Comparison of Millet and Sorghum-Sudangrass Hybrids Grown in Untreated Soil and Soil Treated with Two Nematicides[1]

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Abstract: Aldicarb and Bay 68138 (ethyl 4-(methylthio)-*m*-tolyl isopropylphosphoramidate) were effective in increasing the plant height and yield of millet and sorghum-sudangrass hybrids. Stunting of plants and reduction in yield were inversely proportional to the number of *Pratylenchus* spp. and *Belonolaimus longicaudatus* present in the rhizosphere. Millet and sorghum-sudangrass hybrids supported large numbers of *Criconemoides ornatus*, *Pratylenchus* spp., *B. longicaudatus*, and *Xiphinema americanum*. Funk's sorghum × sudangrass Hybrid 78 was more sensitive to injury by the nematode complex than were Tift 23A × 186 or Gahi-1 pearl millet. 'Tiflate' pearl millet was more resistant than other millets or sorghums to injury caused by *C. ornatus*, *Pratylenchus* spp., *Trichodorus christiei*, and *B. longicaudatus*. Millet and sorghum-sudangrass hybrids are poor summer cover crops because they favor intensive development of *P. brachyurus*, *P. zeae*, *T. christiei*, and *B. longicaudatus*. *Key Words:* chemical control, nematodes, *Pratylenchus brachyurus*, *P. zeae*.

Millet and sorghum-sudangrass hybrids are grown extensively in the southeastern United States; millet primarily for grazing, forage and summer cover crop and sorghum for forage, seed and summer cover crop. The extended period during which these crops can be planted makes them especially adapted to a double-cropping system with winter-grown small grain or vegetable crops. Millet and sorghum follow most crops in rotation without serious cultural and disease problems (7), but many plant-parasitic nematodes that parasitize other crops also attack millet and sorghum-sudangrass hybrids.

Endo (3) reported that sorghum and sudangrass were good hosts for *Pratylenchus brachyurus* and *P. zeae*. McGlohon et al. (8) found that in North Carolina, sudangrass supported reproduction of *Meloidogyne javanica* (Treub) Chitwood and *M. incognita* (Kofoid and White) Chitwood and the millet did not support growth and reproduction of any root-knot nematodes. Good et al. (5) found that millet and sudangrass supported large populations of *Belonolaimus longicaudatus*, *Trichodorus christiei*, *Xiphinema americanum* and *P. brachyurus*. Later, Good (4) reported that corn yields were low following millet, which was a favored host for *B. longicaudatus*. He also showed that numbers of *B. longicaudatus* were greatest in millet-cotton sequences and that millet supported large populations of *T. christiei*, *P. brachyurus* and *P. zeae*, but did not support *Tylenchorhynchus claytoni* or *Criconemoides ornatus*. From the same study, Good reported that sudangrass was an excellent host for *T. claytoni*, *T. christiei* and *P. brachyurus*. Thus, it is well docomented that millet and sorghum are good hosts for many species of plant-parasitic nematodes, but there is no report showing the effects of nonvolatile nematicides on nematode populations or on plant growth of millet and sorghum-sudangrass hybrids under field conditions. The objectives of this experiment were to study the effects of aldicarb and Bay 68138 [ethyl 4-(methylthio)-*m*-tolyl isopropylphosphoramidate] on population dynamics of five species of plant-parasitic nematodes and on growth and yield of selected millet and sorghum-sudangrass hybrids and to evaluate these plants for resistance to the nematode species.

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MATERIALS AND METHODS

Land selected for this experiment was a Dothan loamy sand that was planted to pearl millet, *Pennisetum glaucum* (L.) R. Br., for 2 previous years. The land was infested naturally with the following nematodes: *Criconemoides ornatus* (Raski) Raski; *Trichodorus christiei* Allen; *Belonolaimus longicaudatus* Rau; *Xiphinema americanum* Cobb; *Pratylenchus brachyurus* (Godfrey) Filipjev & Schuur. Stek.; and *P. zeae* Graham. On 12 May 1969, we applied granular formulations of Bay 68138 15G and aldicarb 10G at 11.2 kg/hectare active ingredient to plots 4.6 X 15.8 m with one row/plot 4.6 m long on 1.8-m centers. Nematicide granules were spread on the soil surface and incorporated 10-15 cm deep with a disk harrow. A randomized block split-plot design with five replications was established with nematicide treatment as the main plot and plant variety as the subject. On 21 May, we planted single-row plots of the eight sorghum-sudangrass or millet hybrids listed in Table 2. Good stands of all varieties were obtained, and on 1 July, the height of plants in each plot was measured. Dry matter forage yields were taken on 30 July and 16 September. Soil samples were collected from the root zone on 23 June, 7 August, and 25 September and assayed for plant-parasitic nematodes using Jenkin's centrifugal-flotation method (6).

RESULTS AND DISCUSSION

Data in Table 1 indicate that by 23 June, nematicides significantly reduced the number of *C. ornatus*, *Pratylenchus* spp., *T. christiei* and *B. longicaudatus* in the soil and they remained low at the 7 August sampling.

By 25 September, plots treated with aldicarb contained significantly more *C. ornatus* than did control plots, suggesting that its nematicidal properties to *C. ornatus* had disappeared, and the nematode, possibly freed from competitors killed by aldicarb, plus having a better root system on which to feed, was able to increase rapidly and actually exceed numbers in control plots. There were no longer any differences in numbers of *T. christiei* as a result of soil treatment. Control of *B. longicaudatus* by both nematicide treatments was still effective. Differences in populations of *X. americanum* were significant in aldicarb-treated plots but not in Bay 68138-treated plots.

The two nematicides were equally effective in that plant height of all entries was increased 24% over control plants. Figure 1 illustrates the difference between aldicarb-treated and untreated plants. The height of sorghum-sudangrass hybrids was significantly greater than the height of millets regardless of treatment (Table 2).

In the first yield taken on 30 July, nematicide treatments increased average yield of all varieties by 26%. Gahi-1 and Tift 23A X

TABLE 1. Relationship between average yield of eight sorghum and millet varieties and the number of five plant-parasitic nematodes in the soil as influenced by two nematicides.

Date (1969)	Treatment (11.2 kg a.i./hectare	Forage yield kg dry matter/hectare	Number nematodes/150 cc soil[a] *Cric. orna.*[b]	*Prat.* spp.	*Tric. chri.*	*Belo. long.*	*Xiph. amer.*
23 June	Aldicarb		4 a	21 a	0 a	2 a	0 a
	Bay 68138		3 a	9 a	0 a	2 a	1 a
	Control		7 b	38 b	7 b	15 b	12 a
7 August	Aldicarb	578	18 a	3 a	0 a	0 a	0 a
	Bay 68138	569	5 a	4 a	2 a	0 a	56 a
	Control	454	70 b	253 b	9 b	106 b	186 a
25 September	Aldicarb	445	484 b	19 a	21 a	2 a	4 a
	Bay 68138	436	105 a	44 a	20 a	0 a	157 b
	Control	302	134 a	452 b	20 a	241 b	157 b

[a]Small letters indicate Duncan's multiple range groupings on the same date which do not differ significantly at the 5% level. Mean of eight entries replicated five times.

[b]Cric. orna.; Prat. spp.; Tric. chri.; Belo. long.; Xiph. amer. = Criconemoides ornatus, Pratylenchus spp., Trichodorus christiei, Belonolaimus longicaudatus and Xiphinema americanum, respectively.

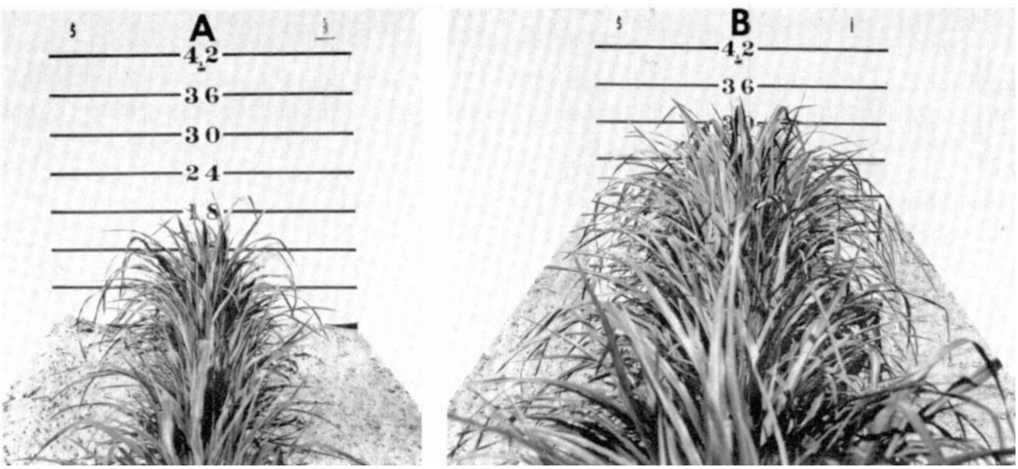

FIG. 1. Millex 22 Pearl millet growing in soil infested with *Criconemoides ornatus, Pratylenchus* spp., *Trichodorus christiei, Belonolaimus longicaudatus* and *Xiphinema americanum*. A = nontreated; B = aldicarb at 11.2 kg/hectare.

TABLE 2. Effect of aldicarb and Bay 68138 at 11.2 kg active/hectare applied 12 May 1969 on the average height of eight millet and sorghum-sudangrass hybrids planted 21 May 1969.

	Height (cm)[a]			
Variety	Aldicarb	Bay 68138	Control	Variety mean
Sorghum				
Funk's hybrid sorghum X sudangrass Hybrid 78	75 a	72 a	61 b	69 m
Haskell Harris' 1746 E sorghum	74 a	78 a	56 bc	69 m
Pearl millet				
Gahi-1	51 c-e	55 bc	43 e-h	50 n
Tift 23A X 186	44 e-h	48 c-f	38 gh	43 p
Millex 22	50 c-e	51 c-e	40 f-h	47 n-p
Tift 23A X 1258	49 c-e	48 c-f	38 h	45 op
Tiflate	46 d-g	53 cd	43 e-h	47 n-p
Pennington's Haygrazer	54 b-d	49 c-e	44 e-h	49 no
Treatment	55 y	57 y	45 z	

[a]Plant height recorded 1 July 1969. Small letters indicate Duncan's multiple range groupings which do not differ significantly at the 5% level. Mean of five replications.

186 were the highest-yielding millet varieties and Funk's Hybrid 78 was the lowest-yielding sorghum hybrid (Table 3). Although treatment X variety interaction was not significant, Millex 22 plots treated with aldicarb yielded as well as other varieties. In control plots, it was the lowest-yielding variety among the millets and yielded the same as the two sorghum-sudangrass hybrids. These results suggest that Millex 22 pearl millet is more susceptible to nematode injury than is Gahi-1 or Tift 23A X 186.

Nematicides increased the average yield of varieties by 45% at the second harvest taken 16 September. In this harvest, sorghum yields in nematicide-treated plots increased 102% over the control. Yield of Millex 22 pearl millet (which seemed to be the variety most susceptible to nematode injury) on plots treated with Bay 68138 was almost twice as high as on control plots (Table 3).

Aldicarb and Bay 68138 were equally effective in that average yields of all varieties were increased 35% by each. When yields across all soil treatments were averaged, Tift 23A X

TABLE 3. Effect of aldicarb and Bay 68138 applied at 11.2 kg active/hectare on forage yield of millet and sorghum varieties planted 21 May 1969.

	Forage yield (kg dry matter/hectare)													
	7-30-69				9-16-69				Total					
Variety	Aldicarb	Bay 68138	Control	% increase[a]	Aldicarb	Bay 68138	Control	% increase	Aldicarb	Bay 68138	Control	% increase	Mean	Resistance index[b]
Sorghum														
Funk's hybrid sorghum × sudangrass Hybrid 78	516	472	391	26	516	463	258	90	1032	935	649	53	881	65.4
Haskell Harris' 1746 E sorghum	560	543	391	41	480	480	222	116	1040	1023	613	69	899	59.2
Pearl millet														
Gahi-1	623	676	525	24	436	489	365	27	1059	1165	890	24	1032	80.3
Tift 23A × 186	605	667	534	19	480	463	418	13	1085	1130	952	16	1050	85.9
Millex 22	614	569	391	51	409	516	267	73	1023	1085	658	60	925	62.4
Tift 23A × 1258	641	525	454	28	391	400	258	53	1042	925	712	40	890	71.4
Tiflate	507	614	516	9	409	294	329	8	916	908	845	7	890	93.1
Pennington's Haygrazer	641	516	454	28	463	400	276	57	1104	916	730	38	916	72.2
Treatment mean	578	569	454	26	445	436	302	45	1023	1005	756	35	-	-
LSD .05 for: Treatment		.71				.64				1.04				
Variety (means)		.70				.74				1.04				

[a]Percent increase was determined by subtracting the yield from controls from the average yields from treated plots and dividing the remainder by the former × 100.
[b]Resistance index was determined by dividing the average yields from controls by the mean yields from treated plots (aldicarb plus Bay 68138) × 100.

TABLE 4. The susceptibility of eight sorghum and millet varieties to nematode attack as indicated by the numbers of nematodes in 150 cc of soil taken from the untreated root zone of each variety in 1969.

	Number nematodes/150 cc soil[a]									
	Criconemoides ornatus		*Pratylenchus* spp.		*Trichodorus christiei*		*Belonolaimus longicaudatus*		*Xiphinema americanum*	
Variety	8-7	9-25	8-7	9-25	8-7	9-25	8-7	9-25	8-7	9-25
Sorghum										
Funk's hybrid sorghum X sudangrass Hybrid 78	56 bc	677 b	163 b	226 bc	3	31 d	31	42	44	55
Haskell Harris' 1746 E sorghum	69 c	719 b	222 b	165 ab	4	29 cd	47	85	25	55
Pearl millet										
Gahi-1	13 a	50 a	41 a	169 a-c	4	19 a-d	47	63	90	111
Tift 23A X 186	18 a	72 a	62 a	135 ab	1	18 a-c	33	95	119	123
Millex 22	28 ab	146 a	37 a	322 c	8	13 ab	30	117	139	165
Tift 23A X 1258	21 ab	62 a	89 a	117 ab	3	23 b-d	55	101	83	88
Tiflate	16 a	49 a	20 a	39 a	2	11 a	17	35	93	132
Pennington's Haygrazer	27 ab	155 a	59 a	201 bc	4	15 ab	23	111	53	119
Sig. of F	**	**	**	*	n.s.	**	n.s.	n.s.	n.s.	n.s.

[a]Small letters indicate Duncan's multiple range groupings which do not differ significantly at the 5% level.

186 and Gahi-1 were top-yielding varieties. When nematicides were applied to these top millets, they yielded only 12% more than nematicide-treated Funk's sorghum X sudangrass Hybrid 78. Untreated top millet varieties yielded 41% more than untreated sorghum-sudangrass. We interpret this to mean that the sorghum-sudangrass was more sensitive to injury by the nematode complex than were the top-yielding millets. Since aldicarb and Bay 68138 also possess insecticidal properties, increased yields may have been due in part to control of certain soil insects.

A comparison of total yields from control plots with total yields from treated plots provides an index of nematode resistance for all varieties (Table 3). If yield of controls from each variety is divided by the average yield of treatments (average of aldicarb and Bay 68138) for each variety and multiplied by 100, values ranging from 59.2 to 93.1 are obtained. The larger these values, presumably, the greater resistance of the variety to the parasitic nematodes. If this assumption is correct, then Gahi-1, Tift 23A X 186 and Tiflate were most resistant and Funk's hybrid sorghum X sudangrass Hybrid 78, Haskell Harris's 1746 E sorghum and Millex 22 pearl millet were most susceptible to nematode injury. Millex 22 is a commercial hybrid having Tift 23A as its female parent. The male parent is known only by Northrup, King and Co. Since Tift 23A X 186 and Millex 22 have the same female parent, differences in their nematode resistance must be due to the male parent. Thus, the male inbred 186 used in producing Tift 23A X 186 must carry considerable resistance to nematodes. One cannot conclude that all millets have greater nematode resistance than sorghum since the resistance index of 62.4 for Millex 22 pearl millet was between indices of 59.2 and 65.4 for the two sorghum-sudangrass hybrids.

Data on nematode counts (Table 4) suggest that Tiflate pearl millet was more resistant to *C. ornatus, Pratylenchus* spp., *T. christiei* and *B. longicaudatus* than were other varieties. Generally, varieties having high resistant indices contained fewer *C. ornatus, Pratylenchus* spp. and *T. christiei* on 7 August. This relationship was evident for *C. ornatus* on 25 September.

Yield and nematode data (Table 1) indicate that *Pratylenchus* spp. and *B. longicaudatus* primarily were responsible for reduction in yield. Had *C. ornatus* been responsible, the September yield from plots treated with aldicarb should not have been greater than yield from plots treated with Bay 68138, because plots treated with aldicarb contained over four times as many *C. ornatus* as plots treated with Bay 68138. The similarity of populations and small numbers of *T. christiei*, regardless of treatment, seem to rule this nematode out as a causative agent in reduction of yield. By September, the *X. americanum* populations in plots treated with Bay 68138 was the same as for control plots, but yield from the former plots was essentially the same as yield from plots treated with aldicarb. Thus, it appeared that *X. americanum* had no effect on forage yields. As the population of *Pratylenchus* spp. and *B. longicaudatus* increased, yield of forage decreased.

Our data indicate that millet and sorghum-sudangrass hybrids support large numbers of *C. ornatus, Pratylenchus* spp., *B. longicaudatus*, and *X. americanum*. Similar results were reported by other workers (1, 2, 4, 5). In south Georgia, millet and sorghum-sudangrass hybrids are poor summer cover crops unless adequate nematode control measures are used because they favor extensive development of four potentially damaging nematode species, *P. brachyurus, P. zeae, T. christiei* and *B. longicaudatus.*

We conclude that plant-parasitic nematodes, especially *P. brachyurus, P. zeae* and *B. longicaudatus*, primarily were responsible for reduction in yield of millet and sorghum-sudangrass hybrids. Use of nematicides and selection of varieties, such as Tiflate pearl millet with some resistance to several species of nematodes, will delay buildup of these pests to damaging levels.

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