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Investigations of the Host Range of the Corn Cyst Nematode, *Heterodera zeae*, from Maryland[1]

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Abstract: The host range of the corn cyst nematode, *Heterodera zeae*, recently detected in Maryland, was investigated. A total of 269 plant entries, representing 68 families, 172 genera, and 204 species, was inoculated with cysts or a mixture of eggs and second-stage juveniles of *H. zeae*. The host range of the Maryland population of *H. zeae* was limited to plants of the Gramineae and included 11 tribes, 33 genera, 42 species, and 77 entries. All 22 corn (*Zea mays*) cultivars tested were hosts. Other economic hosts included certain cultivars of barley (*Hordeum vulgare*), oat (*Avena sativa*), rice (*Oryza sativa*), sorghum (*Sorghum bicolor*), sugar cane (*Saccharum* interspecific hybrid), and wheat (*Triticum aestivum*). Fall panicum (*Panicum dichotomiflorum*), a weed species common to cultivated fields in Maryland, was also a host for *H. zeae*. Other hosts included meadow foxtail (*Alopecurus pratensis*), *Calamagrostis eipgeios*, Job's tears (*Coix Lachryma-Jobi*), green sprangletop (*Leptochloa dubia*), witchgrass (*Panicum capillare*), broomcorn (*Panicum miliaceum*), fountain grass (*Pennisetum rueppeli*), reed canary grass (*Phalaris arundinacea*), common reed (*Phragmites australis*), eastern gamagrass (*Tripsacum dactyloides*), corn (*Zea mays*), and teosinte (*Zea mexicana*).

Key words: corn, corn cyst nematode, *Heterodera zeae*, host range, maize, *Zea mays*.

The corn cyst nematode *Heterodera zeae* Koshy et al., 1971 was first described from corn (*Zea mays*) in India (4). The species is now known to occur in several states of India (3) and to infect several gramineous weeds commonly occurring in Indian corn fields (7,8). *H. zeae* is considered to be an economic pest of corn in India, although its pathogenicity to corn has not been demonstrated in the field. In 1978 *H. zeae* was reported to be widely distributed in Egypt (B. A. Oteifa, unpubl.). In 1981 *H. zeae* was discovered in Kent County, Maryland (6) and in Pakistan (5). Surveys in Maryland conducted cooperatively by the Maryland Department of Agriculture and the University of Maryland resulted in detection of cysts of *H. zeae* in soil from 76 fields totalling 1,332 hectares on 31 farms in four contiguous counties (J. A. Roth, unpubl.). A quarantine of those areas of Maryland infested with *H. zeae* was imposed on 1 May 1984 jointly by the Departments of Agriculture of Maryland and of the United States.

The host ranges of populations of *H. zeae* were studied in India, Egypt, and the United States with differing results. Eleven plant species, cultivated and weed, within the Gramineae have been reported as hosts of the various populations of the nematode (1,4,6–8).

A preliminary study of the host range of the Kent County, Maryland, population of *H. zeae* was reported (6). Our objective was to investigate in some detail the host range of the population of *H. zeae* found in Maryland.

Materials and Methods

Soil infested with *Heterodera zeae* was collected from a field in Kent County, Maryland, and stored at 3.5 C until processed to recover cysts. Nematode cultures were maintained in a greenhouse on *Zea mays* L. 'Pioneer 3184' growing in sand. Nematodes for inoculum were obtained directly from field soil or from greenhouse cultures.

Test plants were grown in steamed sand in three replicate 15-cm-d plastic pots. Numbers of plants per pot varied with the size of the plant and its root system. Plants of Pioneer 3184 corn, all from a single lot

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of seed, were included with each test to monitor inoculum viability and infectivity.

Host range tests were conducted over a 3-year period using either cysts or a mixture of eggs and second-stage juveniles (J2) as inoculum. Cysts were used as inoculum to test 230 plant entries; a mixture of eggs and J2 was the inoculum for 77 plant entries, some of which were repeat tests of plant species already tested with cysts as inoculum.

Cyst inoculum consisted of 100 hand-picked adult females or cysts that were filled with eggs. The inoculum was poured onto the sand in each pot and covered with 3 cm additional sand, and the test plants were immediately seeded. Vegetatively propagated plants or plants whose seed required a long germination period (up to 2 weeks) were allowed to establish root systems in the test pots before inoculation with cysts.

Eggs and J2 used as inoculum were removed from cysts by gently rubbing them with a rubber stopper against a 150-μm-pore sieve. The mixed eggs and J2 were collected on a 25-μm-pore sieve and suspended in tap water. The suspension was pipeted into shallow depressions in the sand around the bases of test plants. The amount of inoculum added per pot ranged from 3,430 to 5,220 eggs and J2 among tests, but was the same within any one test. Plant age at time of nematode inoculation depended on the plant species; plants were allowed to form well-developed root systems before inoculation with nematodes.

Pots with test plants were placed on greenhouse benches; plants were fertilized weeky and watered as required. Air temperature ranged from a minimum daily mean of 11–22 C to a maximum daily mean of 22–40 C. Most plants were harvested 3–4 months after inoculation. The soil and root systems were stored in the pots at 3.5 C until processed; cysts were recovered on a 250-μm-pore sieve. Some inoculated plants were left in the greenhouse for up to 10 months when growth was satisfactory to provide ample opportunity for nematode reproduction. Test plants inoculated with cysts were considered to be hosts if the number of cysts recovered from an entire pot at harvest exceeded the initial inoculum of 100 cysts per pot. Test plants inoculated with a mixture of eggs and J2 were considered to be hosts if one or more adult females or cysts were recovered. A plant was rated as a good host if the number of cysts recovered from a single pot of the plant was 1,000 or more.

Concurrent research with the Kent County population of *H. zeae* showed the temperature optimum for reproduction was above 30 C (S. Sardanelli, unpubl.). Therefore, selected plants that were marginal hosts in greenhouse bench tests were retested in the greenhouse with the pots resting on plant propagation mats that kept the sand temperature at 30 ± 2 C. Established plants in pots were inoculated with a mixture of 5,000 eggs and J2 and harvested 7–8 weeks after inoculation, and any adult females or cysts were recovered and counted.

In yet another test, selected plants were retested in plant growth chambers at 33 ± 1 C. Plant selection was based on agronomic or economic importance and marginal status as a host of *H. zeae* in the greenhouse tests. Seeds of plants to be tested were planted in steamed sand in 12.7-cm-d plastic pots replicated three times and held for 7 days at 27 ± 1 C for germination. Then the chamber temperature was increased to 33 ± 1 C, and an aqueous suspension of 10,000 eggs and J2 of *H. zeae* was pipeted into each pot. Eight days later each pot was inoculated with an additional 5,000 eggs and J2. Six weeks after the first inoculation, the roots and sand were processed to recover adult females and cysts.

Hortus III (2) was the reference for scientific and common names of plants.

Results

Of the 269 plant entries tested, those that were hosts of *H. zeae,* based on cyst production, were all in the family Gramineae. Of the 113 plant entries examined in the Gramineae (Table 1), 77 (68%) were hosts for *H. zeae.* Host plants occurred within 42 of the 71 species (59%) and 33

TABLE 1. Plants supporting reproduction of the Maryland population of *Heterodera zeae*.

Plant	Greenhouse			Growth chamber, 33 C
	Bench		Mat, 30 C	
	Cysts	J2 + eggs	J2 + eggs	J2 + eggs
Andropogoneae				
Coix Lachryma-Jobi		1,380 (52%)†		
Job's-tears				
Saccharum interspecific hybrid				
Sugar cane	1,020 (16%)	28 (28%)		
Sorghum bicolor				
Grain sorghum 'DR 1085'	—‡		4 (< 1%)	
Sorghum bicolor				
Sweet sorghum 'Rio'	—	—		1 (< 1%)
Tripsacum dactyloides				
Eastern gamagrass		3 (< 1%)	1,090 (8%)	
Zea diploperennis				
Chapule	764 (3%)	27 (27%)		
Zea mays amylacea				
Flour corn 'Coroico'	7,820 (26%)			
Zea mays gracillima				
Ornam. corn 'Rainbow'	30,730 (100%)			
Zea mays indentata				
Dent corn				
'DeKalb XL71'	1,200 (62%)			
'Doebler's 88X'	4,020 (206%)			
'Golden Acres TE-6995A'	870 (45%)			
'Gutwein 69B'	1,400 (72%)			
'Gutwein 2610'	2,430 (125%)			
'Jacques JX 247'	770 (40%)			
'Kenworthy KLX 55A'	2,020 (104%)			
'Kenworthy KLX 64'	2,330 (120%)			
'Kenworthy KLX 71'	1,870 (96%)			
'Pioneer 3320'	580 (30%)			
'Premier 639A'	2,250 (115%)			
'Yield Warranty 59'	2,870 (147%)			
Zea mays indurata				
Flint corn 'Caribbean'	32,400 (106%)			
Zea mays praecox				
Popcorn 'Burpee Peppy'	3,680 (12%)			
Zea mays rugosa				
Sweet corn				
'Country Gentleman'	780 (40%)			
'Earliglow E. H.'	550 (28%)			
'Golden Queen'	3,650 (117%)			
'NK 199'	650 (33%)			
'Seneca Chief'	1,080 (35%)			
'Silver Queen'	900 (46%)			
Zea mexicana				
Teosinte				
'Day Neutral'		105 (105%)		
'Guerrero'		1,750 (1,750%)		
'K-67-17'		30 (10%)	20,760 (143%)	
'K-67-24'		1,080 (341%)		
'K-69-3'		1 (< 1%)	15,840 (109%)	
Arundineae				
Phragmites australis				
Common reed	2,920 (13%)	215 (182%)		
Aveneae				
Agrostis tenuis				
Bent grass 'Highland'		1 (< 1%)	—	

TABLE 1. Continued.

Plant	Greenhouse			Growth chamber, 33 C
	Bench		Mat, 30 C	
	Cysts	J2 + eggs	J2 + eggs	J2 + eggs
Alopecurus pratensis				
Meadow foxtail		4 (1%)	1,340 (9%)	
Anthoxanthum odoratum				
Sweet vernal grass		1 (< 1%)	2 (< 1%)	
Avena sativa				
Oats				
'Lang'	—			40 (5%)
'Noble'	—			20 (4%)
'Norline'	—			40 (8%)
'Otee'	—	—	2 (< 1%)	10 (1%)
Calamagrostis eipgeios		73 (2%)	1,140 (10%)	
Phalaris arundinacea				
Reed canary grass 'Vantage'	14,500 (151%)			
Phleum pratense				
Common timothy 'Clair'	—	—		20 (3%)
Bambuseae				
Bambusa sp.				
Bamboo	121 (5%)	2 (2%)	165 (1%)	
Chlorideae				
Bouteloua curtipendula				
Sideoats grama 'Uvalde'		85 (27%)		
Buchloe dactyloides				
Buffalo grass 'Texoka'		1 (< 1%)	72 (< 1%)	
Chloris Gayana				
Rhodes grass 'Bell'		1 (< 1%)	17 (< 1%)	
Leptochloa dubia				
Green sprangletop		18 (< 1%)	2,750 (23%)	
Eragrosteae				
Muhlenbergia montana				
Muhly		9 (< 1%)	340 (3%)	
Festuceae				
Festuca elatior				
Tall fescue 'K-31'	117 (31%)	—	60 (< 1%)	
Festuca rubra				
Red fescue 'Penn Lawn'	—			20 (4%)
Lolium perenne				
Perennial ryegrass				
'Manhattan'	—	7 (7%)	30 (< 1%)	
'Regal'	102 (8%)	36 (1%)	59 (< 1%)	
Poa annua				
Annual bluegrass	630 (3%)	8 (< 1%)	10 (2%)	
Poa pratensis				
Kentucky bluegrass 'Merion'		1 (1%)		
Oryzeae				
Oryza sativa				
Rice 'Calrose'	—	13 (< 1%)	610 (4%)	
Paniceae				
Brachiaria platyphylla				
Broadleaf signal grass	—	109 (109%)		
Echinochloa crus-galli				
Barnyard grass	—	46 (46%)		
Panicum antidotale				
Giant panic		10 (< 1%)		

TABLE 1. Continued.

Plant	Greenhouse			Growth chamber, 33 C
	Bench		Mat, 30 C	
	Cysts	J2 + eggs	J2 + eggs	J2 + eggs
Panicum capillare				
Witchgrass	2,170 (395%)			
Panicum coloratum		7 (< 1%)	484 (3%)	6 (1%)
Panicum dichotomiflorum				
Fall panicum	520 (3%)	7 (1%)	8,120 (56%)	
Panicum miliaceum				
Broomcorn		112 (4%)	18,520 (128%)	
Panicum plenum		317 (12%)		
Pennisetum setaceum				
Fountain grass	109 (< 1%)		10,370 (72%)	
Stipeae				
Oryzopsis hymenoides				
Indian ricegrass 'Nezpar'		2 (< 1%)	94 (< 1%)	
Stipa viridula				
Green needlegrass 'Lodorn'		24 (2%)	220 (2%)	
Triticeae				
Agropyron Smithii				
Western wheatgrass		36 (2%)	430 (3%)	
Hordeum vulgare				
Barley				
'Barsoy'	—	—		50 (7%)
'Henry'	131 (7%)	1 (1%)	20 (< 1%)	
'Maury'	—	—		80 (15%)
'Surry'	104 (1%)	—	530 (4%)	
Secale cereale				
Common rye 'Abruzzi'	—	9 (< 1%)	17 (< 1%)	
Triticum aestivum				
Wheat				
'Arthur'	—			2 (< 1%)
'Potomac'	—			1 (< 1%)
'Tyler'	—			1 (< 1%)

† Greatest number of cysts recovered from a single pot of the test plant (greatest number of cysts recovered from a single pot of the test plant as a percentage of the greatest number of cysts recovered from a single pot of Pioneer 3184 corn control included in the same test).
‡ — = tested, but plant not a host in this test.
Blank = not tested.

of the 51 genera (65%) of Gramineae entries tested. All 156 nongramineous plants and 36 of the gramineous plants tested failed to support reproduction of *H. zeae* (Table 2).

The tribe Andropogoneae contained the greatest number of plants tested as well as many of the plant species in which the greatest nematode reproduction occurred. Of the 42 plant entries tested in this tribe, 33 supported reproduction of *H. zeae*. Pioneer 3184 corn, selected as the standard susceptible plant against which nematode reproduction on all other plants was measured, generally supported good reproduction of *H. zeae*, although reproduction varied on this cultivar among the different tests. All 28 entries tested in the three species of the genus *Zea*, including 22 cultivars of *Z. mays*, supported reproduction of *H. zeae*, many supporting reproduction comparable to that on Pioneer 3184.

The tribe Paniceae also contained many hosts. In the genus *Panicum*, six of nine species tested were hosts of *H. zeae*, including fall panicum (*P. dichotomiflorum*), a common and important weed in cultivated fields in Maryland. Species within seven of the ten genera tested in the tribe Aveneae were hosts of *H. zeae*, but only reed canary grass

TABLE 2. Plants not supporting detectable reproduction of the Maryland population of *Heterodera zea*.

Plant	Plant
Aceraceae	Commelinaceae
Acer rubrum red maple	*Tradescantia albiflora* wandering jew
Agavaceae	Compositae
Sansevieria trifasciata snake plant	*Ageratum* sp. flossflower 'Blue Mink'
Aizoaceae	*Carthamus tinctorius* safflower
Mollugo verticillata carpetweed	*Cirsium vulgare* bull thistle
Amaranthaceae	*Helianthus annuus* common sunflower 'Taiyo'
Amaranthus retroflexus pigweed	*Lactuca sativa* garden lettuce 'Salad Bowl'
Amaryllidaceae	*Tagetes* sp. marigold 'Pumpkin'
Allium cernuum wild onion	*Taraxacum officinale* common dandelion
Narcissus sp. daffodil	*Zinnia elegans* common zinnia
Anacardiaceae	Convolvulaceae
Rhus radicans poison ivy	*Ipomoea Batatas* sweet potato
Annonaceae	'Centennial'
Asimina triloba pawpaw	'Goldmar'
Apocynaceae	*Ipomoea hederifolia* morning-glory
Vinca minor common periwinkle	*Jacquemontia tamnifolia* small flower morning-glory
Aquifoliaceae	Cornaceae
Ilex crenata Japanese holly	*Cornus florida* flowering dogwood
Araceae	Crassulaceae
Philodendron sp. philodendron	*Kalanchoe* sp. kalanchoe
Xanthosoma caracu cocoyam	*Sedum* sp.
Araliaceae	Cruciferae
Hedera Helix English ivy	*Arabis* sp. rock cress
Balsaminaceae	*Aubrieta deltoidea* cress 'Upland cress'
Impatiens Wallerana impatiens 'Sultan's Balsam'	*Brassica juncea*
Begoniaceae	Indian mustard
Begonia scarlanda begonia	yellow turnip mustard
Bignoniaceae	*Brassica oleracea*
Campsis radicans trumpet creeper	kale 'Dwarf Siberian'
Paulownia tomentosa princess tree	broccoli 'Green Comet'
Boraginaceae	cauliflower 'Snow Crown'
Myosotis sylvatica garden forget-me-not	cabbage 'Market Prize'
Bromeliaceae	brussels sprouts 'Prince Marvel'
Bromelia sp. bromeliad	*Brassica Rapa* turnip 'Purple-Top White Globe'
Buxaceae	*Capsella bursa-pastoris* shepherd's purse
Buxus sempervirens common boxwood	*Lepidium campestre* pepperweed
Pachysandra terminalis Japanese pachysandra	*Raphanus sativus* radish 'Scarlet Globe'
Cactaceae	Cucurbitaceae
Opuntia humifusa prickly pear	*Citrullus lanatus* watermelon
Caprifoliaceae	'Charleston Gray'
Lonicera japonica Japanese honeysuckle	'Crimson Sweet'
Caricaceae	*Cucumis melo* cantaloupe 'Summet'
Carica Papaya papaya	*Cucumis sativus* cucumber
Caryophyllaceae	'Calypso'
Cerastium vulgatum mouse-ear chickweed	'Poinsett'
Gypsophila elegans baby's-breath	'Sprint 440N'
Silene alba white cockle	*Cucurbita moschata* winter squash 'Waltham
Celastraceae	Butternut'
Euonymus kiautschovica spindle tree	*Cucurbita Pepo*
Chenopodiaceae	pumpkin 'Howden'
Beta vulgaris garden beet	summer squash 'Seneca Prolific'
'Detroit Dark Red'	zucchini squash
Sugar beet 'USH20'	'Burpee Hybrid'
Chenopodium album lamb's-quarters	'Zucchini Elite'
Spinacia oleracea spinach 'Bloomsdale	Cupressaceae
Long-standing'	*Juniperus chinensis* juniper
Cistaceae	*Thuja occidentalis* arborvitae 'Dark American'
Helianthemum nummularium sun rose	Cyperaceae
	Cyperus esculentus yellow nut sedge

TABLE 2. Continued.

Plant	Plant
Dioscoreaceae	Iridaceae
Dioscorea alata white yam	*Gladiolus* ×*hortulanus* garden gladiolus
Ericaceae	*Sisyrinchium* sp. blue-eyed grass
Leucothoe axillaris leucothoe	Juncaceae
Rhodendron ×*kurume* azalea 'Hershey Red'	*Juncus* sp. rush
Euphorbiaceae	Labiatae
Manihot esculenta cassava	*Coleus* sp. coleus
Geraniaceae	'Rainbow Choice'
Pelargonium sp. geranium	*Ocimum Basilicum* sweet basil
Gesneriaceae	Lauraceae
Sinningia speciosa gloxinia	*Persea americana* avocado
Gramineae	Leguminosae
Andropogoneae	*Glycine Max* soybean
Manisuris tessellata joint grass	'York'
Schizachyrium scoparium little bluestem 'Aldous'	'Williams'
Sorghastrum avenaceum Indian grass 'Llano'	*Lespedeza cuneata* Chinese lespedeza
Sorghum bicolor	*Lespedeza stipulacea* Korean lespedeza
forage sorghum	*Lotus corniculatus* bird's-foot trefoil 'Empire'
'401 R'	*Medicago sativa* alfalfa 'ARC'
'FS 451'	*Phaseolus vulgaris* snap bean
grain sorghum 'BRY 93'	'BBL 47'
Sorghum sudanense Sudan grass 'FFR 66'	'Provider'
Sorghum halepense Johnson grass	'Spurt'
Tripsacum floridanum Florida gamagrass	*Phaseolus limensis* lima bean 'Fordhook 242'
Aveneae	*Pisum sativum* garden pea
Arrhenatherum elatius tall oat grass	'Green Arrow'
Holcus lanatus velvet grass	'Novella'
Koeleria cristata prairie June grass	'Spring'
Chlorideae	'Sugar Snap'
Cynodon Dactylon Bermuda grass	*Psophocarpus tetragonolobus* winged bean
Dactyloctenium aegyptium crowfoot grass	*Robinia Pseudoacacia* black locust
Eleusine indica goose grass	*Trifolium pratense* red clover 'Kenstar'
Eragrosteae	*Trifolium repens* white clover 'Ladino'
Eragrostis curvula weeping love grass	*Vicia villosa* hairy vetch
Eragrostis cilianensis stink grass	Liliaceae
Sporobolus giganteus giant dropseed	*Aloe* sp. aloe
Festuceae	*Asparagus officinalis* garden asparagus 'Mary Washington'
Briza australis quaking grass	*Asparagus setaceus* asparagus fern
Bromus inermis smooth brome	Lobeliaceae
Dactylis glomerata orchard grass	*Lobelia Erinus* edging lobelia 'Bright Eyes'
Lolium temulentum darnel	Magnoliaceae
Poa pratensis Kentucky bluegrass 'Vantage'	*Liriodendron Tulipifera* tulip poplar
Puccinella distans alkaligrass	Malvaceae
Paniceae	*Abutilon Theophrasti* velvetleaf
Digitaria sanguinalis hairy crabgrass	*Gossypium hirsutum* upland cotton
Panicum dilatum dallisgrass	Oleaceae
Panicum notatum bahiagrass 'Wilmington'	*Forsythia* sp. forsythia
Panicum virgatum switch-grass 'Blackwell'	*Ligustrum vulgare* common privet
Pennisetum americanum pearl millet	Onagraceae
Setaria faberii giant foxtail	*Oenothera biennis* evening primrose
Setaria glauca yellow foxtail	Oxalidaceae
Triticeae	*Oxalis stricta* yellow wood sorrel
Agropyron repens quack grass	Pedaliaceae
Triticum aestivum wheat	*Sesamum indicum* sesame 'Arizona'
'McNair 1003'	Phytolaccaceae
'Redcoat'	*Phytolacca americana* poke
'Severn'	Pinaceae
Zoysieae	*Picea Abies* Norway spruce
Zoysia japonica zoysia grass	*Pinus Taeda* loblolly pine

TABLE 2. Continued.

Plant	Plant
Plantaginaceae	*Datura Stramonium* jimsonweed
Plantago lanceolata buckhorn	*Lycopersicon Lycopersicum* tomato
Polygonaceae	'Pik-red'
Fagopyrum esculentum buckwheat	'Supersonic'
Polygonum convolvulus wild buckwheat	'VF 134-1-2'
Rumex crispus curly dock	'Westover'
Portulacaceae	*Nicotiana Tabacum* tobacco
Portulaca grandiflora rose moss	'MD 609'
Punicaceae	'MD 872'
Punica Granatum pomegranate	*Solanum carolinense* horse nettle
Rosaceae	*Solanum Melongena* eggplant 'Classic'
Fragaria ×*Ananassa* strawberry 'Darrow'	*Solanum nigrum* black nightshade
Malus sp. apple	*Solanum tuberosum* potato 'Katahdin'
Potentilla recta sulfur cinquefoil	Tetragoniaceae
Prunus sp. peach	*Tetragonia tetragonioides* New Zealand spinach
Rosa sp. miniature rose	Typhaceae
Rubus occidentalis black raspberry	*Typha latifolia* common cattail
Rubiaceae	Umbelliferae
Gardenia jasminoides common gardenia	*Apium graveolens* celery 'Fordhook'
Scrophulariaceae	*Daucus Carota* carrot 'Danvers 126'
Verbascum bombyciferum mullein 'Arctic Summer'	*Petroselinum crispum* parsley 'Extra Curled Dwarf'
Simaroubaceae	Verbenaceae
Ailanthus altissima tree-of-heaven	*Verbena* sp. verbena
Solanaceae	Vitaceae
Capsicum annuum pepper 'Keystone Resistant Giant'	*Vitis vinifera* grape 'Concord'

(*Phalaris arundinacea* 'Vantage') supported substantial nematode reproduction.

All species of small grains tested supported reproduction of *H. zeae* but were poor hosts compared with corn (Table 1). Four cultivars of oat (*Avena sativa*) and three of wheat (*Triticum aestivum*) supported slight nematode reproduction when grown in growth chambers at 33 C, but not under the lower and fluctuating temperatures of greenhouse benches. The one cultivar of rye (*Secale cereale*) and the one of rice (*Oryza sativa*) tested both supported some nematode reproduction, as did all four barley (*Hordeum vulgare*) cultivars examined.

Common Maryland weed species that supported reproduction of *H. zeae* in these tests included annual bluegrass (*Poa annua*), barnyard grass (*Echinochloa crus-galli*), common reed (*Phragmites australis*), fall panicum, perennial bluegrass (*Poa pratensis*), perennial ryegrass (*Lolium perenne*), and tall fescue (*Festuca elatior*).

Several kinds of plants that were poor hosts when grown in pots on a greenhouse bench were much better hosts when the pots were placed on plant propagation mats to provide a soil temperature of 30 C (Table 1). These plants included eastern gamagrass (*Tripsacum dactyloides*), three panicums, fountain grass (*Pennisetum rueppeli*), green sprangletop (*Leptochloa dubia*), and two teosintes.

DISCUSSION

A broad representation of plant species and genera in many families was tested in the 269 plant entries inoculated with *H. zeae* in this investigation. Within the family Gramineae, *H. zeae* had a relatively broad host range, which appeared to be limited more by the number of plant species, genera, and tribes examined than by taxonomic affinities among the different plants.

Greenhouse temperature varied widely. Over the course of the study average low temperatures ranged from 11 to 22 C, and dropped as low as 2 C for short period of time. Since *H. zeae* developed most rapidly

TABLE 3. Comparison of the host status of certain plants inoculated with populations of *Heterodera zeae* found in India (7,8), Egypt (B. A. Oteifa, unpubl.), and the United States.

Plant	Host status		
	India	Egypt	United States
Avena sativa oats	+, −†		+
Digitaria sp.	+		−
Echinochloa sp.	+		+
Eleusine sp.	−		−
Hordeum vulgare barley	+	+	+
Oryza sativa rice	−	−	+
Panicum spp.	+		+, −‡
Paspalum sp.	−		−
Pennisetum americanum pearl millet	−		−
Sorghum bicolor sorghum	−	+	+, −§
Triticum aestivum wheat	+, −†	+	+, −§
Zea mays indentata dent corn	+	+	+
Zea mays indurata flint corn		−	+
Zea mays rugosa sweet corn		+	+

† Different studies.
‡ Different species, Table 1.
§ Different cultivars, Table 1.

on Pioneer 3184 corn in sandy soil at 33 C in growth chamber experiments (P. A. Hutzell, unpubl.), the same temperature was used for the host range tests in growth chambers. Although the precise optimum temperature for reproduction of *H. zeae* has not been determined, it is obviously high. Therefore, host range studies should perhaps be performed using a minimum soil temperature of 30 C. A more important question, however, is whether plants that were hosts in experiments at controlled high temperatures will support persistence of the nematode at the field temperatures under which those plants normally grow. Research in progress in field microplots will help answer such questions.

A mixture of eggs and J2 as the nematode inoculum for these host range studies permitted a more accurate determination of whether a plant was a host than did the use of cysts. Full cysts of *H. zeae* were used for inoculum in the first host range tests conducted, because with virtually no information available on the nematode's biology, it was felt that full cysts would be the most reliable inoculum until eggs and J2 as inoculum had been evaluated. Also, these first host range tests were being initiated at a time when we were having difficulty culturing this nematode in the greenhouse; as we were not aware of the high temperature optimum for reproduction, we were relying on cysts recovered from field soil for inoculum. With eggs and J2 as inoculum, any cysts found indicated reproduction, whereas with cysts as inoculum, reproduction was indicated only when more than the 100 cysts were recovered. Therefore, some plants on which a few cysts were produced may have been designated as nonhosts.

A plant was considered a host if it supported formation of a single cyst. A host plant was thus defined as one on which the parasite could reproduce, even minimally. Plants that support slight reproduction of a nematode under greenhouse or plant growth chamber conditions may not maintain that nematode under field conditions. Field microplot studies are in progress to determine the population dynamics of *H. zeae* over several years with plants including sorghum, Kentucky bluegrass, Kentucky 31 fescue, and fall panicum.

Three of five sorghums tested failed to support reproduction of *H. zeae* under the conditions used. The two positive sorghums supported poor nematode reproduction. Because sorghums are widely planted in the south and midwest in the United States, their host status towards this nematode should be explored further.

Data on plants in 12 genera reported to be hosts of *H. zeae* in Maryland, India, or Egypt were compiled (Table 3). Of the five crop species tested in all three locations, only dent corn, wheat, and barley were common hosts. The species of *Panicum* and *Echinochloa* that were hosts of *H. zeae* in India differed from those that were hosts in Maryland. The host range and certain other aspects of the biology of the populations of *H. zeae* from the United States, India, and Egypt should be compared at

one location to determine the degree of differences among them.

Plants that support reproduction of *H. zeae* are as divergent as common reed, sugarcane, rice, teosinte, and many grasses as well as corn. This wide host range suggests that surveys for *H. zeae* should include more than corn fields.

Literature Cited

1. Bhargava, S., and B. S. Yadav. 1978. Host range study and evaluation of certain barley varieties to the maize cyst nematode *Heterodera zeae.* Indian Journal of Mycology and Plant Pathology 8:72.

2. Bailey Hortorium. 1976. Hortus III. New York: Macmillan Co.

3. Koshy, P. K., and G. Swarup. 1971. Distribution of *Heterodera avenae, H. zeae, H. cajani* and *Anguina tritici* in India. Indian Journal of Nematology 1: 106-111.

4. Koshy, P. K., G. Swarup, and C. L. Sethi. 1971. *Heterodera zeae* n. sp. (Nematoda: Heteroderidae), a cyst-forming nematode on *Zea mays.* Nematologica 16:511–516.

5. Maqbool, M. A. 1981. Occurrence of root-knot and cyst nematodes in Pakistan. Journal of Nematology 13:448–449 (Abstr.).

6. Sardanelli, S., L. R. Krusberg, and A. M. Golden. 1981. Corn cyst nematode, *Heterodera zeae,* in the United States. Plant Disease 65:622.

7. Srivastava, A. N., and G. Swarup. 1975. Preliminary studies on some graminaceous plants for their susceptibility to the maize cyst nematode, *Heterodera zeae* Koshy et al. 1970. Indian Journal of Nematology 5:257–259.

8. Verma, A. C., and B. S. Yadav. 1978. New hosts of maize cyst nematode *Heterodera zeae.* Indian Journal of Mycology and Plant Pathology 8:72.