6	293.6	309.0	320.0	58.33
T ₈ – T ₁ to T ₇	402.3	155.0	182.6	197.3	213.3	77.21
T ₉ – Carbofuran @ 1kg a.i/ha	410.3	162.6	195.3	209.3	222.3	76.03
T ₁₀ – Untreated control	382.3	530.6	571.0	623.3	792.6	-
SEm	1.27	1.29	1.40	8.40	4.73	
CD (P=0.05)	3.83	3.89	4.19	25.2	14.18	-

Table 2: Ecofriendly management of sugarcane nematode – Main crop

Treatments	Germination percentage	No. Of millable cane (x 1000/ha)	Commercial cane sugar per cent	Cane yield t/ha	Sugar yield t/ha	Cost benefit ratio
T ₁ – Press-mud @ 25t/ha	87.7	176.63	12.26	135.0	16.55	1:1.74
T ₂ – Farm Yard Manure @ 12.5 t/ha	83.3	170.90	12.21	131.3	16.03	1:1.62
T ₃ – Poultry manure @ 1t/ha	83.5	182.93	12.29	139.6	17.15	1:1.88
T ₄ – <i>T. V</i> @ 1.25 kg/ha + <i>P. f</i> @ 1.25 kg/ha	84.4	186.43	12.32	142.0	17.49	1:2.65
T ₅ – Sunhemp intercropping	83.2	150.80	12.13	125.0	15.16	1:1.32
T ₆ – Neem cake @ 2t/ha	82.4	192.90	12.35	147.0	18.15	1:2.72
T ₇ – Mulching with cane trash @ 5t/ha	89.1	161.87	12.25	127.0	15.59	1:1.48
T ₈ – T ₁ to T ₇	86.1	201.23	12.43	153.6	19.09	1:2.90
T ₉ – Carbofuran @ 1kg a.i/ha	81.3	195.97	12.41	149.3	18.52	1:2.75
T ₁₀ – Untreated control	82.7	128.63	12.12	115.6	14.01	-
SEm	2.4	0.60	0.05	7.93	0.57	
CD (P=0.05)	7.2	1.79	0.15	23.80	1.71	-

Table 3: Ecofriendly management of sugarcane nematode in ratoon crop

Treatments	Initial nematode population	Nematode population 90 DAP	Nematode population 180 DAP	Nematode population 270 DAP	Nematode population 360 DAP	Per cent nematode reduction over control
T ₁ – Press-mud @ 25t/ha	375.0	215.3	234.6	246.3	269.0	66.97
T ₂ – Farm Yard Manure @ 12.5 t/ha	370.6	237.6	258.3	271.3	292.0	63.72
T ₃ – Poultry manure @ 1t/ha	379.0	189.3	208.3	233.0	252.3	69.35
T ₄ – <i>T. V</i> @ 1.25 kg/ha + <i>P. f</i> @ 1.25 kg/ha	352.6	172.3	193.0	225.6	238.6	68.84
T ₅ – Sunhemp intercropping	393.0	284.3	307.3	314.6	339.3	60.25

T ₆ – Neem cake @2t/ha	398.3	138.6	157.0	189.3	202.6	76.58
T ₇ – Mulching with cane trash @5t/ha	365.6	263.3	289.3	291.0	313.0	60.58
T ₈ – T ₁ to T ₇	383.3	124.0	143.6	159.6	171.0	79.46
T ₉ – Carbofuran @1kg a.i/ha	390.6	132.3	152.0	172.0	184.3	78.28
T ₁₀ – Untreated control	370.0	484.3	662.3	748.0	803.6	-
SEm	1.54	5.83	7.1	9.5	4.04	
CD (P=0.05)	4.63	17.5	21.3	28.5	12.13	-

Table 4: Ecofriendly management of sugarcane nematode in ratoon crop

Treatments	Establishing percentage	No. Of millable cane (x 1000/ha)	Commercial cane sugar per cent	Cane yield t/ha	Sugar yield t/ha	Cost Benefit ratio
T ₁ – Press-mud @ 25t/ha	86.6	161.26	12.24	131.0	16.03	1:1.46
T ₂ – Farm Yard Manure @ 12.5 t/ha	85.0	155.53	12.20	127.3	15.53	1:1.34
T ₃ – Poultry manure @1t/ha	82.5	167.56	12.27	133.6	16.39	1:1.60
T ₄ – T. V @1.25 kg/ha + P. f @1.25 kg/ha	79.1	171.06	12.30	137.3	16.85	1:2.37
T ₅ – Sunhemp intercropping	83.3	135.43	12.12	120.0	14.54	1:1.04
T ₆ – Neem cake @ 2t/ha	77.5	177.51	12.31	142.6	17.55	1:2.44
T ₇ – Mulching with cane trash @ 5t/ha	79.1	146.57	12.18	123.3	15.01	1:1.20
T ₈ – T ₁ to T ₇	87.5	185.98	12.38	150.6	18.64	1:2.62
T ₉ – Carbofuran @ 1kg a.i/ha	89.1	180.77	12.35	146.0	18.03	1:2.47
T ₁₀ – Untreated control	71.6	113.21	12.0	113.6	13.63	-
SEm	2.3	0.57	0.04	7.11	0.49	
CD (P=0.05)	6.9	1.67	0.13	21.32	1.47	-

Table 5: Ecofriendly management of nematodes in sugarcane -Pooled analysis

Treatments	Initial nematode population	Nematode population 90 DAP	Nematode population 180 DAP	Nematode population 270 DAP	Nematode population 360 DAP	Per cent nematode reduction over control
T ₁ – Press-mud @ 25t/ha	385.6	234.0	255.0	268.1	285.5	65.97
T ₂ – Farm Yard Manure @ 12.5 t/ha	380.8	251.1	270.8	285.3	301.8	62.59
T ₃ – Poultry manure @ 1t/ha	389.3	217.0	235.1	255.8	269.8	68.22
T ₄ – T. v @ 1.25 kg/ha + P. f @ 1.25 kg/ha	364.1	203.6	223.6	247.6	257.4	67.71
T ₅ – Sunhemp intercropping	404.3	283.6	310.3	321.3	339.3	59.12
T ₆ – Neem cake @ 2t/ha	414.0	156.0	184.3	208.1	220.3	75.45
T ₇ – Mulching with cane trash @ 5t/ha	377.0	270.0	291.4	300.0	275.5	59.45
T ₈ – T ₁ to T ₇	392.8	139.5	163.1	178.4	192.1	78.33
T ₉ – Carbofuran @ 1kg a.i/ha	400.4	147.4	173.6	190.6	203.3	77.15
T ₁₀ – Untreated control	376.1	507.4	616.6	685.7	798.1	-
SEm	1.41	3.56	4.23	8.93	4.37	
CD (P=0.05)	4.23	10.7	12.7	26.8	13.1	-

Table 6: Ecofriendly management of nematodes in sugarcane -Pooled analysis

Treatments	Germination/ Establishing percentage	No. of millable cane (x 1000/ha)	Commercial cane sugar per cent	Cane yield t/ha	Sugar yield t/ha	Benefit cost ratio
T ₁ – Press-mud @ 25t/ha	88.8	168.94	12.25	133.0	16.29	1:1.60
T ₂ – Farm Yard Manure @ 12.5 t/ha	84.1	163.21	12.05	129.3	15.78	1:1.48
T ₃ – Poultry manure @ 1t/ha	84.6	175.24	12.28	136.6	16.77	1:1.74
T ₄ – T. v @ 1.25 kg/ha + P. f @ 1.25 kg/ha	86.7	178.74	12.31	139.6	17.17	1:2.51
T ₅ – Sunhemp intercropping	81.1	143.11	12.12	122.5	14.85	1:1.18
T ₆ – Neem cake @ 2t/ha	82.8	185.20	12.33	144.8	17.85	1:2.58
T ₇ – Mulching with cane Trash @ 5t/ha	83.3	154.22	12.21	125.1	15.30	1:1.34
T ₈ – T ₁ to T ₇	87.6	193.60	12.40	152.1	18.86	1:2.76
T ₉ – Carbofuran @1kg a.i/ha	86.9	188.37	12.38	147.6	18.27	1:2.61
T ₁₀ – Untreated control	76.4	120.92	12.06	114.6	13.82	-
SEm	2.3	0.58	0.04	7.52	0.43	
CD (P=0.05)	6.9	1.73	0.14	22.56	1.59	-

References

- Mehta UK. Nematode pests of sugarcane. In: Nematode pests of crops DS Bhatti, RK Walia. (Eds). C.B.S. Publishers and Distributors, India, 1992, 159-176.
- Sasser JN, Freckman DW. A world perspective of nematology, In: Vistas on Nematology, Hyattsville, Society of Nematology, USA, 1987, 7-14.
- Singh SP, Pant V, Khan AM, Saxena SK, Changes in the phenolic contents, related rhizosphere mycoflora and nematode population in tomato inoculated with *Meloidogyne incognita* as a result of soil amendment with organic matter. Indian Journal of Nematology. 1985; 15:197-201.
- Mehta UK, Sundararaj P, Natesan N. Effect of five oil

- cakes on control of *Pratylenchus zae* in sugarcane. *Nematology Mediteranea*. 1994; 22:219-220.
5. Naganathan TG, Arumugam R, Kulasekaran M, Vadivelu S. Effect of antagonistic crops as intercrops on the control of banana nematodes. *South Indian Horticulture*. 1988; 36:268-269.
 6. Prasad D, Nagia DK, Sanjay K, Saini ML. Marigold plants for management of nematode population in fields. *Current Nematology*. 1992; 3:15-18.
 7. Jonathan EI, Gajendran G, Manuel WW. Management of *Helicotylenchus multicinctus* in sugarcane with intercrops and organic amendments. *Nematology Mediteranea*. 1999; 27:221-223.
 8. Cobb NA. Estimating the nematode population of soil. United States Department of Agriculture, 1918, 1-48.
 9. Schindler AF. A simple substitute for a Baermann funnel. *Plant Disease Reporter*. 1961; 45:747-748.
 10. Chen JCP. Definitions and terms in sugar factory control, In: *Cane sugar Hand Book*. John Wiley and Sons Inc., New York, 1985, 921-928.
 11. Jonathan EI, Krishnamoorthy SV, Manoharan ML, Muthukrishnan K. Effect of organic amendments on the control of sugarcane nematodes. *Bharatiya Sugar*. 1991; 16:39-49.
 12. Jayakumar J. Integrated management of lesion nematode *Pratylenchus zae* in sugarcane under field conditions. *Annals of Plant Protection Sciences*. 2016; 24:157-159.
 13. Jayakumar J. An evaluation of biocontrol agents for the management of sugarcane nematodes under field conditions. *Annals of Plant Protection Sciences*. 2019; 27:261-263.
 14. Mahendran S. Studies on the effect of intercropping, geometry and weed management on sugarcane. Ph.D. Thesis, Tamil Nadu Agricultural University, Coimbatore, 1994, 258.
 15. Sahoo CR, Sahu SC. Effect of different nematicides in control of the root lesion nematode, *Pratylenchus zae* in rice. *Annals of Plant Protection Sciences*. 1993; 1:139-140.
 16. Sahoo CR, Sahu SC. Studies on the effect of different oilcakes and two nematicides in the control of lesion nematode, *Pratylenchus zae* in rice. *Annals of Plant Protection Sciences*. 1994; 2:30-32.
 17. Jayakumar J. Eco-friendly management of sugarcane nematode, *Pratylenchus zae*. *Annals of Plant Protection Sciences*. 2019; 27:279-281.
 18. Mehta Usha K, Sundararaj P. Chemical control of nematodes in sugarcane. *Annals of Plant Protection Sciences*. 1996; 4:1-7.
 19. Haider MG, Askary TR. Management of plant parasitic nematodes through botanicals and growth of sugarcane. *Annals of Plant Protection Sciences*. 2011; 19:433-436.
 20. Haider MG, Kumkum Dutta. Integrated management of nematodes and their effects on yield and juice quality of sugarcane. *Annals of Plant Protection Sciences*. 2004; 12:143-146.