Original Research

Journal Home page : www.jeb.co.in ★ E-mail : editor@jeb.co.in

Journal of Environmental Biology

JEB™ p-ISSN: 0254-8704
e-ISSN: 2394-0379
CODEN: JEBIDP

DOI : http://doi.org/10.22438/jeb/41/6/SI-277

Management of *Aphelenchoides besseyi* infecting *Polianthes tuberosa* in West Bengal, India

V. Kadam[1]*, R.K. Patidar[1], R. Thangjam[3], M. Pathak[1] and A.K. Mukhapadhyay[2]

[1]College of Post Graduate Studies, Umroi Road, Umiam-793103, India
[2]Bidhan Chandra Krishi Viswavidyalaya, P.O. Krishi Viswavidyalaya, Nadia-741 252, India
[3]College of Horticulture, CAU, Thenzawl, Mizoram

***Corresponding Author Email :** veronica.kadam@gmail.com

Paper received: 13.06.2020 *Revised received*: 03.10.2020 *Accepted*: 30.10.2020

Abstract

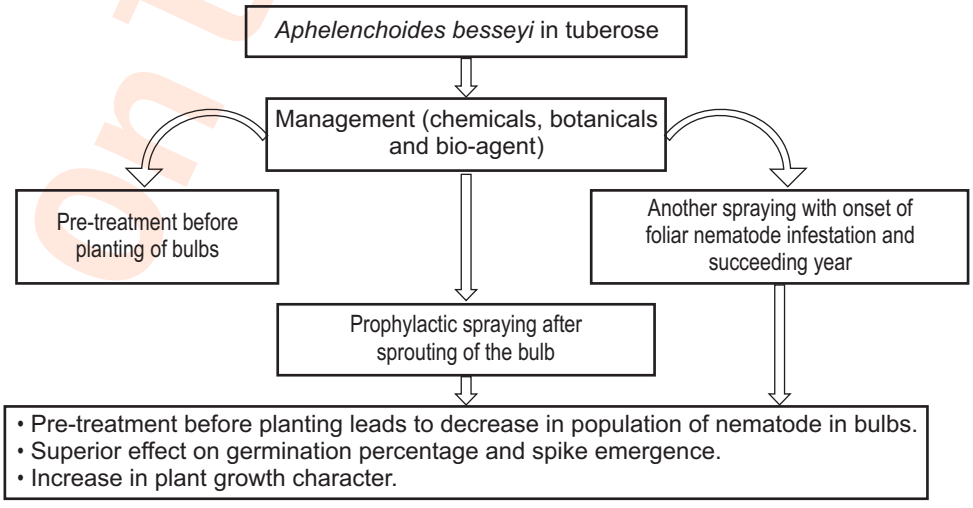
Aim: The study was conducted for management of foliar nematode, *Aphelenchoides besseyi* through different treatment modules in tuberose, *Polianthes tuberose*.

Methodology: A field experiment was carried out with seven treatment modules with four replications to assess the efficacy of treatment modules to manage the foliar nematode in tuberose variety, Calcutta Double. Observations on germination percentage and spike emergence as well as initial and final nematode population in bulbs and plant growth parameters were analysed.

Results: The experiment was conducted with naturally infected plant of tuberose bearing an initial nematode population per five bulbs. The per cent change over treated bulb was found significantly different from the control. The experiment revealed that the germination percent of tuberose bulbs increased under the treatment modules compared to untreated control. Emergence of 55 per cent and 100 per cent spike in treatment modules was earlier than the untreated check. Plant growth parameters were superior in treatment modules as compared to control. Symptoms like stunted growth of plants prickle like structures on the scape and flower and hardy brown flowers in untreated plants were not found in the treated plots.

Interpretation: Symptom development in different parts of tuberose plants increased with increase in population of foliar nematode rendering to the unmarketable tuberose plants. Therefore, an urgent need of management of foliar nematode is documented with seven treatment modules and the modules were found effective in managing the nematode population in field condition.

Key words: *Aphelenchoides besseyi*, Foliar nematode, *Polianthes tuberosa*, Tuberose



How to cite : Kadam, V., R.K. Patidar, R. Thangjam, M. Pathak and A.K. Mukhapadhyay: Management of *Aphelenchoides besseyi* infecting *Polianthes tuberosa* in West Bengal, India. *J. Environ. Biol.*, **41**, 1774-1780 (2020).

Introduction

Polianthes tuberosa, commonly know as "Rajanigandha" is a bulbous ornamental crop that has gained considerable importance in the world market. *P. tuberosa* is grown all over the world for cut flower production, for floriculture trade and as a source of oil (Datta, 2017). It is commercially cultivated for various uses like decoration of floral ornaments, perfumes, beautification of home gardens and as cut flower. It is commercially cultivated in many countries like Vietnam, China, Brazil, Italy, Iran, UK, USA etc., including India (Kadam *et al.,* 2019). The total flower production is 2785 thousand MT (National Horticultural Board, 2017-2018) in India, out of which, the cut flowers production is 823 thousand MT. Among the cut flowers tuberose is also consider one of the important cut flower. Bhattacharya (1997) observed that 2,110 ha are cultivated under cut flower in West Bengal and West Bengal ranks first both areas and production wise. In West Bengal, the cultivation of tuberose is mainly confined to Panskura, Kolaghat and Debra of Midnapore (East and West), Ranaghat and Haringhata area of Nadia, Rajarhat of 24-Parganas (North) and Bhangar-I of South 24-Parganas districts. Mukhopadhyay *et al.* (2010) had identified five blocks of North 24 Parganas and one block of South 24 Parganas districts, as hot spots for the *Aphelenchoides besseyi* with 14-82% frequency of occurrence. Among the PPN, the most important were foliar nematode and root knot nematode, *Meloidogyne incognita* (Chawla *et al.,* 2006) infecting tuberose crop. Foliar nematode can cause yield loss up to 59% in tuberose (Pathak and Khan, 2009). Mukhopadhyay (1997) reported that nematodes cause serious problem in tuberose by reducing almost 50% of earning of the flower growers of the state. Dastur (1936) reported the foliar nematode for the first time on rice from Madhya Pradesh in India. However, on tuberose the nematode was first time reported on the leaves by Holtzmann (1968) at Hawaii Island. Subsequently, it was recorded from Ranaghat region of Nadia district (West Bengal, India) by Chakraborti and Ghosh (1993) to cause severe loss due to malformed flowers and in Odisha, India (Das *et al*., 2011) and Mekon delta of Vietnam (Cuc *et al*., 2010). Development of symptoms due to foliar nematode can be seen right from the early stages of tuberose plants which continues till harvest (Kadam *et al*., 2019).

Higher temperature and longer growing season induce more nematode generations, and consequently an increased nematode population. *Aphelenchoides besseyi* produce maximum population during July month of rainy season that coincides with the start of heavy flush of tuberose (Kadam *et al.,* 2019). This nematode can survive in coiled anhydrobiotic condition for survival and dissemination (Khan, 2004; Khan *et al*., 2012). Therefore, managing this nematode is an demanding issue. In tuberose cultivar 'Calcutta Double', 30-40% flower stalk were rendered unmarketable (Khan and Pal, 2001). There is a tremendous potentiality to earn foreign currency through exporting tuberose cut flowers in many countries mound the globe. For using tuberose as export item, there is a need to grow pest and disease free flower stalks. This nematode has become one of the serious problem for cultivation of quality flowers (Mukhopadhyay, 1997). The nematode infested flowers have no value in export market and there is a great chance to reject the consignment due to the presence of foliar nematode. The foliar nematode, *Aphelenchoides besseyi is* still continued to be a threat for cultivation of tuberose. Our farmers are eagerly waiting for an economic executable management schedule for foliar nematode. Keeping the all above information in view, the present study was undertaken to manage the Aphelenchoides besseyi in tuberose.

Materials and Methods

A field experiment was carried out during 2014 - 2015 on cv. Culcatta Double at Central research farm of Bidhan Chandra Krishi Viswavidyalaya, Gayeshpur, Nadia, West Bengal for managing foliar nematode. The infected bulbs (2.0-2.5 cm diameter) of tuberose were collected from the field (Ranaghat, West Bengal) and soaked overnight in plain water. Followed by soaking of bulbs in nematicides at different doses and durations according to the treatment schedule of the experiment. *Paecilomyces lilacinus* and Neem Seed Kernel Powder (NSKP) were also used as treatment bio-agent before planting and treatment after sprouting of bulbs. The infected bulbs were planted in the plot size- (3 × 1.5 m^2) at a spacing of 50 × 37.5 cm^2. There were 7 treatment modules; each replicated 4 times in a Randomized Block Design. Details of the module are as follows : M_1- (a) Overnight pre-soaking of bulb in water followed by dipping in carbosulfan 25 EC @ 1000 ppm for 4 hrs; (b) Prophylactic spraying with chlorfenapyr 10 SC @ 75g a.i. ha^{-1} and cartap hydrochloride 50 SP @ 375g a.i. ha^{-1} at 4 and 6 weeks after sprouting of bulb; (c) Spraying of chlorfenapyr 10 SC @ 75g a.i. ha^{-1} alternated with cartap hydrochloride 50 SP @ 375g a.i. ha^{-1} at 15 days interval after onset of foliar nematode infestation in the 1st year and succeeding year crop. M_2- (a) Overnight pre soaking of bulb in water followed by dipping in carbosulfan 25 EC @ 1000 ppm for 4 hrs; (b) Prophylactic spraying with cartap hydrochloride 50 SP @ 375g a.i. ha^{-1} and carbosulfan 25 EC @ 500g a.i. ha^{-1} at 4 and 6 weeks after sprouting of bulb; (c) Spraying of cartap hydrochloride 50 SP @ 375g a.i. ha^{-1} alternated with carbosulfan 25 EC @ 500g a.i. ha^{-1} at 15 days interval after onset of foliar nematode infestation in the 1st year and succeeding year crop. M_3- (a) Overnight pre-soaking of bulb in water followed by dipping in monocrotophos 36 SL @ 750 ppm for 4 hrs; (b) Prophylactic spraying with cartap hydrochloride 50 SP @ 375g a.i. ha^{-1} and chlorfenapyr 10 SC @ 75g a.i. ha^{-1} at 4 and 6 weeks after sprouting of bulb; (c) Spraying of cartap hydrochloride 50 SP @ 375g a.i. ha^{-1} alternated with chlorfenapyr 10 SC @ 75g a.i. ha^{-1} at 15 days interval after onset of foliar nematode infestation during 1st year and succeeding year crop. M_4- (a) Overnight pre-soaking

of bulb in water followed by dipping in monocrotophos 36 SL @ 750 ppm for 4 hrs; (b) Prophylactic spraying with carbosulfan 25 EC @ 250g a.i. ha^{-1} and cartap hydrochloride 50 SP @ 375g a.i. ha^{-1} at 4 and 6 weeks after sprouting of bulb; (c) Spraying of monocrotophos 36 SL @ 360g a.i. ha^{-1} alternated with cartap hydrochloride 50 SP @ 375g a.i. ha^{-1} at 15 days interval after onset of foliar nematode infestation during 1st year and succeeding year crop. M_5- (a) Overnight pre soaking of bulb in water followed by dipping in *Paecilomyces lilacinus* (spore load 24×10^7) spore suspension; (b) Prophylactic spraying with NSKP @ 50g l^{-1} of water at 4 and 6 weeks after sprouting of bulbs and twice at 15 days interval starting from emergence of flower spike in the 1st year and succeeding year crop. M_6- (a) Overnight dipping of bulbs in water; (b) Spraying of water along with sticker at 4 and 6 weeks after sprouting of bulbs and twice at 15 days interval after onset of foliar nematode infestation during 1st year and succeeding year crop. M_7- Untreated control. Sticker along with water was added during all nematicides application. Pre-treatment population of foliar nematode was carefully examined in 35 bulbs (5 bulbs for each treatment) where post treatment populations in bulbs before planting were recorded at five bulbs/ replication/ treatment. The pre population and final population of nematode from infected bulbs were estimated by counting the population under stereoscopic binocular microscope and the population was extracted from slash bulb keeping in wire gauge assembly, followed by killing and fixing of the nematodes (Seinhorst, 1962). The germination percentage was observed and calculated by the formula: Germination Percent = number of bulbs germinated / total number of bulbs x 100. The 1st spike emergence, 50% of 1st spike emergence and 100% of 1st spike emergence from day of sowing of bulb were taken in days per plot from every treatment module. To observe the effect of treatment modules, the plant growth parameters of the crop namely, stalk length, spike length, length of single flower, weight of single flower, number of florets/spike, spike weight and vigour of plants were assessed.

Crop vigour was taken by visual appearance on 1-5 rating as follows: complete sterility of flower stalk, *i.e.*, Stalk length- < 60cm, Spike length < 8cm and Spike weight < 30g; flower stalk and flowers distorted and sometimes no flower bloom i.e. Stalk length- 61-70 cm, Spike length 9-17cm and Spike weight 31 - 40g;

Table 1 : Effect of treatment modules on germination and spike emergence of tuberose cv. Calcutta Double during 2014-15

Treatment in Modules*	Germination percentage	1st spike emergence (DAS)	50% spike emergence (DAS)	100% spike emergence (DAS)
M_1	95.00 (77.97)^{b**}	216.25^{abc}	303.25^{a}	395.25^{a}
M_2	94.17 (78.24)^{b}	211.75^{abc}	302.75^{a}	426.25^{ab}
M_3	91.67 (74.25)^{b}	221.00^{abc}	304.75^{a}	430.00^{ab}
M_4	91.66 (74.98)^{b}	156.75^{a}	305.50^{a}	462.00^{bc}
M_5	89.16 (71.50)^{b}	189.50^{ab}	320.50^{a}	480.50^{bc}
M_6	96.67 (80.55)^{b}	250.50^{bc}	296.75^{a}	492.50^{c}
M_7	75.00 (60.91)^{a}	286.50^{c}	310.50^{a}	497.25^{c}
Sem±	3.05	25.27	7.01	14.37
CD (5%)	9.05	75.07	NS	42.69

*In each nematicidal application sticker along with water was added; **Figure marked by common letter are not significantly different according to Duncan's Multiple Range Test at P<0.05; **NS**= Non-Significant; **M_1**- a)Overnight pre soaking of bulb in water followed by dipping in Carbosulfan 25 EC @ 1000 ppm for 4 hrs; b) Prophylactic spraying with chlorfenapyr 10SC @ 75g a.i./ha and cartap hydrochloride 50SP @ 375g a.i./ha at 4 weeks and 6 weeks after sprouting of bulb, respectively. c) Spraying of chlorfenapyr 10SC @ 75g a.i./ha alternated with cartap hydrochloride 50SP @ 375g a.i./ha at 15 days interval after onset of foliar nematode infestation in the 1st year and succeeding year crop. **M_2**- a) Overnight pre soaking of bulb in water followed by dipping in carbosulfan 25 EC @ 1000 ppm for 4 hrs. b) Prophylactic spraying with cartap hydrochloride 50SP @ 375g a.i./ha and carbosulfan 25EC @ 500g a.i./ha at 4 weeks and 6 weeks after sprouting of bulb, respectively. c) Spraying of cartap hydrochloride 50SP @ 375g a.i./ha alternated with carbosulfan 25 EC @ 500g a.i./ha at 15 days interval after onset of foliar nematode infestation in the 1st year and succeeding year crop. **M_3**- a)Over night pre soaking of bulb in water followed by dipping in monocrotophos 36SL @ 750 ppm for 4 hrs.
.b) Prophylactic spraying with cartap hydrochloride 50SP @ 375g a.i./ha and chlorfenapyr 10SC @ 75g a.i./ha at 4 weeks and 6 weeks after sprouting of bulb, respectively. c) Spraying of cartap hydrochloride 50SP @ 375g a.i./ha alternated with chlorfenapyr 10SC @ 75g a.i./ha at 15 days interval after onset of foliar nematode infestation in the 1st year and succeeding year crop. **M_4**- a) Overnight pre soaking of bulb in water followed by dipping in monocrotophos 36SL @ 750 ppm for 4 hrs. b) Prophylactic spraying with carbosulfan 25EC @ 250g a.i./ha and cartap hydrochloride 50SP @ 375g a.i./ha at 4 weeks and 6 weeks after sprouting of bulb, respectively. c) Spraying of monocrotophos 36SL @ 360g a.i./ha alternated with cartap hydrochloride 50SP @ 375g a.i./ha at 15 days interval after onset of foliar nematode infestation in the 1st year and succeeding year crop.
M_5- a) Overnight pre soaking of bulb in water followed by dipping in *Paecilomyces lilacinus* (spore load 24×10^7) spore suspension. b) Prophylactic spraying with NSKP @ 50g/l of water at 4 weeks and 6 weeks after sprouting of bulbs and twice at 15 days interval starting from emergence of flower spike in the 1st year and succeeding year crop. **M_6**- a) Over night dipping of bulbs in water. b)Spraying of water along with sticker at 4 weeks and 6 weeks after sprouting of bulbs and twice at 15 days interval after onset of foliar nematode infestation in the 1st year and succeeding year crop.
M_7- Untreated control, DAS-Days after sowing.

distortions in flower stalk but few flowers bloomed at the tip, *i.e.*, Stalk length-71-80 cm, Spike length 18-25 cm and Spike weight 51-50g; flowers bloom with little distortion in stalk i.e. Stalk length-81- 90cm, Spike length 26-33 cm and Spike weight 51-60 g; and no malady symptoms on flower stalk healthy *i.e.*, Stalk length- > 91cm, Spike length > 34 cm and Spike weight > 61g). The difference between means of studied treatment modules were tested by ANOVA at 5% probability level. Duncan's Multiple Range Test at P<0.05 was applied using MSTAT-C Software.

Results and Discussion

A. besseyi were recovered up to two and half years from the bulbs and no nematodes were recovered beyond two and half years of storing. (Das and Swain, 2013). The results of the present study in germination percentage of tuberose plant showed that the treated plants were significantly different from the control (Table 1) due to reduction of nematode population in treated bulbs. Similar results were observed by Pal *et al*. (2013) who demonstrated that bulb dipping as well as foliar spray with carbosulfan caused reduction in *A. besseyi* population. Togashi and Hoshino (2003) revealed that foliar nematode can endure as a long-lived form able to withstand several months of storage before resuming growth when returned to the field. Spike emergence from day of sowing revealed that earliest spike emergence occurred in the plots of M_4, which took nearly five months (156.75 DAS) for the 1st spike emergence from the day of sowing. On the other hand, in case of 100% spike emergence all the treatment modules were significantly different from control (M_7) which was at par with M_6. Cope with Das *et al.* (2011) reported that initial inoculum density of 100 nematodes kg^{-1} soil was found to be pathogenic causing significant reduction in plant height, number of spike and overall flower yield. The effect of monocrotophos at 1000 ml ha^{-1} on *A. besseyi* in rice (Kumar and Sivakumar, 1998) and at 0.15% in tuberose (Chakraborti, 1995) was found effective. With the adoption of nematode management practice, spike yield could be saved up to 38% and that could be to the extent of 59% when loose flower yield/plot was taken into consideration (Pathak and Khan, 2009).

The result revealed that the stalk length in all the treatment modules during 2014 and 2015 were significantly

Table 2 : Effect of treatment modules on growth attributes of tuberose (cv. Calcutta Double) during 2014-15

Treatment in Modules*	Stalk length (cm) 2014	Stalk length (cm) 2015	Spike length (cm) 2014	Spike length (cm) 2015	Length of single flower (cm) 2014	Length of single flower (cm) 2015	Weight of Single flower (g) 2014	Weight of Single flower (g) 2015
M1	82.31^{b**}	87.02^{c}	30.50^{ab}	27.89^{c}	3.94^{ab}	4.56^{b}	1.61^{bc}	2.58^{bc}
M2	83.03^{b}	85.71^{c}	31.72^{b}	28.54^{c}	4.11^{abc}	4.49^{b}	1.81^{c}	2.64^{c}
M3	82.39^{b}	83.79$_{bc}$	32.36^{b}	28.40^{c}	4.21^{bc}	4.59^{b}	1.62^{bc}	2.26^{abc}
M4	83.97^{b}	82.98^{bc}	32.25^{b}	26.37^{bc}	4.39^{c}	4.43^{b}	1.42^{ab}	2.18^{ab}
M5	81.50^{ab}	83.82^{bc}	30.89^{ab}	27.27^{c}	4.13^{abc}	4.63^{b}	1.61^{bc}	2.52^{abc}
M6	81.97^{b}	79.78^{ab}	30.33^{ab}	24.32^{ab}	4.13^{abc}	4.27^{b}	1.40^{ab}	2.09^{a}
M7	78.72^{a}	76.82^{a}	29.36^{a}	22.44^{a}	3.71^{a}	3.85^{a}	1.30^{a}	2.13^{a}
SEm±	0.84	0.91	0.56	0.53	0.09	0.12	0.07	0.11
CD (5%)	2.48	2.72	1.68	1.59	0.27	0.35	0.22	0.32

*In each nematocidal application sticker along with water was added; **Figure marked by common letter are not significantly different according to Duncan's Multiple Range Test at P<0.05. (all the data on growth attributes were taken during 4th week age of the flower stalk after the emergence of flower head stalk) **M_1**- a)Overnight pre soaking of bulb in water followed by dipping in Carbosulfan 25 EC @ 1000ppm for 4 hrs. b) Prophylactic spraying with chlorfenapyr 10SC @ 75g a.i. ha^{-1} and cartap hydrochloride 50SP @ 375g a.i. ha^{-1} at 4 weeks and 6 weeks after sprouting of bulb, respectively. c) Spraying of chlorfenapyr 10SC @ 75g a.i. ha^{-1} alternated with cartap hydrochloride 50SP @ 375g a.i. ha^{-1} at 15 days interval after onset of foliar nematode infestation in the 1st year and succeeding year crop. **M_2**- a) Overnight pre soaking of bulb in water followed by dipping in carbosulfan 25 EC @ 1000 ppm for 4 hrs. b) Prophylactic spraying with cartap hydrochloride 50SP @ 375g a.i. ha^{-1} and carbosulfan 25EC @ 500g a.i./ha at 4 weeks and 6 weeks after sprouting of bulb, respectively. c) Spraying of cartap hydrochloride 50SP @ 375g a.i. ha^{-1} alternated with carbosulfan 25 EC @ 500g a.i. ha^{-1} at 15 days interval after onset of foliar nematode infestation in the 1st year and succeeding year crop. **M_3**- a)Over night pre soaking of bulb in water followed by dipping in monocrotophos 36SL @ 750 ppm for 4 hrs. b) Prophylactic spraying with cartap hydrochloride 50SP @ 375g a.i. ha^{-1} and chlorfenapyr 10SC @ 75g a.i. ha^{-1} at 4 weeks and 6 weeks after sprouting of bulb, respectively. c) Spraying of cartap hydrochloride 50SP @ 375g a.i. ha^{-1} alternated with chlorfenapyr 10SC @ 75g a.i. ha^{-1} at 15 days interval after onset of foliar nematode infestation in the 1st year and succeeding year crop. **M_4**- a) Over night pre soaking of bulb in water followed by dipping in monocrotophos 36SL @ 750 ppm for 4 hrs. b) Prophylactic spraying with carbosulfan 25EC @ 250g a.i. ha^{-1} and cartap hydrochloride 50SP @ 375g a.i. ha^{-1} at 4 weeks and 6 weeks after sprouting of bulb, respectively. c) Spraying of monocrotophos 36SL @ 360g a.i. ha^{-1} alternated with cartap hydrochloride 50SP @ 375g a.i. ha^{-1} at 15 days interval after onset of foliar nematode infestation in the 1st year and succeeding year crop. **M_5**- a) Overnight pre soaking of bulb in water followed by dipping in *Paecilomyces lilacinus* (spore load 24×10^7) spore suspension. b) Prophylactic spraying with NSKP @ 50g l^{-1} of water at 4 weeks and 6 weeks after sprouting of bulbs and twice at 15 days interval starting from emergence of flower spike in the 1st year and succeeding year crop. **M_6**- a) Over night dipping of bulbs in water. b) Spraying of water along with sticker at 4 weeks and 6 weeks after sprouting of bulbs and twice at 15 days interval after onset of foliar nematode infestation in the 1st year and succeeding year crop. **M_7**- Untreated control, DAS-Days after sowing.

Table 3 : Effect of treatment modules on growth attributes of tuberose (cv. Calcutta Double) during 2014-15

Treatment in Modules*	Nos. of floret 2014	Nos. of floret 2015	Weight of Spike (g) 2014	Weight of Spike (g) 2015	Vigour of plant (1-5) 2014	Vigour of plant (1-5) 2015
M1	29.97^{b**}	36.64^{ab}	48.44^{bc}	94.47^{b}	4.06^{c}	4.36^{c}
M2	30.75^{b}	37.18^{ab}	55.48^{c}	98.21^{b}	3.58^{bc}	4.00^{bc}
M3	30.19^{b}	36.48^{ab}	48.88^{bc}	82.49^{ab}	3.51^{bc}	4.08^{bc}
M4	30.28^{b}	38.17^{b}	43.01^{b}	82.81^{ab}	3.45^{bc}	3.78^{bc}
M5	30.86^{b}	38.29^{b}	49.62^{bc}	96.41^{b}	3.47^{bc}	3.97^{bc}
M6	30.72^{b}	36.43^{ab}	42.92^{b}	76.06^{a}	3.16^{b}	3.39^{b}
M7	26.83^{a}	35.30^{a}	35.04^{a}	74.89^{a}	2.29^{a}	1.93^{a}
SEm±	0.49	0.59	2.38	4.26	0.18	0.22
CD (5%)	1.46	1.76	7.07	12.65	0.53	0.65

(Rating 1-5; 1- complete sterility of flower stalk, 2 –flower stalk and flowers distorted and sometimes no flower bloom, 3- distortions in flower stalk but few flowers bloom at the tip; 4 – Flowers bloom with little distortion in stalk 5- no malady symptoms on flower stalk); *In each nematicidal application sticker along with water was added; **Figure marked by common letter are not significantly different according to Duncan's Multiple Range Test at P<0.05. **M_1**- a)Overnight pre soaking of bulb in water followed by dipping in Carbosulfan 25 EC @ 1000 ppm for 4 hrs. b) Prophylactic spraying with chlorfenapyr 10SC @ 75g a.i. ha^{-1} and cartap hydrochloride 50SP @ 375g a.i. ha^{-1} at 4 weeks and 6 weeks after sprouting of bulb, respectively. c) Spraying of chlorfenapyr 10SC @ 75g a.i. ha^{-1} alternated with cartap hydrochloride 50SP @ 375g a.i. ha^{-1} at 15 days interval after onset of foliar nematode infestation in the 1st year and succeeding year crop. **M_2**- a) Overnight pre soaking of bulb in water followed by dipping in carbosulfan 25 EC @ 1000 ppm for 4 hrs. b) Prophylactic spraying with cartap hydrochloride 50SP @ 375g a.i. ha^{-1} and carbosulfan 25EC @ 500g a.i. ha^{-1} at 4 weeks and 6 weeks after sprouting of bulb, respectively. c) Spraying of cartap hydrochloride 50SP @ 375g a.i. ha^{-1} alternated with carbosulfan 25 EC @ 500g a.i. ha^{-1} at 15 days interval after onset of foliar nematode infestation in the 1st year and succeeding year crop. **M_3**- a) Over night pre soaking of bulb in water followed by dipping in monocrotophos 36SL @ 750 ppm for 4 hrs. b) Prophylactic spraying with cartap hydrochloride 50SP @ 375g a.i. ha^{-1} and chlorfenapyr 10SC @ 75g a.i. ha^{-1} at 4 weeks and 6 weeks after sprouting of bulb, respectively. c) Spraying of cartap hydrochloride 50SP @ 375g a.i. ha^{-1} alternated with chlorfenapyr 10SC @75g a.i. ha^{-1} at 15 days interval after onset of foliar nematode infestation in the 1st year and succeeding year crop. **M_4**- a) Over night pre soaking of bulb in water followed by dipping in monocrotophos 36SL @ 750 ppm for 4 hrs. b) Prophylactic spraying with carbosulfan 25EC @ 250g a.i. ha^{-1} and cartap hydrochloride 50SP @ 375g a.i. ha^{-1} at 4 weeks and 6 weeks after sprouting of bulb, respectively. c) Spraying of monocrotophos 36SL @ 360g a.i. ha^{-1} alternated with cartap hydrochloride 50SP @ 375g a.i. ha^{-1} at 15 days interval after onset of foliar nematode infestation in the 1st year and succeeding year crop. **M_5**- a) Overnight pre soaking of bulb in water followed by dipping in *Paecilomyces lilacinus* (spore load 24×10^{7}) spore suspension. b) Prophylactic spraying with NSKP @ 50g l^{-1} of water at 4 weeks and 6 weeks after sprouting of bulbs and twice at 15 days interval starting from emergence of flower spike in the 1st year and succeeding year crop. **M_6**- a) Over night dipping of bulbs in water. b)Spraying of water along with sticker at 4 weeks and 6 weeks after sprouting of bulbs and twice at 15 days interval after onset of foliar nematode infestation in the 1st year and succeeding year crop. **M_7**-

different from untreated control, while the maximum stalk length was observed in M_4 (83.97cm) and M_1 (87.02 cm) in 2014 and 2015 respectively (Table 2). The length of the stalks of tuberose plant signifies healthy appearance of the plant, and the stalks in treated plots were healthy without any symptoms of infected foliar nematode like spiny structure on the surface Bala and Nihal (2018); Kadam *et al.* (2019) reported that appearance of symptoms in tuberose due to foliar nematode infections are irregular and rugged, spiny structures of variable number on the surface of the flower stalk along the length and brownish patches noticed on the flower stalks. In respect to spike length, performance of the treatment modules was found statistically at par to each other and significantly superior to the control in 2014. However, in 2015, all the treatment modules performed better than the untreated control (Table 2). Considering the length of individual flower during 2014, it appeared to show statistically superior results plants in untreated plots. While during 2015, as compared length of individual flower in all the treated plots were statistically at par with each other and they all were found to be superior to untreated plots (Table 2). The maximum length of flower was observed in treatment module M_4 (4.39 cm) and M_5 (4.63 cm) in 2014 and 2015 respectively. Chakraborti and Ghosh (1993) observed that the nematodes invade flower bud ectoparasitically, pierce the stigma as well as ovary before anthesis leading to crinkled flower.

The quality as well as quantity of this important growth attribute was better in treated plots over the untreated ones in both the years and the maximum weight was observed in M_2 (1.81g and 2.64g) during both the year. During 2014, the number of florets in all the treatment modules were significantly different than the untreated ones whereas all the treatment modules were statistically at par to each other. However, during 2015, M_4 (38.17) and M_5 (38.29) were found superior to all the treatments over the control plots and these two were statistically at par to each other (Table 3). All the treatment modules in 2014 were found to be significantly better in spike weight as compared to control, while in 2015 the treatment module except M_6 was at par with control. Foliar nematode infestation led to radical loss in the vigour of tuberose crop. Comparing the treated plants with untreated plants during the experimental period, it was found that the vigour was very less in untreated plots (M_7) with 2.29 during 2014 and

Table 4 : Initial nematode population (INP) before bulb treatment and post treatment population, *i.e.*, after 4 hour bulb treatment of tuberose (cv. Calcutta Double)

Treatment in modules*	Initial nematode population/5 bulbs	Post population after treatment/5 bulbs	% change over treated bulb
M1	104.00 (10.22)^{a**}	56.75 (7.55)^{a}	45.01^{cd}
M2	104.00 (10.22)^{a}	59.75 (7.76)^{a}	42.44^{cd}
M3	178.00 (13.32)^{c}	47.00 (6.87)^{a}	72.18^{d}
M4	111.50 (10.58)^{ab}	44.50 (6.70)^{a}	60.11^{cd}
M5	103.50 (10.19)^{a}	70.75 (8.43)^{a}	30.88^{bc}
M6	167.75 (12.87)^{c}	157.75 (12.40)^{b}	5.30^{ab}
M7	157.75 (12.40)^{bc}	172.25 (13.03)^{b}	-15.46^{a}
SEm±	0.61	0.63	9.91
CD (5%)	1.83	1.87	29.43

*In each nematicidal application sticker along with water was added; **Figure marked by common letter are not significantly different according to Duncan's Multiple Range Test at P<0.05. Figures in the parenthesis indicate angular transformed values; **M_1**- a)Overnight pre soaking of bulb in water followed by dipping in Carbosulfan 25 EC @ 1000 ppm for 4 hrs. b) Prophylactic spraying with chlorfenapyr 10SC @ 75g a.i. ha^{-1} and cartap hydrochloride 50SP @ 375g a.i. ha^{-1} at 4 weeks and 6 weeks after sprouting of bulb, respectively. c) Spraying of chlorfenapyr 10SC @ 75g a.i. ha^{-1} alternated with cartap hydrochloride 50SP @ 375g a.i. ha^{-1} at 15 days interval after onset of foliar nematode infestation in the 1st year and succeeding year crop. **M_2**- a) Overnight pre soaking of bulb in water followed by dipping in carbosulfan 25 EC @ 1000 ppm for 4 hrs. b) Prophylactic spraying with cartap hydrochloride 50SP @ 375g a.i. ha^{-1} and carbosulfan 25EC @ 500g a.i. ha^{-1} at 4 weeks and 6 weeks after sprouting of bulb, respectively. c) Spraying of cartap hydrochloride 50SP @ 375g a.i. ha^{-1} alternated with carbosulfan 25 EC @ 500g a.i. ha^{-1} at 15 days interval after onset of foliar nematode infestation in the 1st year and succeeding year crop. **M_3**- a)Over night pre soaking of bulb in water followed by dipping in monocrotophos 36SL @ 750 ppm for 4 hrs. b) Prophylactic spraying with cartap hydrochloride 50SP @ 375g a.i. ha^{-1} and chlorfenapyr 10SC @ 75g a.i. ha^{-1} at 4 weeks and 6 weeks after sprouting of bulb, respectively. c) Spraying of cartap hydrochloride 50SP @ 375g a.i. ha^{-1} alternated with chlorfenapyr 10SC @ 75g a.i. ha^{-1} at 15 days interval after onset of foliar nematode infestation in the 1st year and succeeding year crop. **M_4**- a) Over night pre soaking of bulb in water followed by dipping in monocrotophos 36SL @ 750ppm for 4 hrs. b) Prophylactic spraying with carbosulfan 25EC @ 250g a.i. ha^{-1} and cartap hydrochloride 50SP @ 375g a.i. ha^{-1} at 4 weeks and 6 weeks after sprouting of bulb, respectively. c) Spraying of monocrotophos 36SL @ 360g a.i. ha^{-1} alternated with cartap hydrochloride 50SP @ 375g a.i. ha^{-1} at 15 days interval after onset of foliar nematode infestation in the 1st year and succeeding year crop. **M_5**- a) Overnight pre soaking of bulb in water followed by dipping in *Paecilomyces lilacinus* (spore load 24×10^7) spore suspension. b) Prophylactic spraying with NSKP @ 50g l^{-1} of water at 4 weeks and 6 weeks after sprouting of bulbs and twice at 15 days interval starting from emergence of flower spike in the 1st year and succeeding year crop. **M_6**- a) Over night dipping of bulbs in water. b) Spraying of water along with sticker at 4 weeks and 6 weeks after sprouting of bulbs and twice at 15 days interval after onset of foliar nematode infestation in the 1st year and succeeding year crop. **M_7**- Untreated control, DAS-Days after sowing.

1.93 during 2015 (Table 3). All the treatment modules performed significantly better over the control plot in regard to vigour of the plants during 2014 and 2015. The results of the present findings is in agreement with the findings of Holtzmann (1968), Khan and Pal (2001), Cuc and Pilon (2007), Das and Khan (2007) and Kadam *et al*. (2019) where they observed that diseased plants exhibited stunted stalks bearing florets which failed to open with varying degree of necrosis, and flower stalks in the infected plants were rough and distorted which can be related with the loss of plant vigour. The nematode population was found to decrease in case of treated bulb. It was also found that the percent change was very less in untreated control and was negative. The percent change over treated bulb of nematode population was found to be best in module, M_3 (72.18%) (Table 4). The germination per cent of tuberose was found to be increase in treatment modules by reducing the nematode population in bulb. Treatment module were found to be most effective in almost all the months during the programme to reduce the infestation caused by foliar nematode *Aphelenchoides besseyi.* Therefore, keeping in view the results obtained, it can be concluded that the treated plots were effective in managing the nematode population with all the growth attributes superior in treated plots over untreated plots Pathak and Khan (2009), stated that treated plots comprise of low nematode infestation as all the growth attributes are superior when compared to untreated plots. These findings can be useful for successful management of *Aphelenchoides besseyi* in tuberose.

Acknowledgments

Author thank Dr. A. K. Mukhopadhyay and Dr. K. Roy, Department of Entomology, B.C.K.V., Nadia, West Bengal for providing supervision, moral support and help for carrying out this study.

References

Bala, S.C. and R. Nihal: Field evaluation of tuberose cultivars and symptom manifestation caused by foliar nematode, *Aphelenchoides besseyi* in tuberose. *Int. J. Cur. Microbiol. App. Sci.,* **7**, 2319-7706 (2018).

Bhattacharya, H.K.: Floriculture management. *Floric. Today*, **7**, 15-23 (1997).

Chakrabarti, H.S.: Chemical control of floral malady of *Polianthes tuberosa* L. *J. Mycopatho. Res.*, **33**, 25-28 (1995).

Chakraborti, H.S. and S.C. Ghosh: Studies on the floral malady of *Polianthes tuberosa* L. in West Bengal. *J. Mycopatho. Res.*, **31**, 109-115. (1993).

Chawla, G., P.K. Singh and A.N. Srivastava: Study on propagation of root knot nematode *Meloidogyne incognita* (Kofoid and White) Chitwood, through tuberose (*Polianthes tuberosa* Linn.) bulbs. *J. Orna. Horti.*, **9**, 73-74 (2006).

Cuc, N.T.T. and M. Pilon: An *Aphelenchoides sp*. Nematode parasite of *Polianthes tuberosa* in the Mekong Delta. *J. Nematol.*, **39**, 248-257 (2007).

Cuc, N.T.T., N.T. Son, T.M. Trung, N.V. Trang, L.M. Dang and M. Pilon: Hot water treatment prevents *Aphelenchoides besseyi* damage to *Polianthes tuberosa* crops in the Mekong Delta of Vietnam. *Crop Prot.,* **30**, 1-4 (2010).

Das, N. and P.K. Swain: Survival and persistence of foliar nematode, *Aphelenchoides besseyi* infecting tuberose. *Indian J. Nematol.*, **43**, 215-217 (2013).

Das, N., P.K. Swain and U.K. Nanda: Pathogenicity of foliar nematode, *Aphelenchoides besseyi* in tuberose. *J. Pl. Prot. Environ.,* **8**, 97-99 (2011).

Das, T.K. and M.R. Khan: Occurrence and distribution of white tip nematode, *Aphelenchoides besseyi* in West Bengal, India. *Indian J. Nematol.*, **37**, 94-97 (2007).

Dastur, J.F.: A nematode disease of rice in the central provinces. *Proc. Indian Acad. Sci.*, **4,** 108-122 (1936).

Datta, S.K.: Breeding of ornamentals: Tuberose (*Polianthes tuberosa* L.). *Curr. Sci.*, **113**, 1255-1236 (2017).

Holtzmann, O.V.: A foliar disease of tuberose caused by *Aphelenchoides besseyi. Plant Disease Rep.,* **52,** 56 (1968).

Huang, C.S. and S.P. Huang: Dehydration and survival of rice white tip nematode, *Aphelenchoides besseyi. Nematol.,* **20**, 9–18 (1974).

Kadam, V., D. Chettri and A.K. Mukhopadhyay: Study on the symptomatology of floral malady of tuberose associated with foliar nematode infestation on the plants. *Pharma Inn. J.,* **8**, 29-32 (2019).

Khan, M.R. and A.K. Pal: Plant parasitic nematodes associated with tuberose *(Polianthes tuberosa* L.) in West Bengal. *Ann. Plant Prot. Sci.,* **9**, 357-359 (2001).

Khan, M.R., Z.A. Handoo., U. Rao., S.B. Rao and J.S. Prasad: Observations on the foliar nematode, Aphelenchoides besseyi, infecting tuberose and rice in India. *J. Nematol.,* **44**, 391-398 (2012).

Khan, M.R.: Observation on foliar nematode, *Aphelenchoidesbesseyi* in tuberose (*Polianthes tuberosa* L.) in West Bengal. *Ann. Plant Prot. Sci.,* **12,** 106-109 (2004).

Kumar, S. and C.V. Sivakumar: Management of rice white tip nematode, *Aphelenchoides besseyi. Indian J. Nematol.,* **28,** 85-87 (1998).

Mukhopadhyay, A.K., S.C. Bala and T.N. Goswami: Investigation on the occurrence and distribution of *Aphelenchoides besseyi* Christie on tuberose in West Bengal. *Paper presented in the National Symposium on 'Floriculture Scenario in the Changing Global Perspective' organized by the Department of Floriculture and Landscaping* and held at the FTC, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India, from 16th-18th April (2010).

Mukhopadhyay, A.K.: Two Decades of Nematology. Directorate of Research, Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India, p. 15 (1997).

National Horticultural Board: Annual Report. p. 84 (2018-2019).

Pal, A.K., S. Gonsalves, K. Roy and G. Saha: Controlling *Aphelenchoides besseyi* in tuberose- an integrated approach. ISSN: 2279-3682, Paper Proceedings of Agri Animal (2013).

Pathak, B. and M.R. Khan: Yield loss potential of foliar nematode, *Aphelenchoides besseyi in tuberose*. *Indian J. Nematol.,* **39**, 38-40 (2009).

Seinhorst, J.W.: On the killing, fixing and transferring to glycerine of nematode. *Nematol.,* **8**, 29-32 (1962).

Togashi, K. and S. Hoshino: Trade-off between dispersal and reproduction of a seed-borne nematode, *Aphelenchoides besseyi*, parasitic on rice plants. *Nematol*., **5**, 821–829 (2003).