COMPARATIVE HOST SUITABILITY OF SELECTED CROP SPECIES TO *TYLENCHORHYNCHUS ZAMBIENSIS*†

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ABSTRACT

Venditti, M. E., and G. R. Noel. 1995. Comparative host suitability of selected crop species to *Tylenchorhynchus zambiensis*. Nematropica 25:15-25.

The host suitability of five genotypes of maize (*Zea mays*), alfalfa (*Medicago sativa* cv. Cimarron), red clover (*Trifolium pratense* cv. Mammoth), soybean (*Glycine max* cv. Bragg), sunflower (*Helianthus annus* cv. CCA82-2), wheat (*Triticum aestivum* cv. Pioneer 2508), and white clover (*Trifolium repens* cv. Dutch White) to *Tylenchorhynchus zambiensis* were evaluated in two greenhouse experiments. Plants were inoculated with 5 000 nematodes, and populations and effects on growth were determined 60 days later. The host status was determined by calculating a reproductive factor (R) where R = final population (Pf)/initial population (Pi) and where R ≤ 1 = nonhost; R = 1.1-4 = poor host; R = 4.1-10 = fair host; R = 10.1-20 = good host; and R > 20 = excellent host. Maize genotypes 'MO17 × A634', 'MM603', 'ZM-1760', 'TGR 1349', and 'Natal 8-Row Flint' were excellent hosts for *T. zambiensis*. Although plant growth was minimally affected by *T. zambiensis*, highest numbers of nematodes per gram of dry root weight were recovered from 'MO17 × A634'. The maize genotype 'TGR1349' was the most susceptible of the maize genotypes evaluated, exhibiting a significant reduction in plant growth. Dry root weights in all the maize genotypes were higher in noninoculated controls compared to inoculated treatments. Wheat was a good host for *T. zambiensis*, but plant growth was not affected by the nematode. Alfalfa, red clover, and white clover were poor hosts for *T. zambiensis*. Soybean was a poor host in the first experiment but was a fair host in the second test. Sunflower was a nonhost.

Key words: alfalfa, *Glycine max*, *Helianthus annus*, host suitability, maize, *Medicago sativa*, nematode, red clover, soybean, sunflower, *Trifolium pratense*, *Trifolium repens*, *Triticum aestivum*, *Tylenchorhynchus zambiensis*, wheat, white clover, *Zea mays*.

RESUMEN

Venditti, M. E. y G. R. Noel. 1995. Comparación de la aptitud de cultivos seleccionados como hospederos de *Tylenchorhynchus zambiensis*. Nematrópica 25:15-25.

La aptitud hospedera de cinco genotipos de maíz (*Zea mays*), alfalfa (*Medicago sativa* cv. Cimarron), trébol rojo (*Trifolium pratense* cv. Mammoth), soya (*Glycine max* cv. Bragg), girasol (*Helianthus annus* cv. CCA82-2), trigo (*Triticum aestivum* cv. Pioneer 2508), y trébol blanco (*Trifolium repens* cv. Dutch White) a *Tylenchorhynchus zambiensis* fue evaluada en dos experimentos de invernadero. Las plantas fueron inoculadas con 5 000 nematodos y las poblaciones y los efectos en el desarrollo de las plantas fueron determinados 60 días después de la inoculación. La capacidad hospedera fue determinada calculando un factor reproductivo (R) donde R = población final (Pf)/población inicial (Pi) y donde R ≤ 1 = no hospedero; R = 1.1-4 = hospedero pobre; R = 4.1-10 = hospedero intermedio; R = 10.1-20 = buen hospedero; y R > 20 = excelente hospedero. Los genotipos de maíz 'MO17 × A634', 'MM603',

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'ZM-1760', 'TGR1349', 'Natal 8-Row Flint' fueron excelentes hospederos de *T. zambiensis.* A pesar que el desarrollo de las plantas fue afectado mínimamente por *T. zambiensis,* el mayor número de nematodos por gramo de raíz seca fue recuperado de 'MO17×A634'. El genotipo de maíz 'TGR1349' fue el más susceptible de los genotipos de maíz evaluados, encontrándose una reducción significativa en el desarrollo de las plantas. El peso seco de las raíces en todos los genotipos de maíz fueron mayores en los controles en comparación con los tratamientos inoculados. El trigo fue un buen hospedero de *T. zambiensis,* pero el desarrollo de las plantas no fue afectado por el nematodo. La alfalfa, el trébol rojo, y el trébol blanco fueron hospederos pobres de *T. zambiensis.* La soya fue un hospedero pobre en el primer experimento pero un hospedero intermedio en el segundo experimento. El girasol fue considerado no hospedero.

Palabras clave: alfalfa, aptitud hospedera, girasol, *Glycine max, Helianthus annus,* maíz, *Medicago sativa,* nematodo, soya, trébol blanco, trébol rojo, *Trifolium pratense, Trifolium repens, Triticum aestivum, Tylenchorhynchus zambiensis,* trigo, *Zea mays.*

INTRODUCTION

A large segment of Zambian agriculture is based upon maize (*Zea mays* L.) production. Maize is the dominant staple and main subsistence crop in the Republic of Zambia and is grown in monoculture on about 633 000 ha annually (1). Maize is important not only as a food crop but also as a basic feed in the production of poultry, beef cattle, and hogs (28). Crops such as sunflower (*Helianthus annuus* L.), soybean (*Glycine max* (L.) Merr.) and cotton (*Gossypium hirsutum* L.) are the major oilseed crops in Zambia. About 39 450 ha of sunflower, 19 863 ha of soybean and 79 388 ha of cotton are planted annually (1). At the present time, a large number of commercial farmers are growing soybean in rotation with wheat (*Triticum aestivum* L.) (16).

Species of *Tylenchorhynchus* and related genera damage many crops world wide (6,10,17,19,20,23,27,29). In Southern Africa, species of *Tylenchorhynchus* and related genera reproduce on alfalfa (*Medicago sativa* L.), sunflower, soybean, maize, wheat, and white clover (*Trifolium repens* L.) (5,8,14). Previous studies in Zambia have shown that maize, sunflower, and soybean are hosts to several species of plant-parasitic nematodes (8,14). During experimentation in two production areas of Zambia, an undescribed species of *Tylenchorhynchus* [subsequently described as *Tylenchorhynchus zambiensis* n. sp. (24)] was associated with yield loss of maize (12) and was pathogenic to maize in greenhouse experiments (25). Recognition of the host suitability of different crops to the nematode pest is fundamental to developing appropriate nematode management practices. Crop rotation is one of the oldest and most effective methods to minimize the impact of plant-parasitic nematodes (2), but successful implementation requires detailed knowledge of the host status of crops intended for inclusion in rotations (21). Limited information exists regarding the host suitability of different crops to *T. zambiensis.* Due to the potential economic importance of *T. zambiensis* in Zambia, a host-range study was conducted in the greenhouse. In addition, data were developed on the potential for yield loss of the crops evaluated. This study included four genotypes of maize grown in Zambia, Zimbabwe and South Africa in addition to crops such as alfalfa, red clover (*Trifolium pratense* L.), soybean, sunflower, wheat, and white clover.

MATERIALS AND METHODS

The host suitability of 11 genotypes of seven crops species to *T. zambiensis* was tested in the greenhouse. The crop species evaluated are grown in Zambia, but in some cases, cultivars adapted to Zambia could not be obtained. Five genotypes of maize, 'MO17 × A634' (origin U.S.A.), 'MM603' (origin Zambia), 'ZM-1760' (origin Zambia), 'TGR 1349' (origin Zimbabwe), and 'Natal 8-Row Flint' (origin South Africa) were evaluated in this study. The last three maize genotypes were supplied by the U.S. Department of Agriculture, Plant Introduction Station at Ames, Iowa. Maize 'MM603' was obtained in Zambia. One cultivar each of soybean (cv. Bragg, grown in Zambia), sunflower (cv. CCA82-2, origin Zambia), white clover (cv. Dutch White), red clover (cv. Mammoth), alfalfa (cv. Cimarron), and spring wheat (cv. Pioneer 2508), also were included in the study.

A population of *T. zambiensis*, originally collected from a maize field in Magoye, Zambia, was brought into the U.S. under quarantine and maintained in the greenhouse on maize hybrid 'MO17 × A634'. Two experiments were conducted, one from July to September and the second from September to November 1993. Soil temperature was recorded each morning and each afternoon.

Seed of alfalfa, red clover, and white clover were planted 14 days before inoculation in 17-cm diam clay pots, containing 1 200 cm^3 of autoclaved soil (3:1 sand/sandy loam mixture). Seedlings were thinned before inoculation to 20 plants per pot. Seeds of maize, sunflower, soybean, and wheat were germinated on moist filter paper and transplanted when the radicles were 3-4 cm long. One seedling of maize and sunflower, two of soybean, and four of wheat were planted immediately prior to inoculation. During filling of pots with soil, three 1.5-cm-diam centrifuge tubes were inserted into the soil in each pot to a depth of 3 cm. The tubes were removed and nematode inoculum was pipetted into the holes and then holes were filled with 50 cm^3 of autoclaved soil.

Experimental units were arranged in a completely randomized design. Five of the ten experimental pots of each cultivar were infested with 5 000 *T. zambiensis*/pot obtained by the centrifugal-flotation technique (7). The remaining five served as noninoculated controls. An additional treatment was pots of fallow soil infested with 5 000 *T. zambiensis* and maintained as were the other experimental units. Each week all plants received 200 ml of Hyponex® (1.2% ammoniacal nitrogen, 5.8% nitrate nitrogen, 6% phosphorus, and 19% potassium). At 27 and 41 days after inoculation, 400 ml of Rapid Gro® (5.3% ammoniacal nitrogen, 5.1% nitrate nitrogen, 12.6% urea nitrogen, 19% phosphorus, and 17% potassium) were applied. Both fertilizers were constituted according to the manufacturer's instructions. When pest control was necessary, plants were sprayed with dienochlor, malathion, or carbaryl.

Sixty days after inoculation, soil and roots were removed from pots and nematodes were extracted from the entire volume of soil (7). Number of nematodes in each pot was determined by calculating the mean of three aliquants and multiplying by the extract volume. Reproduction (R) (18) was determined by calculating Pf/Pi where Pf is the final population density and Pi is the initial population of the nematode. Relative host status was based on the host rating scales proposed by Coates (4) where $R \leq 1$ = nonhost, R = 1.1-4 = poor host, R = 4.1-10 = fair host, R = 10.1-20 = good host, and $R > 20$ = excellent host. Plants were dried for 4 days at 55°C, and dry foliar weights, dry root weights, and total dry plant weights were recorded. Plant heights also were determined for maize and sunflower.

Data from the two experiments were analyzed using analysis of variance and means separated using Fisher's least significant difference test (13). Due to heterogeneity of variances, data were transformed to $\log_{10}(x)$. Differences among means were compared at the 5% level of significance. Data of both repetitions of the experiment were compared using analysis of combined experiments to determine whether experiments could be combined (15).

RESULTS

The analysis of combined experiments demonstrated significant differences between the two experiments in number of nematodes/g of dry root, final population densities, and R. Consequently, both experiments were analyzed separately. Soil temperatures ranged from 20 to 35°C ($\bar{x}$ = 26.3°C) during the first experiment and from 20 to 34°C ($\bar{x}$ = 24.9°C) in the second experiment.

Host suitability: In the first experiment, greatest reproduction of *T. zambiensis* was on maize (Table 1). All the maize genotypes evaluated were excellent hosts for the nematode (R > 20). However, some differences in final population and R were observed. Highest final density was recovered from 'MO17 × A634' (1 940 000), and the lowest final population was recovered from 'TGR1349' (1 110 000). Wheat was a good host (R = 10.8), whereas soybean, white clover, red clover, and alfalfa were poor hosts (R = 1.2-1.6). Nematode populations decreased on sunflower (Pf = 820) and in the fallow treatment (Pf = 600).

Table 1. Host suitability of 11 genotypes of seven plant species to *Tylenchorhynchus zambiensis* 60 days after inoculation with 5 000 nematodes per pot, experiment 1.[y]

Crop	Genotype	Total nematodes/pot	Nematodes/g dry root	R[z]
Maize	MO17 × A634	1 940 000 a	99 000 a	388.0 a
	ZM-1760	1 660 000 ab	97 800 a	332.0 ab
	Natal 8-Row Flint	1 380 000 ab	94 000 a	276.0 ab
	MM603	1 160 000 ab	75 000 a	232.0 ab
	TGR1349	1 110 000 b	75 000 a	222.0 b
Wheat	Pioneer 2508	54 000 c	15 600 b	10.8 c
White clover	Dutch White	8 000 d	1 200 cd	1.6 d
Alfalfa	Cimarron	6 700 d	760 d	1.3 d
Soybean	Bragg	6 400 d	740 d	1.3 d
Red clover	Mammoth	6 200 d	2 000 c	1.2 d
Sunflower	CCA82-2	820 e	120 e	0.2 e
Fallow soil	——	600 e	——	0.1 e

[y]Data are means of five replications. Untransformed data are presented, but data were transformed to log10(x) for analysis. Means in columns followed by the same letter do not differ significantly ($P \leq 0.05$) according to Fisher's LSD.

[z]Reproductive factor (R) = final nematode population/initial nematode population (Pf/Pi).

Table 2. Host suitability of 11 genotypes of seven plant species to *Tylenchorhynchus zambiensis* 60 days after inoculation with 5 000 nematodes per pot, experiment 2.[y]

Crop	Genotype	Total nematodes/pot	Nematodes/g dry root	R[z]
Maize	MO17 × A634	2 080 000 a	215 000 a	416.0 a
	Natal 8-Row Flint	1 420 000 ab	207 000 ab	284.0 ab
	MM603	1 360 000 ab	154 000 ab	272.0 ab
	ZM-1760	910 000 bc	97 000 b	182.0 bc
	TGR1349	685 000 c	145 000 ab	137.0 c
Wheat	Pioneer 2508	51 000 d	15 400 c	10.2 d
Soybean	Bragg	40 000 d	6 700 d	8.0 d
Red clover	Mammoth	7 500 e	2 500 e	1.5 e
White clover	Dutch White	7 100 e	2 200 e	1.4 e
Alfalfa	Cimarron	6 000 e	970 f	1.2 e
Sunflower	CCA82-2	1 960 f	320 g	0.4 f
Fallow soil	——	870 g	——	0.2 g

[y]Data are means of five replications. Untransformed data are presented, but data were transformed to log10(x) for analysis. Means in columns followed by the same letter do not differ significantly ($P \leq 0.05$) according to Fisher's LSD.
[z]Reproductive factor (R) = final nematode population/initial nematode population (Pf/Pi).

Similar trends existed among the crop species when numbers of nematodes/g of dry root were compared. Numbers of *T. zambiensis*/g of dry root ranged from 99 000 in maize 'MO17 × A634' to 120 in 'CCA82-2' sunflower.

In the second experiment similar tends were observed regarding final population densities and R except for 'Bragg' soybean for which the final population density and R were greater than in experiment 1 (Table 2). A sightly different order of host suitability occurred among the maize genotypes evaluated and among the leguminous species. Numbers of nematodes/g of dry root ranged from 215 000 in the maize 'MO17 × A634' to 320 in 'CCA82-2' sunflower. As in experiment 1, 'MO17 × A634' supported the greatest population increase per pot (2 080 000) and 'TGR1349' the lowest (685 000). However, 'ZM-1760' supported the lowest numbers of nematode/g of dry root (97 000).

'Bragg' soybean was rated as a fair host for *T. zambiensis* (R = 8.0). All the other crops exhibited similar trends in R values when compared to the first experiment (Tables 1, 2). Graminaceous plants were either excellent or good hosts. Legumes (except soybean) were poor hosts, and sunflower was a nonhost (R < 1) for *T. zambiensis.*

Effects on plant growth: In both experiments, plant height of 'TGR1349' and 'MM603' was significantly less in inoculated plants compared to those not inoculated with *T. zambiensis* (Table 3). Plant height of 'MO17 × A634' also was affected by inoculation with *T. zambiensis* in experiment 1 but not in experiment 2. Height of 'Natal 8-Row Flint' and 'ZM-1760' was not reduced in either experiment. In both experiments,

Table 3. Height of five maize genotypes and one sunflower cultivar 60 days after inoculation with 5 000 *Tylenchorhynchus zambiensis*.[z]

	Plant height (cm)					
Treatment	Natal 8-Row Flint	TGR1349	MO17 × A634	ZM-1760	MM603	CCA82-2
			Experiment 1			
Control	135.5	148.2	199.0	156.2	129.5	141.0
T. zambiensis	118.2	117.8*	170.6*	151.4	106.2*	139.5
			Experiment 2			
Control	116.7	125.4	151.6	126.4	108.0	108.8
T. zambiensis	107.8	100.2*	149.2	109.8	83.0*	99.6

[z]Data are means of five replications.
*Differs significantly ($P \leq 0.05$) from the control according to Student's *t*-test.

only the dry foliar weight of 'TGR1349' was reduced significantly by inoculation with the nematode. The foliar dry weights of 'Natal 8-Row Flint', 'ZM-1760', and 'MM603' were reduced numerically in both experiments by inoculation with *T. zambiensis*, but the differences were not statistically significant. In both experiments, dry root weights of all maize genotypes inoculated with the nematode were significantly less than the controls (Table 4). Total dry plant weight of 'Natal 8-Row Flint', 'ZM-1760', 'TGR1349', and 'MM603' was reduced significantly in the two experiments by inoculation with *T. zambiensis*. However, total dry plant weight of 'MO17 × A634' was not affected in either experiment.

In the first experiment, inoculation with *T. zambiensis* did not affect dry foliar, root, or total plant weights of alfalfa, red clover, soybean, sunflower, wheat, or white clover (Table 5). In experiment 2, dry foliar weights and dry root weights of alfalfa, red clover, soybean, and sunflower did not differ significantly between inoculated and noninoculated treatments (Table 5). Only white clover exhibited a reduction in dry foliar weight and total dry plant weight when inoculated with the nematode. Although dry root weight of nematode inoculated white clover was 43% less than noninoculated controls, the difference was not statistically significant. Wheat inoculated with *T. zambiensis* showed a reduction in dry foliar weight when compared to uninoculated plants. However, no significant differences were found between infected and noninfected plants in either root dry weight or total plant weights.

DISCUSSION

A plant is a host if it supports development and reproduction of a particular nematode species, whereas on a nonhost the nematode can not complete its life cycle (21). The terms "good" and "poor" hosts are expressions of resistance, and resistance or susceptibility of a host can be determined by the relationship between Pi and Pf of the nematode on a host plant (26). A host was defined as "poor" when the nematode population decreased and $Pf/Pi < 1$, but if $Pf/Pi > 1$ the plant species was defined as "good" host. Classifying host suitability based only on the nema-

Table 4. Dry foliar, root, and total plant weights of five maize genotypes 60 days after inoculation with 5 000 *Tylenchorhynchus zambiensis*.[z]

	Experiment 1					Experiment 2				
Treatment	Natal 8-Row Flint	TGR1349	MO17 × A634	ZM-1760	MM603	Natal 8-Row Flint	TGR1349	MO17 × A634	ZM-1760	MM603
					Foliar weight (g)					
Control	45.4	44.4	47.1	45.4	41.2	42.1	37.6	42.6	40.9	41.3
T. zambiensis	35.4	30.1*	40.3	37.7	30.5	34.6	27.0*	42.3	30.8	32.8
					Root weight (g)					
Control	32.1	28.4	31.3	36.3	29.1	18.9	16.5	20.0	27.6	21.7
T. zambiensis	15.3*	14.7*	19.5*	17.1*	16.6*	8.3*	6.6*	10.8*	11.0*	9.9*
					Total plant weight (g)					
Control	77.5	72.8	78.4	81.7	70.2	60.9	54.1	59.5	68.5	63.1
T. zambiensis	50.7*	44.7*	59.9	54.8*	47.1*	42.9*	33.6*	52.7	41.8*	42.7*

[z]Data are means of five replications.
*Differs significantly ($P \leq 0.05$) from the control according to Student's *t*-test.

Table 5. Dry foliar, root, and total plant weights of alfalfa, red clover, soybean, sunflower, wheat, and white clover cultivars 60 days after inoculation with 5 000 *Tylenchorhynchus zambiensis*.[z]

	Experiment 1						Experiment 2					
Treatment	Alfalfa	Red clover	Soybean	Sunflower	Wheat	White clover	Alfalfa	Red clover	Soybean	Sunflower	Wheat	White clover
						Foliar weight (g)						
Control	13.6	9.4	23.3	30.4	8.5	10.6	13.1	6.6	19.8	28.4	10.1	10.7
T. zambiensis	14.4	9.0	18.5	24.7	8.9	10.3	15.3	7.4	17.5	24.9	6.7*	7.0*
						Root weight (g)						
Control	8.0	5.2	8.7	7.8	4.9	7.4	5.9	4.3	6.3	5.5	3.9	6.1
T. zambiensis	9.1	3.7	8.2	7.2	3.4	6.8	6.7	3.8	6.3	6.5	3.8	3.5
						Total plant weight (g)						
Control	21.6	14.6	31.4	38.2	13.4	18.0	19.0	11.5	26.1	33.9	13.9	16.8
T. zambiensis	23.5	12.7	27.2	31.9	12.3	17.2	22.0	11.2	23.7	31.4	10.5	10.5*

[z]Data are means of five replications.
*Differs significantly ($P \leq 0.05$) from the control according to Student's *t*-test.

tode population density in a pot may not be completely appropriate because the root system of the plant species evaluated may vary greatly in size, morphology, and availability of feeding sites. Therefore, the crops evaluated in this study were categorized on the basis of the number of nematodes/g of dry root and on the relative host status based on an expanded rating scale (4).

Previous field research with *T. zambiensis* provided limited information regarding the host suitability of different plant species to this nematode. Results reported herein demonstrated that *T. zambiensis* reproduced on all plants tested except sunflower. The graminaceous crops maize and wheat were respectively, excellent and good hosts for *T. zambiensis.* Both maize and wheat also have been reported as hosts for other species of *Tylenchorhynchus.* Maize and wheat are "highly favorable" hosts for *T. claytoni* Steiner (9) and *T. agri* Ferris (4). Sharma (22,23) reported that maize is a "suitable" host for *T. dubius* (Butschli) Filipjev.

During the 60-day experimental period utilized in these studies, inoculation with *T. zambiensis* reduced root weight of the five maize genotypes. With the exception of 'TGR1349', foliar weight was not affected. Root weight of certain plants can be reduced by much lower populations of nematodes than needed to affect foliar weight (21). Some plant species can compensate for low to moderate loss of functional roots and do not exhibit loss of foliar weight. In an earlier study using 'MO17 × A634', consistent reduction in foliar weight was observed when plants were inoculated with 50 000 nematodes/pot compared with pots inoculated with 5 000 *T. zambiensis* (25). In the present study, 'MO17 × A634' supported the highest Pf of the maize genotypes evaluated but was the only genotype for which total dry plant weight was not affected. Thus 'MO17 × A634' may express some tolerance to *T. zambiensis.* In contrast to 'MO17 × A634', foliar and root growth of 'TGR1349' were reduced significantly. However, populations of *T. zambiensis* were lower on 'TGR1349' than on those of the other maize genotypes, suggesting that 'TGR1349' was the least tolerant of the genotypes evaluated. Under favorable growing conditions, nematode damage to roots may not be enough to cause a significant reduction in foliar growth, but water or nutritional stress could affect the plant's capacity to overcome unfavorable conditions (3).

The leguminous crops (alfalfa, red clover, and white clover) were poor hosts for *T. zambiensis.* Krusberg (9) ranked these crops only as "favorable" for *T. claytoni,* whereas the legumes are "excellent" hosts for *T. dubius* (22,23) and *T. agri* (4). Data concerning the host status of soybean were contradictory. In the first experiment, soybean supported minimal nematode reproduction with Pf attaining a level slightly higher than the initial inoculation level. However, in the second experiment, the host suitability of soybean to *T. zambiensis* was greater than that observed in the first experiment. Soybean growth was not affected by the nematode in either experiment. These data support previous findings that *T. zambiensis* does not cause yield reduction in soybean (11). Although white clover was a poor host, growth of white clover was affected by inoculation with *T. zambiensis* in the second experiment. These discrepancies in results between the two repetitions of the experiment could be attributed to differences in environmental conditions (temperature and light conditions) between the time of the year the tests were conducted. Greenhouse temperature varied widely and could have affected nematode activity. During the first experiment the foliage of the legumes was damaged by insect feeding, and the reduction in foliage may have affected the food available to *T. zambiensis.*

Although soybean growth was not reduced by *T. zambiensis,* the conflicting results obtained in the ability of *T. zambiensis* to reproduce on soybean necessitate further tests to determine its status as a crop used in rotation to control this nematode. In both greenhouse experiments reported herein, sunflower failed to support reproduction of *T. zambiensis.* The status of sunflower as a nonhost supports previous findings that populations of *T. zambiensis* decreased in sunflower fields in Zambia (12). Sunflower can be used as a rotation crop to attain low population densities of *T. zambiensis.*

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