HOST AND NON-HOST STATUS OF PLANT SPECIES FOR THE MAIZE CYST NEMATODE, *HETERODERA ZEAE*, IN INDIA

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Summary. The host status of 41 plant species belonging to 34 genera of ten families was evaluated towards an Indian population of the maize cyst nematode, *Heterodera zeae*, under glass-house conditions. Only thirteen plant species were found to be hosts for *H. zeae*. They were the poaceous maize, sorghum, rice, wheat, barley, foxtail millet, barnyard millet, finger millet, little millet, oat, rye, sugarcane and khus-khus grass. All the non-poaceous plant species tested (soybean, sunflower, mustard, tomato, brinjal, okra, chilli, bottle gourd, mung bean, urd bean, broad bean, cowpea, common beet, pigeon pea, chickpea, pea, peanut, onion, garlic, carrot, common bean and radish) were non-hosts for the nematode. The host status of fourteen crop plant species to populations of *H. zeae*, from India, Egypt, Pakistan and USA is discussed.

Key words: Corn**,** host status, poaceous plants, *Zea mays*.

Maize (*Zea mays* L.) is an important cereal crop that is widely cultivated throughout the world. It ranks first in production and third (after wheat and rice) in terms of area under cultivation in the world. The USA is the largest producer and exporter of maize with an output of 333 million tonnes, accounting for 30% of global maize production. Other major maize producing countries are China (15%), EU-25 (14%) and Brazil (4%). India is the fifth largest producer of maize in the world with a production of 17.3 million tonnes contributing 3% to global production (FAOSTAT, 2009).

The maize cyst nematode, *Heterodera zeae* Koshy, Swarup *et* Sethi, is a severe pest of maize in India causing yield loss to the maize crop of 21-29% (Srivastava and Chawla, 2005). In India, the nematode was first reported from Udaipur (Rajasthan) in 1970, on maize (Koshy *et al*., 1970), but it is now widely spread in the major maize growing regions of northern, western, central and eastern parts of the country (Koshy and Swarup, 1971; Srivastava and Swarup, 1975; Srivastava *et al*., 1995). The nematode has also been reported from Egypt (Aboul-Eid and Ghorab, 1981), Pakistan (Maqbool, 1981; Shahina and Maqbool, 1990), USA (Sardanelli *et al*., 1981; Krusberg, 1988; Eisenback *et al*., 1993), Thailand (Chinnarsi *et al*., 1995), Nepal (Sharma *et al*., 2001), Portugal (Correia and Abrantes, 2005), and Greece (Subbotin *et al*., 2010).

Inclusion of non-hosts or poor hosts in maize cropping sequences can minimize the nematode population and its negative impact on maize. The host range of *H. zeae* has been studied in India, Egypt, Pakistan and the USA with varying results. It appears to be confined to plants of the family Poaceae. Besides maize, other economically important *kharif* and *rabi* cereals and millets, viz. rice (*Oryza sativa* L.), foxtail millet [*Setaria italica* (L.) Beauv.], barnyard millet [*Echinochloa colona* (L.) Link], finger millet (*Eleusine* coracana Gaertn.), barley (*Hordeum vulgare* L.), wheat (*Triticum aestivum* L.), rye (*Secale cereale* L.), pearl millet [*Pennisetum glaucum* (L.) R.Br.], Job's tears (*Coix lachrymal* L.), mexican teosinte [*Zea mexicana* (Schrad.) Kuntze] and khus-khus grass [*Chrysopogon zizanioides* (L.) Roberty], are also hosts for *H. zeae* in India (Srivastava and Swarup, 1975; Lal and Mathur, 1982; Sharma and Swarup, 1984). Also, the nematode was found infecting several poaceous weeds grown in association with corn in India (Srivastava and Swarup, 1975; Verma and Yadav, 1978; Parihar *et al*., 1991) and in Egypt (Ismail and Hasabo, 1995). In Maryland (USA), Ringer *et al*. (1987) reported that *H. zeae* has other economically important host crops, including certain cultivars of barley, rice, sorghum, sugarcane and wheat as well as many species of weeds. Moreover, in Pakistan, Maqbool (1981) reported gram, citrus, pear and garlic as hosts of *H. zeae*. Furthermore, Nasira and Shahina (2007) found *H. zeae* in the rhizosphere of mango (*Mangifera indica* L.), but the host status for *H. zeae* of this plant species has not been assessed.

Some earlier workers reported host and non-host status of plants for *H. zeae* based on the presence of cysts of the nematode in the rhizosphere, which does not clearly indicate that the nematodes was reproducing on those plants. Therefore, the present investigation is an attempt to resolve the conflicting reports available in the literature and to obtain more insights on the host and non-host status of various plants to an Indian population of *H. zeae* under glass-house conditions.

The stock culture of *H. zeae* was maintained on maize cv. Deccan-103. Forty-one plant species belonging to 34 genera of ten families were tested (Table I). The experi-

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ment was conducted in 15-cm-diameter earthen pots containing 1000 g steam-sterilized loamy soil and sand mixture in the ratio of 3:2. The seeds or planting material of each crop cultivar were first surface sterilized in 0.1% mercuric chloride for 5 minutes, rinsed in distilled water 3-4 times and then sown. Sugarcane and khus-khus grass were sown with cane setts and clumps, respectively, in 30-cm-diameter pots. Four days after emergence, seedlings were inoculated with freshly hatched second stage juveniles of *H. zeae* at an initial inoculum level of four J_2/g soil. The pots were arranged according to a randomized block design in a glass-house at 30-36 °C and there were five replicates per plant species. Plants were regularly watered throughout the experiment. Sixty days after nematode inoculation, the soil from each pot was thoroughly mixed and a 250 g sub-sample was processed with Cobb's sieving and decanting technique using 20- and 60-mesh sieves. The nematode cysts were observed under a stereoscopic microscope, using an incident light, picked-up, collected in 50 mm Petri-dishes and counted.

Table I. Host and non-host status of different plant species for an Indian maize cyst nematode, *Heterodera zeae*, population, based on the numbers of new cysts produced under controlled conditions.

Common name	Scientific name	Family	Cultivar	No. of cysts/ 250 g soil	Host status
Okra	*Abelmoschus esculentus*	Malvaceae	Pusa Sawani	-	-
Onion	*Allium cepa*	Amaryllidaceae	Pusa Red	-	-
Garlic	*A. sativum*	Amaryllidaceae	Yamuna Safed-4	-	-
Peanut	*Arachis hypogaea*	Fabaceae	ICGS-5	-	-
Oat	*Avena sativa*	Poaceae	Bundel Jai-851	2	+
Common beet	*Beta vulgaris*	Chenopodiaceae	Ramonskaya-6	-	-
Mustard	*Brassica juncea*	Brassicaceae	Pusa Bold	-	-
Pigeon pea	*Cajanus cajan*	Fabaceae	Pusa-2001	-	-
Chilli	*Capsicum annum*	Solanaceae	Pusa Jwala	-	-
Foxtail buffalo grass	*Cenchrus cillaris*	Poaceae	Bundel Anjan-1	-	-
Bird wood grass	*C. setigerus*	Poaceae	CV-3126	-	-
Khus-khus grass	*Chrysopogon zizanioides*	Poaceae	KS-1	71	+
Chickpea	*Cicer arietinum*	Fabaceae	Pusa-212	-	-
Carrot	*Daucus carota*	Apiaceae	Pusa Yamdagini	-	-
Barnyard millet	*Echinochloa colona*	Poaceae	CO-1	21	+
Finger millet	*Eleusine coracana*	Poaceae	VL-149	55	+
Soybean	*Glycine max*	Fabaceae	PK-1042	-	-
Sunflower	*Helianthus annuus*	Asteraceae	Surya	-	-
Barley	*Hordeum vulgare*	Poaceae	Amber	25	+
Bottle gourd	*Lagenaria siceraria*	Cucurbitaceae	Pusa Meghdoot	-	-
Rice	*Oryza sativa*	Poaceae	Pusa-1460	3	+
Little millet	*Panicum miliare*	Poaceae	TNAU-63	18	+
Kodo millet	*Paspalum scrobiculatum*	Poaceae	CO-3	-	-
Pearl millet	*Pennisetum glaucum*	Poaceae	Pusa Hybrid-605	-	-
Kyasuma grass	*P. pedicellatum*	Poaceae	Bundel Dinanath-1	-	-
Common bean	*Phaseolus vulgaris*	Fabaceae	VL Bean-2	-	-
Pea	*Pisusm sativum*	Fabaceae	Pusa Mukta	-	-
Radish	*Raphanus sativus*	Brassicaceae	Pusa Chetki	-	-
Sugarcane	*Saccharum officinarum*	Poaceae	CoS-8436	121	+
Rye	*Secale cereale*	Poaceae	Assam Rye	5	+
Foxtail millet	*Setaria italica*	Poaceae	Chitra	126	+
African bristle grass	*S. sphacelata*	Poaceae	CPI-15899	-	-
Tomato	*Solanum lycopersicum*	Solanaceae	Pusa Ruby	-	-
Egg plant	*S. melongena*	Solanaceae	Pusa Hybrid-6	-	-
Sorghum	*Sorghum bicolor*	Poaceae	Pusa Chari-23	2	+
Wheat	*Triticum aestivum*	Poaceae	Pusa Gold	15	+
Broad bean	*Vicia faba*	Fabaceae	Kashi Haritima	-	-
Urd bean	*Vigna mungo*	Fabaceae	T-9	-	-
Mung bean	*V. radiata*	Fabaceae	Pusa Vishal	-	-
Cowpea	*V. unguiculata*	Fabaceae	Pusa Komal	-	-
Maize	*Zea mays*	Poaceae	Ganga-5, Ganga Safed-2, Deccan-103, Hi-starch, Shakti	574 - 889	+

(+) = Host; (-) = Non-host

Table II. Comparison of the host status of some common crops for the maize cyst nematode, *H. zeae*, populations from India, Egypt, Pakistan and the USA.

Plant Species	Host status for nematode population from			
	India	Egypt[4]	Pakistan[5]	USA[6]
Oat (*Avena sativa*)	+[1]	*	*	+
Job's tears (*Coix lachrymal- jobi*)	+[2]	*	*	+
Barnyard millet (*Echinochloa colona)*	+[1]	*	*	+
Finger millet (*Eleusine coracana*)	+[2]	*	*	*
Barley (*Hordeum vulgare*)	+[1]	+	*	+
Rice (*Oryza sativa*)	+[2]	-	*	+
Little millet (*Panicum miliare*)	+[1]	+	*	+
Sugarcane (*Saccharum officinarum*)	+[3]	*	+	+
Rye (*Secale cereale*)	+[2]	*	*	+
Foxtail millet (*Setaria italica*)	+[1]	*	*	*
Sorghum (*Sorghum bicolor*)	+[2]	*	*	+
Wheat (*Triticum aestivum*)	+[1]	+	+	+
Maize/Corn (*Zea mays*)	+[1]	+	+	+
Teosinte (*Z. mexicana*)	+[2]	*	*	+

(+) =: Host; (-) = Non-host; (*) = Not studied.

Information in this table from: [1]Srivastava and Swarup, 1975; [2]Sharma and Swarup, 1984; [3]this study; [4]Aboul-Eid and Ghorab, 1981; [5]Maqbool, 1981; [6]Ringer *et al.,* 1987.

Of the 41 plant species tested, only thirteen (32%) were hosts for *H. zeae* (Table I). All host plants were poaceous. The remaining six plant species of the Poaceae family examined were not hosts for *H. zeae*. All 22 non-poaceous plant species failed to support the reproduction of *H. zeae*. Cysts formed in the pots planted to maize, sorghum, rice, wheat, barley, foxtail millet, barnyard millet, finger millet, little millet, oat, rye, sugarcane and khus-khus grass, hence these plant species are considered as hosts for *H. zeae*. Except for kodo and pearl millet, all species of small grains, viz. barnyard millet, finger millet, little millet and foxtail millet, supported the reproduction of *H. zeae*. Almost all grasses, except khus-khus grass, belonging to the family Poaceae, viz. foxtail buffalo grass, bird wood grass, kyasuma grass and African bristle, did not allow the reproduction of *H. zeae* and, therefore, are considered non-hosts for this nematode. Maize, foxtail millet and sugarcane were the best hosts for *H. zeae*.

Of the fourteen crop plant species reported to be hosts for *H. zeae* in India, Egypt, Pakistan and USA (Table II), only two (maize and wheat) were hosts for the nematode in all four countries. Barley and sorghum are reported as hosts for the population of the nematode from India, Egypt and USA, while sugarcane is host for the nematode in India, Pakistan and USA. Oat, Job's tears, barnyard millet, rice, little millet, rye and teosinte are hosts only for the nematode populations from India and USA, while finger and foxtail millets are very good hosts only for the Indian population.

These results are consistent with the findings of Srivastava and Swarup (1975), Sardanelli *et al.* (1981), Lal and Mathur (1982), Bajaj *et al.* (1986), Ringer *et al.* (1987), Ismail and Youssef (1993) and Ismail (2009), thus clearly indicating that the plant hosts for *H. zeae* are all poaceous. Maqbool (1981) reported also chickpea (*Cicer arietinum* L.) and garlic (*Allium sativum* L.) as hosts for *H. zeae* in Peshawar and Mardan areas of Pakistan, while in our studies these two crop plants failed to support the reproduction of *H. zeae*. The difference in the results may be attributed to ambiguity in the record of cyst presence. It is not clear whether this author found the cysts on the roots of these plants or merely from the rhizospheric soil. Doubts on the host status of these two plants were also expressed by Sharma and Swarup (1984) and Luc (1986). Rice was considered as non-host for *H. zeae* in Egypt (Aboul-Eid and Ghorab, 1981), and as host in India (Sharma and Swarup, 1984) and USA (Ringer *et al*., 1987). These differences may be attributed to differences in the genotypes of the plant species and to difference in the virulence of the geographical isolate of the nematode population tested. Kheir *et al.* (1989) reported three different biotypes of *H. zeae* in Egypt, based on their differential reproduction on fifteen corn cultivars. Bajaj and Gupta (1994) found that of three Indian populations of *H. zea*e, one reproduced on both maize and vetiver [*Vetiveria zizanioides* (L.) Nash], one on vetiver only and one on maize only, thus confirming the occurrence of races within populations of the nematode.

Ringer *et al.* (1987) tested 14 different species of Leguminosae and found that none was host for the Maryland population of the nematode. In Egypt, Ismail (2009) reported that broad bean (*Vicia faba* L.) and Egyptian clover (*Trifolium alexandrinum* L.) were non-hosts. In our study, the ten leguminous species tested were also non-hosts for the Indian population of the nematode. All this would indicate that leguminous species

are non-hosts for *H. zeae*, which therefore makes them good species to include in rotation with maize.

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