Nematology 3:154-162; *10*. Mac Donald, D. H. 1969. J. Nematology 1:296-297; *11*. Mac Donald, D. H. 1972. J. Nematology 4:229-230; *12*. Willis, C. B. 1976. J. Nematology 8:116-121; *13*. Mojtahedi, H. y B. F. Lownsbery. 1976. J. Nematology 8:306-309; *14*. Oostenbrink, M. Economic Nematology. *In* J. M. Webster (ed). Academic Press. 563 pp.; *15*. Ponchilla, P. 1972. J. Nematology, 4:189-193; *16*. Seinhorst, J. W. y J. Kozlowska. 1977. Nematologica 23: 1-23; *17*. Sutherland, J. R. y D. A. Ross. 1971. J. Nematology 3:276-279; *18*. Van der Plank J. E. 1963. Plant Diseases. Academic Press. 349 pp; *19*. Walker, J. T. 1969. J. Nematology 1:260-264; *20*. Walker, J. T. 1971. J. Nematology 3: 43-49.

FORAGE PRODUCTION OF *PHALARIS* SPECIES AS AFFECTED BY NEMATODE POPULATIONS [PRODUCCION DE PASTO *PHALARIS* Y POBLACIONES DE NEMATODOS]. C. S. Hoveland, R. L. Haaland, and R. Rodríguez-Kábana; Departments of Agronomy and Soils and Botany and Microbiology, Agricultural Experiment Station, Auburn, Alabama 36830, USA.

Accepted:
10.I.1979
Aceptado:

ABSTRACT

Phalaris species have excellent potential for cool season forage production in the southeastern USA but plant-parasitic nematodes have caused erratic performance on sandy soils. The objectives of this study were to determine prevalent plant-parasitic nematode species infecting *Phalaris* species and to measure the effects of these nematodes on total forage yield and distribution of yield. Forage production of three *Phalaris* cultivars, 'Siro 1146' hybrid *(P. aquatica* x *P. arundinacea)*, 'AP-2' *(P. aquatica)*, and 'Auburn' reed canary *(P. arundinacea)*, was studied in a central Alabama field experiment on Cahaba fine sandy loam soil (Typic Hapludult, Fine-loamy, Siliceous, Thermic). Forage yields were measured on untreated soil and on soil treated with methyl bromide (MB). Winter and early spring production of *P. aquatica* x *P. arundinacea* during the establishment year was increased 39% with MB above that grown on untreated soil, 71% for *P. aquatica,* and 232% for *P. arundinacea.* Autumn production the second year of *P. aquatica* x *P. arundinacea* was unaffected by MB while yields of *P. aquatica* and *P. arundinacea* were increased 24% and 30% respectively. Soil populations of stubby root *(Trichodorus christiei,* also classified as *Paratrichodorus (Nanidorus))* nematodes were low for all *Phalaris* species and unaffected by MB except with *P. arundinacea.* However, a technique was developed foı assessing numbers of migratory endoparasitic nematodes in the roots, and it was found that lance *(Hoplolaimus galeatus)* nematode populations in the roots of all *Phalaris* species were high. These results indicate that *Phalaris* species differ in forage production when lance nematode populations are high. Numbers of nematodes in the roots, rather than soil nematode populations, may in some cases be a better indicator of potential yield losses in grasses.
Key Words: Trichodorus christiei, Hoplolaimus galeatus, forage breeding, nematode resistance.

INTRODUCTION

Phalaris aquatica L. (also classified as *P. tuberosa)* and reed canarygrass *(P. arundinacea)* offer promise as cool season perennial grasses in the southeastern USA because of high autumn-winter production of forage with high digestibility (1, 4). However, production and persistence of *P. aquatica* may be reduced by plant-parasitic nematodes on sandy soils (2). To our knowledge, there are no other reports in the literature on productivity of various *Phalaris* species as affected by nematodes.

The objectives of this investigation were to determine prevalent nematode species infecting *Phalaris* species in the field and to measure the effects of these nematodes on total forage yield and seasonal distribution of yield.

MATERIALS AND METHODS

A 2-year field experiment was conducted in central Alabama on Cahaba fine sandy loam (Typic Hapludult, Fine-loamy, Siliceous, Thermic) soil which had been fallowed for four months prior to planting. Mineral fertilizer and lime were applied according to soil test recommendations. Nitrogen totaling 336 kg/ha was applied in four equal increments in September, November, February, and April of each year.

Three *Phalaris* entries were planted October 20, 1975, in 15-cm rows at 5.5 kg/ha: 'Siro 1146' hybrid from Australia *(P. aquatica* x *P. arundinacea),* 'AP-2' *P. aquatica* from the Auburn University breeding program, and 'Auburn' reed canarygrass *(P. arundinacea).* Two soil treatments were used: methyl bromide (MB) applied under polyethylene sheets at 490 kg/ha, and non-treated soil. Methyl bromide (Dow MC 2) is a commonly used soil fumigant active against nematodes and to a lesser extent against soil fungi and bacteria. This fumigant was chosen as a more practical means of providing a positive control with the realization that some of the responses obtained may not be a result of nematode control. All combinations of grasses and soil treatments were incorporated into a randomized complete block design with 1.2 x 6.1-m plots and eight replications.

Forage was harvested to a stubble height of 5 cm with a flail harvester at 4 to 8 week intervals during the growing season, beginning in March 1976. Forage was harvested the second season from September until May.

Plant-parasitic nematodes were sampled by collecting 25 soil cores on each plot, and these were taken every 30 cm along a central line using 2.54-cm diam. soil probes to a depth of 15 to 20 cm. A 50 cm^3 subsample was then taken from the mixed sample and nematodes extracted following the flotation-sieving technique of Rodriguez-Kabana and King (3). Samples were collected in November 1975, June 1976, and February 1977 to monitor development of plant parasitic nematode populations.

Since few plant parasitic nematodes were found in any of the soil samples from the plots during the first two sampling dates, a technique was developed to handle large numbers of samples in determining endoparasitic nematode populations in grass roots. Three 10 x 20 cm cores were collected in the grass rows in each plot during February 1977. Ten to fifty g of fresh root samples were used to determine nematode populations by a modified pie-pan technique. Roots were placed on fiber glass screens (mesh : 1 mm) sandwiched between two vertical sections of 15 cm diam. polyvinyl chloride pipes, one section 10 cm and the other 2.5 cm long. The sieves with the roots were immersed in 1000 ml of water so that the roots were barely covered with the water. After 72 hrs incubation at room temperature (25 C) the nematodes in the water were collected on a 40 mesh sieve. Nematodes were washed into a dish and counted.

RESULTS AND DISCUSSION

Forage Yields

During the establishment year, total forage yields of all three *Phalaris* entries were substantially higher where the soil had been treated with MB compared with the controls (Table 1). Winter and early spring production from the March 11 and April 22 harvest dates were affected to a much greater extent by MB. Forage production during this period was increased with MB by 39% on *P. aquatica* x *P. arundinacea,* 71% on *P. aquatica,* and 232% on *P. arundinacea.* The increased production on MB treated soil at this season was probably a result of more rapid development of root systems and better use of available deep soil moisture during autumn. Weeds were not a problem on any of the plots. Lower yields on *P. arundinacea* than the other two entries reflect the slower seedling growth of this species.

Table 1. Forage yield of *Phalaris* species as affected by methyl bromide (MB) during establishment year in central Alabama.

Phalaris species	Soil Treatment	Dry forage yield, kg/ha March 11	April 22	June 9	Total
P. aquatica x *P. arundinacea*	MB	1120 a*	3480 a	3870 a	8470 a
	None	410 c	2890 b	4140 a	7440 b
P. aquatica	MB	890 b	3450 a	3870 a	8210 a
	None	290 cd	2250 c	4030 a	6570 c
P. arundinacea	MB	160 de	1800 d	3960 a	5920 c
	None	30 e	560 e	3860 a	4450 d

*Means within a column marked with the same letter are not significantly different at P:0.05 level.

High total forage yields were obtained on all *Phalaris* entries the second year (Table 2). Soil treatment with MB the year of seeding had no effect on second year total yields of the *P. aquatica* x *P. arundinacea* hybrid but increased yields of the other two entries.

Seasonal forage distribution of two entries the second season was substantially affected by MB. Autumn production (28 September and 16 December harvest dates) was increased by MB compared with the controls, 24% on *P. aquatica* and 30% on *P. arundinacea.* The yield of the *P. aquatica* x *P. arundinacea* hybrid was increased by MB only at the 16 December harvest. February-March production on all three entries was similar, regardless of soil treatment. Second-year autumn yield response of *P. aquatica* to MB soil treatment was less than that obtained in a previous experiment where plant-parasitic nematodes severely damaged the root system (2). In the current study, autumn rainfall was much higher than in the previous experiment where autumn drought prevailed. Thus, soil moisture and nutrients were available to the plants even though root systems were probably damaged by nematodes.

Table 2. Forage yield of *Phalaris* species as affected by methyl bromide (MB) during second year in central Alabama.

Phalaris spec.	Soil Treat.	Sep. 28	Dec. 16	March 10	April 11	May 5	Total
		Dry forage yield, kg/ha					
P. aquatica x							
P. arundinacea	MB	3410 b*	2380 b	980 a	1960 a	3380 b	12,110 ab
	None	4130 a	1530 c	1140 a	1980 a	3180 b	11,960 ab
P. aquatica	MB	2410 c	3110 a	1150 a	1870 a	3910 a	12,450 a
	None	2360 c	2100 bc	1130 a	1910 a	3530 ab	11,030 b
P. arundinacea	MB	4610 a	2160 bc	1100 a	1930 a	2520 c	12,320 a
	None	3690 b	1530 c	1010 a	1880 a	2340 c	10,450 b

*Means within a column marked with the same letter are not significantly different at P:0.05 level.

Nematode Populations

No plant parasitic nematodes were found in any of the soil samples collected on November 19, 1975, six weeks after fumigation (Table 3). Further sampling at two subsequent dates showed soil nematode populations to be relatively low. Only for *P. arundinacea* was there any difference in nematode population (P : .05) between the MB and untreated soil. Virtually all the plant-parasitic nematodes found in the soil were stubby root.

Table 3. Effect of methyl bromide (MB) on plant-parasitic nematodes in soil and roots from plots planted to *Phalaris* species.

Phalaris species	Treat.	Total plant parasitic nematodes per 50 cc soilnemat 19 Nov. 1975	9 June 1976	15 Feb. 1977	15 Feb. 1977 Lance nematodes per 10x20 cm root core	Lance nematodes per gram of root
P. aquatica x						
P. arundinacea	MB	0	6 b*	17 a	1 c	2 c
	None	0	8 b	16 a	115 a	28 a
P. aquatica	MB	0	5 b	16 a	2 c	0 c
	None	0	12 ab	13 a	152 a	21 ab
P. arundinacea	MB	0	6 b	11 a	2 c	1 c
	None	0	17 a	17 a	59 b	18 b

*Means within a column marked with the same letter are not significantly different at P:0.05 level.

The low soil nematode populations did not reflect the reduced forage yields obtained on untreated soil. However, lance nematode populations were found to be high in grass roots on untreated soil while virtually none were present in roots on MB treated soil. The high population of this endoparasitic nematode in roots of grasses grown on untreated soil probably explains the forage yield response from MB. Although lance nematode populations were high in roots of *P. aquatica* x *P. arundinacea,* forage yields were affected to a lesser extent than in the other two *Phalaris* entries. This suggests that the hybrid may be more tolerant of lance nematodes than the other two *Phalaris* entries. Tolerance could be a result of better regenerative capacity for roots such as has been shown with other forage species for the same nematode (2).

At present we do not have a precise relation between nematode numbers and the effect on forage yields of *Phalaris* species. However, our data suggest that damage from this nematode or a complex of the nematode with fungal pathogens in *Phalaris* roots must be considered. It remains to be determined the minimum numbers of lance nematodes that are necessary for significant yield reductions in *Phalaris.* Our results should be considered as preliminary to more precise studies on the relation of lance nematode number to plant damage.

CONCLUSIONS

Results of this study show that *Phalaris* species may differ in forage production on soils where plant parasitic nematodes are a problem. The slow establishment and poor performance of reed canarygrass in the southeastern USA may be caused to a large extent by plant-parasitic nematodes and possible associated fungi. More importantly, conventional soil sampling for nematodes may furnish erroneous or misleading results. Although soil populations of ectoparasitic nematodes are often low, severe damage may result from endoparasitic nematodes which may be undetected when soil samples are analyzed. Therefore, nematode studies with grasses should include sampling for endoparasitic nematode species.

RESUMEN

Aunque especies de *Phalaris* tienen un potencial excelente para la producción de pastos invernales en el sudeste americano los rendimientos obtenidos han sido erráticos debido al ataque de nematodos fitoparásitos. Los objetivos de este estudio fueron determinar que especies de nematodos infectan *Phalaris* sp. y estimar los efectos de éstas en el rendimiento de pasto y su distribución. La producción de pasto de tres cultivares de *Phalaris,* híbrido Siro 1146 *(P. aquatica* x *P. arundinacea),* "AP-2" *(P. aquatica)* y "Auburn" reed canary *(P. arundinacea)* se estudió en un experimento de campo en la región central de Alabama en un limo arenoso fino (Típico Hapludult, limoso-fino, silíceo, térmico). Los rendimientos de forrage fueron medidos en suelo tratado y sin tratar con bromuro de metilo (BM). La producción de invierno y primavera de *P. aquatica* x *P. arundinacea* durante el primer año aumentó en 39% con BM, en 71% para *P. aquatica,* y en 232% para *P. arundinacea.* La producción de otoño en el segundo año de *P. aquatica* x *P. arundiacea* no fue afectada por BM mientras que los rendimientos de *P. aquatica* y *P. arundinacea* aumentaron en 24% y 30% respectivamente. Las poblaciones de *Paratrichodorus* en el suelo fueron bajas en todas las especies de *Phalaris* y no fueron afectadas por BM excepto en *P. arundinacea.* Cuando se incubaron raíces en agua se encontraron poblaciones altas de *Hoplolaimus galeatus.* Los resultados indican que especies de *Phalaris* difieren en rendimiento de pasto en presencia de altas poblaciones de *H. galeatus.* El número de nematodos en las raíces y no en el suelo parece ser mejor índice de rendimiento potencial de estos pastos.

Claves: fitomejoramiento de pastos, resistencia a nematodos, respuesta de variedades Trichodorus christiei, Hoplolaimus galeatus.

LITERATURE CITED

1. Hoveland, C. S. and W. B. Anthony. 1971. Crop Sci. 11:461-463; *2.* Hoveland, C. S., R. Rodríguez-Kábana, and C. D. Berry. 1975. Agron. J. 67:714-717; *3.* Rodríguez-Kábana, R. and Peggy S. King. 1972. Pl. Dis. Repr. 56:1093-1096 *4.* Saibro, J. C., C. S. Hoveland, and J. C. Williams. 1978. Agron. J. 70:497-500.

RESPONSE OF A RESISTANT SOYBEAN CULTIVAR TO FUMIGATION AT-PLANTING FOR THE CONTROL OF SOYBEAN CYST AND ROOT-KNOT NEMATODES [REACCION DE UN CULTIVAR DE SOYA RESISTENTE A LA FUMIGACION PARA EL COMBATE DE LOS NEMATODOS ENQUISTADOR DE LA SOYA Y EL NODULADOR].

Robert A. Kinloch, Associate Nematologist, University of Florida, Agricultural Research Center, Jay, Florida 32565, U.S.A.

Accepted:
21.II.1979
Aceptado:

ABSTRACT

In field soil infested with the soybean cyst nematode, *Heterodera glycines* Ichinohe, dibromoethane (Soilbrom® 90EC at 4.7 and 9.4 l/ha) and dibromochloropropane (Fumazone® 86 E at 9.4 l/ha) significantly increased yields over untreated checks of the resistant soybean, *Glycine max* L. Merr. cultivar 'Centennial'. In a companion study involving 'Centennial' growing in soil infested with the southern root-knot nematode, *Meloidogyne incognita* (Kofoid and White) Chitwood, no treatment significantly increased yields. However, Soilbrom 90EC at 18.7 and 37.4 l/ha had a significantly adverse effect on the levels of root-knot nematode in the soil. Early season stand and vigor ratings, which decreased with increases in treatment rates, were highly correlated with harvested yields in both studies.
Key Words: dibromoethane, dichloropropene, dichloropropene — dichloropropane mixture.

INTRODUCTION

Nematodes are a major limiting factor in soybean *(Glycine max* (L.) Merr.) production in the southeastern United States. Of particular importance are the soybean cyst nematode *Heterodera glycines* Ichinohe, and the southern root-knot nematode, *Meloidogyne incognita* (Kofoid and White) Chitwood. Selective soybean breeding has been successful in producing several cultivars that have a high degree of resistance to these nematodes (6), and their cultivation has become a major means of nematode control. However, additional nematicidal fumigation of a resistant cultivar has been required for optimum yields in heavily infested fields (5). Because of its efficacy, relatively low cost, and its ease of application, dibromochloropropane (DBCP) has been the most widely used nematicide for this purpose.