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Effect of variety and spacing on the incidence and severity of *Aphelenchoides besseyi* in tuberose

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Abstract

An experiment was conducted to study the effect of varieties and spacing on the incidence and severity of foliar nematode Aphelenchoides besseyiChristie in tuberose (Polianthes tuberosa L.) which is one of the important cut flower in the eastern part of India (West Bengal and Odisha), and also in the northern plains and parts of the south. The production of tuberose is constrained mainly by plant parasitic nematodes, insect-pests and diseases. Among nematodes, the foliar nematode, A. besseyi is a serious threat to sustainable tuberose production in West Bengal. Incidence of A. besseyi on tuberose was 1st noticed during 3rd week of August, 2015 in both the cultivars. The per cent plant infestation i.e. incidence of A. besseyi gradually increased after their initiation and the maximum was recorded during 2nd week of October, 2015. From 4th week of October, 2015 a gentle decline on the incidence of A. besseyi was noticed till 2nd week of January, 2016. The sign of foliar nematode infestation was again detected on the 2nd year tuberose crop during 2nd week of May, 2016 and gradually increased till 4th week of August, 2016. Calcutta Single suffered more from the infestation of A. besseyi. Narrow spaced crop also suffered comparatively more from the foliar nematode infestation than the wide spaced crop. The variety played more influential role as compared to the spacing towards manifestation of disease due to A. besseyi in tuberose.

Keywords: incidence, severity, Aphelenchoides besseyi, infestation

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Introduction

Tuberose (*Polianthes tuberosa* L.) is one of the important tropical bulbous flowering plants grown for production of eternal floral spikes. It is popularly known as Rajanigandha, Nishigandha, Sword Lilly etc. It belongs to the family Amaryllidaceae and is a native of Mexico from where it spread to different parts of the world during 16th Century. The spikes of tuberose are used as cut flowers due to its delightful appearance, sweet and elegant fragrance and good keeping quality (i.e. long vase-life). The individual florets are used for making *Veni* and *Garlands*. It has long been cherished for the aromatic oils extracted from its fragrant white flowers. Tuberose blooms throughout the year and its florets are star shaped, waxy and loosely arranged on spike. Single flowered varieties are more fragrant than double flowered and usually preferred for *Gajara* and *Garlands*, while doubles and semi-doubles are preferably used for vase decoration. Tuberose is propagated by bulb having a diameter of 1.5 to 2.0 cm and weight approximately 30 g. Three to four months after planting, tuberose starts blooming. Though they bloom all-round the year but the summer and rainy seasons are the peak period. Bulbs once planted give commercial production up to 3 years.

One of the important biotic constraints of tuberose cultivation in West Bengal is the infestation of plant parasitic nematodes. Among the few plant parasitic nematodes, the foliar nematode, *Aphelenchoides besseyi* Christie has shown some threat to the cultivation of the crop in the state. The first report of foliar nematode infestation on tuberose to cause foliar disease was made from Hawaii by Holtzmann in 1968. In India, '*floral malady*' of tuberose

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due to*A. besseyi* was reported first from the Ranaghat areas of the Nadia district of West Bengal (Chakraborti and Ghosh, 1993). Besides India, *A. besseyi* had been reported to cause a serious foliar disease of tuberose in the Mekong Delta of Vietnam (Cuc and Pilon, 2007). Widespread occurrence of foliar nematode on rice, tuberose, onion and gladiolus was also reported from West Bengal (Roy *et al*., 2010; Roy *et al*., 2011a & 2011b).

Infestations of *A. besseyi* leads to primary appearance of light chlorotic lesion along the mid axis (rib) of the leaf starting from base extending upward but never touch the apex. Subsequently, it becomes yellowish and finally turns to brown or black, elongated necrotic spot. Infected leaves later on die and abscise. Scape becomes curled and twisted. Endoparasitic feeding of *A. besseyi* was observed in leaves, bracts and tepals (petals) where brown to black necrotic spots of varying shapes and sizes develop. Sometimes inflorescence gets aborted completely. Nematode may survive on bulbs, leaves, scapes, bracts, tepals and anthers but not in the soil (Roy *et al*., 2010; Roy *et al*., 2011b).Second year onwards tuberose crop suffers most from the infestation of foliar nematode, this may lead to annual yield loss of 30 to 40% in the 'Calcutta Double' cultivar as against 59% in 'Calcutta Single' cultivar (Khan and Pal, 2001; Pathak and Khan, 2009).

Infested bulbs harbour anhydrobiotic forms of *A. besseyi* and meant for widespread distribution. The nematode may also survive in the dried leaves and flowers in anhydrobiotic form; but unable to survive in soil for long time.

Considering the importance of nematodes in the integrated pest management system and increasing concern of environment, adoption of low input plant protection technologies like, summer ploughing, soil solarization, organic manuring, adjustment of dates of sowing/planting, spacing, adoption of resistant varieties, clean cultivation and judicious use of pesticides are gaining significance. Integration of two or more above mentioned methods could be adopted, for managing nematode like, *A. besseyi*.

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In view of the widespread occurrence and increasing importance of *A. besseyi* on the tuberose crop in the changing agricultural scenario,the present investigation was undertaken with the objectives of studying the effect of variety and spacing on the incidence and severity of *A. besseyi* in tuberose.

Materials and methods

The experiment was designed in Factorial RBD. Infected bulbs of approximately 2.5cm diameter of two cultivars of tuberose viz. Calcutta Single and Calcutta Double were planted in two different spacings (30 × 20 cm and 30 × 25 cm). The crop was raised by following recommended horticultural practices. Bulbs were investigated for confirming the presence of *A. bessseyi* before planting.

Observations:

Following observations were recorded during the period of experimentation.

i. Observation on first appearance of leaf symptoms due to nematode infestation corresponding to crop phenological stages.

ii. Observation on incidence and severity of leaf infestation

Numerical grading scale for evaluation of nematode pest severity/ intensity

Scale value	% leaf or flower infestation
1	No infection
2	Up to 10.0
3	>10– 30.0
4	> 30 – 50.0
5	>50 – 70.0
6	>70.0

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The percent disease index (PDI) or disease severity was calculated using the following formula (Wheeler, 1969):

$$\textbf{PDI} = \frac{\text{Sum of numerical grading}}{\text{Number of leaves / flowers examined} \times \text{Maximum disease grade}} \times 100$$

Results and discussion

The effect of variety and spacings on incidence of *A. besseyi* in tuberose over the growing period has been presented in Table 1). Incidence of *A. besseyi* on tuberose was 1st noticed on 489th DAP (3rd week of August, 2015) of the crop on both the cultivars. With the spread of foliar nematodes, the disease symptom gradually escalated to the other plant parts like scape, spikes, flowers etc. The per cent plant infestation i.e. incidence of *A. besseyi* was gradually increased after their initiation and the maximum was recorded on 545th DAP (2nd week of October, 2015). From 559th DAP (4th week of October, 2015) a gentle decline on the incidence of *A. besseyi* was noticed till 629th DAP (2nd week of January, 2016).

Tuberoses are herbaceous and perennial flowering plants which usually become exhausted after giving flowers over the year and start rejuvenating again from March onwards in the *Gangetic* plain areas of West Bengal. Hence, no sign of foliar nematode infestation was traced in the field till 1st week of May, 2016.

The sign of foliar nematode infestation was again detected on the 2nd year tuberose crop at 747th DAP (2nd week of May, 2016) and gradually increased till 859th DAP (4th week of August, 2016). In the 2nd year crop, significant maximum infestation of *A. besseyi* was recorded as 40% and 17.5% in the Calcutta Single and Calcutta Double cultivar, respectively at 859th DAP. Subsequently, plants revealed reduction in nematode infestation as they were going to be exhausted.

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Out of two cultivars of tuberose, Calcutta Single suffered more from the infestation of *A. besseyi* than the Calcutta Double as supported by the data on incidence over the growing period (Table 1). The significant maximum foliar nematode infestation was 67.5% and 46.7% in the Calcutta Single and Calcutta Double cultivar, respectively at 545th DAP (Table 1).

Here, closely spaced crops succumbed to more nematode infestation than the widely spaced crops in general. Significant effect of close spacing on the increased incidence of foliar nematode infestation was observed at 503rd, 531st, 587th, 747th, 761st and 789th DAP (Table 1). The significant maximum foliar nematode infestation was 55.8% and 40.0% in the close (30cm ×20 cm) and wide (30cm ×25 cm) spaced crops, respectively at 587th DAP (Table 1). The recorded data revealed that in very few cases spacing had significant effect on the incidence of the foliar nematodes on tuberose. Mostly variety played the vital role towards governing the nematode infestation. Calcutta Single was found more susceptible to *A. besseyi* than the Calcutta Double.

Interaction between variety and spacing on the incidenceof *A. besseyi* in tuberose

The effect of interaction between variety and spacing on incidence of *A. besseyi* in tuberose has been presented below (Table 2). None of the interactions between the variety and spacing used in the experiment showed significant influence on the incidence of *A. besseyi* during the crop growing period (Table 2). Incidence of *A. besseyi* was usually more in the Calcutta Single than the Calcutta Double.

Effect of variety and spacing on the severity of *A. besseyi* infestation in tuberose

The effect of variety and spacing on the severity of *A. besseyi* infestation in tuberose during the crop growing period has been presented in the table-3. Out of two cultivars used in the experiment, Calcutta Single suffered most; here severity of foliar nematode induced disease ranged from 0.7 to 45.1% (Table 3). The least disease severity in the Calcutta Single cultivar was recorded at the time of initiation (489 DAP) of nematode infestation while, the

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highest disease severity was noted on 545th DAP (2nd week of October, 2015). In the Calcutta Double cultivar minimum disease severity (3.9%) was observed on 629th DAP (2nd week of January, 2016) and the maximum severity (28.3%) was recorded on 545th DAP (2nd week of October, 2015).

Soon after the commencement of foliar nematode infestation in the second year tuberose crop on 747th DAP (2nd week of May, 2016) the disease progressed gradually to reach its maximum level on 859th DAP (4th week of August, 2016).

Usually, narrow spaced (30cm × 20cm) tuberose crop suffered comparatively more from the foliar nematode infestation than the wide spaced (30cm × 25cm) crop. The data indicated that the variety played more influential role as compared to the spacing towards manifestation of disease due to *A. besseyi* in tuberose.

Scape becomes curled and twisted. The infected plants bear many a time smaller scapes than healthy and normal ones.Sometimes inflorescence gets aborted completely (Roy *et al*., 2010; Roy *et al*., 2011b). In the present experiment also such abnormalities were observed on the leaves, bracts and inflorescence of tuberose when the infestation was severe.

Effect of interaction between variety and spacing on the severity of *A. besseyi* infestation in tuberose during 2014-16

Non-significant interaction between variety and spacing was observed on the severity of foliar nematode infestation (Table 4). Interaction study revealed severe infestation of *A. besseyi* in the Calcutta Single variety when grown in narrow spacing.

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Table 1: Effect of variety and spacing on the incidence of *A. besseyi* in tuberose

Treatments	Incidence of *A. besseyi* in tuberose (%)					
	489 DAP	503 DAP	517 DAP	531 DAP	545 DAP	559DAP
V_1: Calcutta Single	6.6 (1.7)	25.4 (21.7)	40.9 (44.2)	44.2 (48.3)	56.5 (67.5)	53.9 (62.5)
V_2: Calcutta Double	18.3 (17.5)	18.5 (13.3)	21.5 (18.3)	35.2 (36.7)	41.7 (46.7)	36.0 (37.5)
SEm (±)	4.22	3.10	4.54	4.31	4.35	5.89
LSD (0.05)	NS	NS	13.70	NS	13.12	17.76
S_1: (30×20) cm	12.9 (9.2)	29.2 (25.0)	28.9 (27.5)	48.0 (53.3)	48.8 (56.7)	41.0 (45.8)
S_2: (30×25) cm	11.9 (10.0)	14.7 (10.0)	33.5 (35.0)	31.4 (31.7)	49.5 (57.5)	48.9 (54.2)
SEm (±)	4.22	3.10	4.54	4.31	4.35	5.89
LSD (0.05)	NS	9.36	NS	12.99	NS	NS

Treatments	Incidence of *A. besseyi* in tuberose (%)				
	573 DAP	587 DAP	601DAP	615 DAP	629 DAP
V_1: Calcutta Single	51.1 (60.8)	45.6 (50.8)	38.5 (40.0)	29.9 (27.5)	23.6 (19.2)
V_2: Calcutta Double	31.0 (30.8)	42.1 (45.0)	25.4 (21.7)	17.9 (11.7)	12.3 (6.7)
SEm (±)	5.51	3.28	4.21	4.26	3.66
LSD (0.05)	16.62	NS	12.70	NS	11.04
S_1: (30×20) cm	38.7 (43.3)	48.7 (55.8)	29.6 (28.3)	24.1 (20.0)	16.3 (11.7)
S_2: (30×25) cm	43.4 (48.3)	38.9 (40.0)	34.3 (33.3)	23.7 (19.2)	19.6 (14.2)
SEm (±)	5.51	3.28	4.21	4.26	3.66
LSD (0.05)	NS	9.88	NS	NS	NS

Treatments	Incidence of *A. besseyi* in tuberose (%)				
	747 DAP	761DAP	775 DAP	789 DAP	803DAP
V_1: Calcutta Single	18.5 (12.1)	19.8 (13.3)	22.5 (15.4)	22.9 (16.7)	23.8 (17.5)
V_2: Calcutta Double	14.7 (8.3)	14.6 (9.2)	14.1 (7.5)	20.9 (14.2)	15.2 (7.5)
SEm (±)	2.10	3.08	2.69	2.21	2.79
LSD (0.05)	NS	NS	8.13	NS	8.42
S_1: (30×20) cm	22.3 (15.4)	22.2 (15.8)	17.7 (11.7)	26.4 (20.0)	20.0 (13.3)
S_2: (30×25) cm	10.9 (5.0)	12.2 (6.7)	18.8 (11.3)	17.3 (10.8)	18.9 (11.7)
SEm (±)	2.10	3.08	2.69	2.21	2.79
LSD (0.05)	6.34	9.29	NS	6.66	NS

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Treatments	Incidence of *A. besseyi* in tuberose (%)				
	817 DAP	831DAP	845 DAP	859 DAP	873DAP
V_1: Calcutta Single	25.5 (20.0)	30.5 (27.5)	37.9 (40.8)	38.2 (40.0)	38.0 (38.3)
V_2: Calcutta Double	13.4 (6.7)	23.3 (17.5)	23.4 (19.2)	23.4 (17.5)	27.7 (23.3)
SEm (±)	2.53	3.84	5.09	4.25	4.39
LSD (0.05)	7.64	NS	NS	12.82	NS
S_1: (30×20) cm	19.1 (12.5)	26.1 (21.7)	30.9 (30.8)	31.3 (29.2)	33.6 (32.5)
S_2: (30×25) cm	19.8 (14.2)	27.7 (23.3)	30.5 (29.2)	30.3 (28.3)	32.1 (29.2)
SEm (±)	2.53	3.84	5.09	4.25	4.39
LSD (0.05)	NS	NS	NS	NS	NS

Note: Data shown are (x+0.5) angular transformed values, figures in parentheses indicate original values

Table 2: Interaction between variety and spacings on the incidence of *A. besseyi* in tuberose during 2014-16

Treatments	Incidence of *A. besseyi* in tuberose (%)					
	489 DAP		503 DAP		517 DAP	
	S_1 (30×20) cm	S_2 (30×25) cm	S_1 (30×20) cm	S_2 (30×25) cm	S_1 (30×20) cm	S_2 (30×25) cm
V_1: Calcutta Single	9.0 (3.3)	4.1 (0.0)	33.2 (30.0)	17.6 (13.3)	34.6 (35.0)	47.3 (53.3)
V_2: Calcutta Double	16.9 (15.0)	19.8 (20.0)	25.3 (20.0)	11.7 (6.6)	23.2 (20.0)	19.8 (16.6)
SEm (±)	5.97		4.39		6.43	
LSD (0.05)	NS		NS		NS	

Treatments	Incidence of *A. besseyi* in tuberose (%)					
	531 DAP		545 DAP		559 DAP	
	S_1 (30×20) cm	S_2 (30×25) cm	S_1 (30×20) cm	S_2 (30×25) cm	S_1 (30×20) cm	S_2 (30×25) cm
V_1: Calcutta Single	54.2 (61.6)	34.3 (35.0)	53.7 (63.3)	59.4 (71.6)	49.3 (56.6)	58.6 (68.3)
V_2: Calcutta Double	41.9 (45.0)	28.6 (28.3)	43.9 (50.0)	39.6 (43.3)	32.7 (35.0)	39.3 (40.0)
SEm (±)	6.09		6.15		8.33	
LSD (0.05)	NS		NS		NS	

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Treatments	Incidence of *A. besseyi* in tuberose (%)					
	573 DAP		587 DAP		601 DAP	
	S_1 (30×20) cm	S_2 (30×25) cm	S_1 (30×20) cm	S_2 (30×25) cm	S_1 (30×20) cm	S_2 (30×25) cm
V_1: Calcutta Single	48.9 (58.3)	53.3 (63.3)	51.1 (60.0)	40.1 (41.6)	36.6 (38.3)	40.4 (41.6)
V_2: Calcutta Double	28.5 (28.3)	33.5 (33.3)	46.3 (51.6)	37.8 (38.3)	22.6 (18.3)	28.2 (25.0)
SEm (±)	7.80		4.64		5.96	
LSD (0.05)	NS		NS		NS	

Treatments	Incidence of *A. besseyi* in tuberose (%)					
	615 DAP		629 DAP		747 DAP	
	S_1 (30×20) cm	S_2 (30×25) cm	S_1 (30×20) cm	S_2 (30×25) cm	S_1 (30×20) cm	S_2 (30×25) cm
V_1: Calcutta Single	31.5 (30.0)	28.4 (25.0)	22.3 (18.3)	24.9 (20.0)	24.2 (17.5)	12.8 (6.6)
V_2: Calcutta Double	16.6 (10.0)	19.1 (13.3)	10.4 (5.0)	14.2 (8.3)	20.4 (13.3)	9.0 (3.3)
SEm (±)	6.03		5.18		2.98	
LSD (0.05)	NS		NS		NS	

Treatments	Incidence of *A. besseyi* in tuberose (%)					
	761 DAP		775 DAP		789 DAP	
	S_1 (30×20) cm	S_2 (30×25) cm	S_1 (30×20) cm	S_2 (30×25) cm	S_1 (30×20) cm	S_2 (30×25) cm
V_1: Calcutta Single	24.2 (16.6)	15.3 (10.0)	22.6 (16.6)	22.3 (14.1)	27.8 (21.6)	17.9 (11.6)
V_2: Calcutta Double	20.2 (15.0)	9.0 (3.3)	12.8 (6.6)	15.3 (8.3)	25.1 (18.3)	16.6 (10.0)
SEm (±)	4.36		3.82		3.12	
LSD (0.05)	NS		NS		NS	

Treatments	Incidence of *A. besseyi* in tuberose (%)					
	803 DAP		817 DAP		831 DAP	
	S_1 (30×20) cm	S_2 (30×25) cm	S_1 (30×20) cm	S_2 (30×25) cm	S_1 (30×20) cm	S_2 (30×25) cm
V_1: Calcutta Single	23.6 (18.3)	24.0 (16.6)	22.9 (16.6)	28.1 (23.3)	29.5 (26.6)	31.5 (28.3)
V_2: Calcutta Double	16.4 (8.3)	13.9 (6.6)	15.3 (8.3)	11.5 (5.0)	22.6 (16.6)	23.9 (18.3)
SEm (±)	3.95		3.58		5.43	
LSD (0.05)	NS		NS		NS	

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Treatments	Incidence of *A. besseyi* in tuberose (%)					
	845 DAP		859 DAP		873 DAP	
	S_1 (30×20) cm	S_2 (30×25) cm	S_1 (30×20) cm	S_2 (30×25) cm	S_1 (30×20) cm	S_2 (30×25) cm
V_1: Calcutta Single	39.5 (43.3)	36.5 (38.3)	39.2 (40.0)	36.8 (36.6)	39.8 (41.6)	36.6 (38.3)
V_2: Calcutta Double	22.3 (18.3)	24.6 (20.0)	28.0 (25.0)	27.3 (21.6)	22.9 (16.6)	23.9 (18.3)
SEm (±)	7.21		6.21		6.01	
LSD (0.05)	NS		NS		NS	

Table 3: Effect of variety and spacing on severity of *A. besseyi* infestation in tuberose

Treatments	Severity of *A. besseyi* infestation in tuberose (%)					
	489 DAP	503 DAP	517 DAP	531 DAP	545 DAP	559 DAP
V_1: Calcutta Single	5.5 (0.7)	19.1 (12.7)	27.2 (21.0)	28.6 (24.0)	42.5 (45.1)	38.9 (39.6)
V_2: Calcutta Double	12.4 (7.6)	15.4 (9.0)	27.0 (20.8)	23.2 (17.4)	29.8 (28.3)	29.0 (26.4)
SEm (±)	2.40	2.20	1.80	2.73	3.31	3.24
LSD (0.05)	NS	NS	NS	NS	9.98	9.76
S_1: (30×20) cm	9.4 (4.2)	22.9 (15.9)	30.0 (22.1)	30.3 (25.8)	36.5 (37.5)	33.8 (32.9)
S_2: (30×25) cm	8.5 (4.2)	11.6 (5.8)	24.2 (19.4)	21.5 (15.6)	35.9 (36.0)	34.2 (33.1)
SEm (±)	2.40	2.20	1.80	2.73	3.31	3.24
LSD (0.05)	NS	6.63	5.43	8.23	NS	NS

Treatments	Severity of *A. besseyi* infestation in tuberose (%)				
	573 DAP	587 DAP	601 DAP	615 DAP	629 DAP
V_1: Calcutta Single	38.5 (38.5)	36.8 (36.0)	30.8 (27.5)	23.9 (18.6)	18.9 (12.1)
V_2: Calcutta Double	28.9 (25.6)	24.3 (19.9)	15.9 (10.1)	15.8 (8.3)	9.9 (3.9)
SEm (±)	3.26	3.08	3.43	2.69	2.73
LSD (0.05)	9.83	9.28	10.33	8.12	8.23
S_1: (30×20) cm	32.0 (33.5)	29.8 (27.6)	21.6 (16.3)	19.4 (13.5)	14.2 (7.8)
S_2: (30×25) cm	35.4 (31.0)	31.2 (28.2)	25.1 (21.4)	20.3 (13.5)	14.6 (8.2)
SEm (±)	3.26	3.08	3.43	2.69	2.73
LSD (0.05)	NS	NS	NS	NS	NS

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Treatments	Severity of *A. besseyi* infestation in tuberose (%)				
	747 DAP	761 DAP	775 DAP	789 DAP	803 DAP
V_1: Calcutta Single	19.1 (12.7)	21.1 (15.1)	23.2 (16.2)	24.8 (17.5)	25.2 (19.9)
V_2: Calcutta Double	14.72 (8.2)	15.4 (10.1)	15.5 (8.1)	15.9 (9.0)	21.5 (14.9)
SEm (±)	2.20	3.04	2.52	2.29	2.18
LSD (0.05)	NS	NS	7.60	6.90	NS
S_1: (30×20) cm	22.21 (15.1)	23.98 (18.3)	19.00 (12.4)	21.1 (14.3)	28.3 (22.5)
S_2: (30×25) cm	11.61 (5.8)	12.48 (6.9)	19.68 (11.9)	19.6 (12.2)	18.4 (12.2)
SEm (±)	2.20	3.04	2.52	2.29	2.18
LSD (0.05)	6.64	9.18	NS	NS	6.56

Treatments	Severity of *A. besseyi* infestation in tuberose (%)				
	817 DAP	831 DAP	845 DAP	859 DAP	873 DAP
V_1: Calcutta Single	27.4 (22.5)	28.3 (24.2)	28.4 (24.0)	39.3 (41.5)	38.5 (39.0)
V_2: Calcutta Double	14.2 (7.6)	20.8 (16.0)	20.2 (12.9)	25.9 (23.8)	27.2 (22.2)
SEm (±)	2.80	3.74	3.13	4.57	3.38
LSD (0.05)	8.45	NS	NS	13.76	10.20
S_1: (30×20) cm	19.4 (12.9)	24.79 (20.8)	24.5 (18.9)	31.91 (31.5)	32.55 (30.7)
S_2: (30×25) cm	22.2 (17.2)	24.34 (19.3)	24.1 (18.1)	33.28 (33.8)	33.21 (30.6)
SEm (±)	2.80	3.74	3.13	4.57	3.38
LSD (0.05)	NS	NS	NS	NS	NS

Note: Data shown are (x+0.5) angular transformed values; figures in parentheses indicate original values

Table 4: Interaction between variety and spacing on the severity of *A. besseyi* infestation in tuberose during 2014-16

Treatments	Severity of *A. besseyi* infestation in tuberose (%)					
	489 DAP		503 DAP		517 DAP	
	S_1 (30×20) cm	S_2 (30×25) cm	S_1 (30×20) cm	S_2 (30×25) cm	S_1 (30×20) cm	S_2 (30×25) cm
V_1: Calcutta Single	6.9 (1.3)	4.1 (0.0)	24.5 (17.6)	13.7 (7.7)	30.5 (25.5)	23.9 (16.5)
V_2: Calcutta Double	11.9 (6.9)	12.8 (8.3)	21.2 (14.1)	9.5 (3.8)	29.5 (24.4)	24.5 (17.2)
SEm (±)	3.40		3.11		2.55	
LSD (0.05)	NS		NS		NS	

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Treatments	Severity of *A. besseyi* infestation in tuberose (%)					
	531 DAP		545 DAP		559 DAP	
	S_1 (30×20) cm	S_2 (30×25) cm	S_1 (30×20) cm	S_2 (30×25) cm	S_1 (30×20) cm	S_2 (30×25) cm
V_1: Calcutta Single	32.3 (28.6)	24.9 (19.4)	42.2 (44.7)	42.7 (45.6)	40.0 (41.3)	37.9 (37.7)
V_2: Calcutta Double	28.3 (23.0)	18.0 (11.6)	30.7 (30.3)	29.0 (26.4)	27.6 (24.4)	30.4 (28.3)
SEm (±)	3.86		4.68		4.58	
LSD (0.05)	NS		NS		NS	

Treatments	Severity of *A. besseyi* infestation in tuberose (%)					
	573 DAP		587 DAP		601 DAP	
	S_1 (30×20) cm	S_2 (30×25) cm	S_1 (30×20) cm	S_2 (30×25) cm	S_1 (30×20) cm	S_2 (30×25) cm
V_1: Calcutta Single	36.4 (35.0)	40.6 (42.0)	37.2 (36.9)	36.4 (35.0)	26.1 (21.1)	35.5 (33.8)
V_2: Calcutta Double	27.6 (23.5)	30.3 (27.7)	22.4 (18.3)	26.1 (21.4)	17.2 (11.3)	14.7 (8.8)
SEm (±)	4.60		4.35		4.85	
LSD (0.05)	NS		NS		NS	

Treatments	Severity of *A. besseyi* infestation in tuberose (%)					
	615 DAP		629 DAP		747 DAP	
	S_1 (30×20) cm	S_2 (30×25) cm	S_1 (30×20) cm	S_2 (30×25) cm	S_1 (30×20) cm	S_2 (30×25) cm
V_1: Calcutta Single	23.9 (19.2)	23.8 (18.1)	17.4 (11.1)	20.3 (13.1)	24.5 (17.6)	13.7 (7.7)
V_2: Calcutta Double	14.8 (7.8)	16.8 (8.9)	10.9 (4.5)	8.9 (3.3)	19.9 (12.5)	9.5 (3.8)
SEm (±)	3.81		3.86		3.12	
LSD (0.05)	NS		NS		NS	

Treatments	Severity of *A. besseyi* infestation in tuberose (%)					
	761 DAP		775 DAP		789 DAP	
	S_1 (30×20) cm	S_2 (30×25) cm	S_1 (30×20) cm	S_2 (30×25) cm	S_1 (30×20) cm	S_2 (30×25) cm
V_1: Calcutta Single	27.0 (20.5)	15.2 (9.7)	23.2 (16.9)	23.2 (15.5)	25.3 (18.3)	24.3 (16.6)
V_2: Calcutta Double	20.9 (16.1)	9.8 (4.2)	14.8 (7.7)	16.1 (8.3)	16.9 (10.2)	14.9 (7.7)
SEm (±)	4.30		3.57		3.23	
LSD (0.05)	NS		NS		NS	

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Treatments	Severity of *A. besseyi* infestation in tuberose (%)					
	803 DAP		817 DAP		831 DAP	
	S_1 (30×20) cm	S_2 (30×25) cm	S_1 (30×20) cm	S_2 (30×25) cm	S_1 (30×20) cm	S_2 (30×25) cm
V_1: Calcutta Single	30.4 (25.3)	20.0 (14.4)	23.8 (17.7)	31.1 (27.2)	30.6 (26.1)	26.1 (22.2)
V_2: Calcutta Double	26.2 (19.7)	16.8 (10.0)	15.0 (8.1)	13.4 (7.2)	19.0 (15.5)	22.6 (16.3)
SEm (±)	3.08		3.97		5.30	
LSD (0.05)	NS		NS		NS	

Treatments	Severity of *A. besseyi* infestation in tuberose (%)					
	845 DAP		859 DAP		873 DAP	
	S_1 (30×20) cm	S_2 (30×25) cm	S_1 (30×20) cm	S_2 (30×25) cm	S_1 (30×20) cm	S_2 (30×25) cm
V_1: Calcutta Single	27.8 (24.4)	28.9 (23.6)	39.6 (40.2)	39.1 (42.7)	37.9 (37.7)	39.2 (40.2)
V_2: Calcutta Double	21.1 (13.3)	19.2 (12.5)	24.3 (22.7)	27.5 (24.7)	27.2 (23.6)	27.3 (20.8)
SEm (±)	4.43		6.46		4.79	
LSD (0.05)	NS		NS		NS	

Note: Data shown are (x+0.5) angular transformed values, figures in parentheses indicate original values

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