Differences in the Response of Certain Weed Host Populations to Heterodera schachtii[1]

G. D. GRIFFIN[2]

Abstract: Significant differences ($P = 0.05$) in nematode reproduction were observed among populations of *Heterodera schachtii* and weed collections of black nightshade, common lambsquarters, common purslane, redroot-pigweed, shepherdspurse, and wild mustard from Colorado, Idaho, Oregon, and Utah. Colorado weeds supported the greatest nematode development ($P = 0.05$). Weeds collected from Idaho and Utah were similar with respect to their response to *H. schachtii* with the exception of shepherdspurse. At increasing soil temperatures, a Utah redroot-pigweed collection showed a higher percent susceptibility to a Utah nematode population than to nematode populations from the other states ($P = 0.05$). There was a higher percentage of susceptible plants when the weed host population was collected from the same geographical area as the nematode inoculum. *Key words:* sugarbeet cyst nematode, *Amaranthus retroflexus, Chemopodium album, Capsella bursa-pastoris, Portulaca oleraceae, Solanum nigrum, Brassica kaber, susceptibility, soil temperature,* genetic variability.

Journal of Nematology 14(2):174-182. 1982.

The host range of the sugarbeet cyst nematode, *Heterodera schachtii* Schm., is well documented and summarized by Raski (4), Steele (6), and Winslow (8). Most of the host species are weeds commonly found in cultivated fields. However, little attention has been given to either the degree of susceptibility of weeds to *H. schachtii* or the reproductive potential of *H. schachtii* on weed hosts in a sugarbeet rotation program. Field observations may not accurately reflect the true relationship between *H. schachtii* and weed hosts since the degree of susceptibility of certain weeds varies between locations. Certain weeds have been found to be heavily parasitized by sugarbeet nematode females in one location but not in another with comparable nematode densities (7). This difference may have been due to genetic variability in the nematode or weed population.

A study was made, therefore, to determine the host/parasite relationship between four geographically different but taxonomically identical weed population and *H. schachtii* populations from the same area.

MATERIALS AND METHODS

Heterodera schachtii and weed seed populations were collected from infested

Received for publication 22 May 1981.

[1]Cooperative investigation, USDA ARS and the Utah Agricultural Experiment Station. Journal paper no. 2676.

[2]Nematologist, USDA ARS, Crops Research Laboratory, Logan, UT 84322.

fields in Colorado, Idaho, Oregon, and Utah during 1979. Only one species of weed seed were collected from each field, and unless stated otherwise, the weed collection for each species and the *H. schachtii* population were collected from the same field. Field locations: For black nightshade (*Solanum nigrum* L.)—Loveland, Colorado; Dayton, Idaho; Ontario, Oregon; and Lewiston, Utah. For common lambsquarters (*Chenopodium album* L.)—Greeley, Colorado; Rupert, Idaho; Nyssa, Oregon; and Ogden, Utah. For common purslane (*Portulaca oleraceae* L.)—Loveland, Colorado; Nampa, Idaho; Vale, Oregon; and Ogden, Utah. For redroot-pigweed (*Amaranthus retroflexus* L.)—Loveland, Colorado; Rupert, Idaho; Ontario, Oregon; and Lewiston, Utah. For shepherdspurse (*Capsella bursa*—pastoris [L] Medic.)—Windsor, Colorado; Burley, Idaho; Ontario, Oregon; and Lewiston, Utah. For wild mustard (*Brassica kaber* [DC] L. C. Wheeler)—Loveland, Colorado; Dayton, Idaho; and Lewiston, Utah.

Weeds were threshed and seeds stored at 5 C for 6 months (1), scarified and germinated on captan (cis-N-L [trichloromethyl] thio-4-cyclohexene-1,2-dicarboxmide) treated filter paper at 25 C, and planted into metal flats (34 × 45 cm) of fumigated sandy loam soil.

The *H. schachtii* populations were cultured on sugarbeet, *Beta vulgaris* L., cv. Tasco AH3 at 25 C in isolation chambers for 6 months. Cysts were extracted with an elutriator, surface sterilized with a 0.5% sodium hypochlorite solution, rinsed in distilled water, and hatched in a $ZnCl_2$ solution.

Seedlings were transplanted when 28 days old into 15-cm containers of bromoethane-fumigated sandy loam soil that had been inoculated with *H. schachtii* larvae (4.0 larvae/per g soil). Each treatment (plant species) was replicated 25 times; replicates consisted of one container of four plants. After 100 days growth, on a greenhouse bench at 22 ± 4 C and 16 h daylight, the plants were harvested, and the percentage of susceptible plants (containing one or more female or cyst per plant) determined. The number of females and cysts per plant were determined with a stereomicroscope and by processing the soil wth an elutriator. Four fully developed brown cysts were chosen at random from each of 20 susceptible plants of each treatment. Larvae from two of the cysts were hatched at 25 C in a $ZnCl_2$ solution; the solution was decanted daily and the total number of larvae hatching over a 28-day period was determined. The other two cysts from each of the plants were mechanically broken and eggs and larvae counted as a control.

In another study, 28-day-old redroot-pigweed seedlings from the Lewiston, Utah, weed collection were planted in soil infested with *H. schachtii* (4.0 larvae/per g soil) collected from redroot-pigweed/nematode infested fields in Utah, Idaho, Oregon, or Colorado. Plants (five replicates per treatment, and four plants per replicate) were grown in a growth chamber for 40 days at constant 16, 20, 24, and 28 C and 16 h daylight. After 40 days growth, the percent susceptibility, females per plant, and larvae per cysts were determined as previously described.

In a reciprocal study, redroot-pigweed collections from Lewiston, Utah (UT1); Ogden, Utah (UT2); Rupert, Idaho (ID1); Dayton, Idaho (ID2); Ontario, Oregon (OR1, OR2); Loveland, Colorado (CO1); and Greeley, Colorado (CO2) were inoculated with the Lewiston, Utah (UT1) *H. schachtii* population. Seedlings (23 days old) were transplanted into nematode-infested soil (6.0 larvae per g soil) and grown at 16, 20, 24, and 28 C. Each treatment consisted of five replicates, four plants per replicate. After 40 days growth, plants were harvested and the percentage of susceptible plants, females per plant, and larvae per cyst were determined as previously described.

RESULTS

Variability in the susceptibility to *H. schachtii* depended on the plant species and the nematode population. The most uniform host response to *H. schachtii* was observed in wild mustard, which was 98–100% susceptible to the nematode populations regardless of geographic origin ($P = 0.05$) (Fig. 1). Conversely, the most variable plant species, was redroot-pigweed, which showed a 46–92% susceptibility over the four

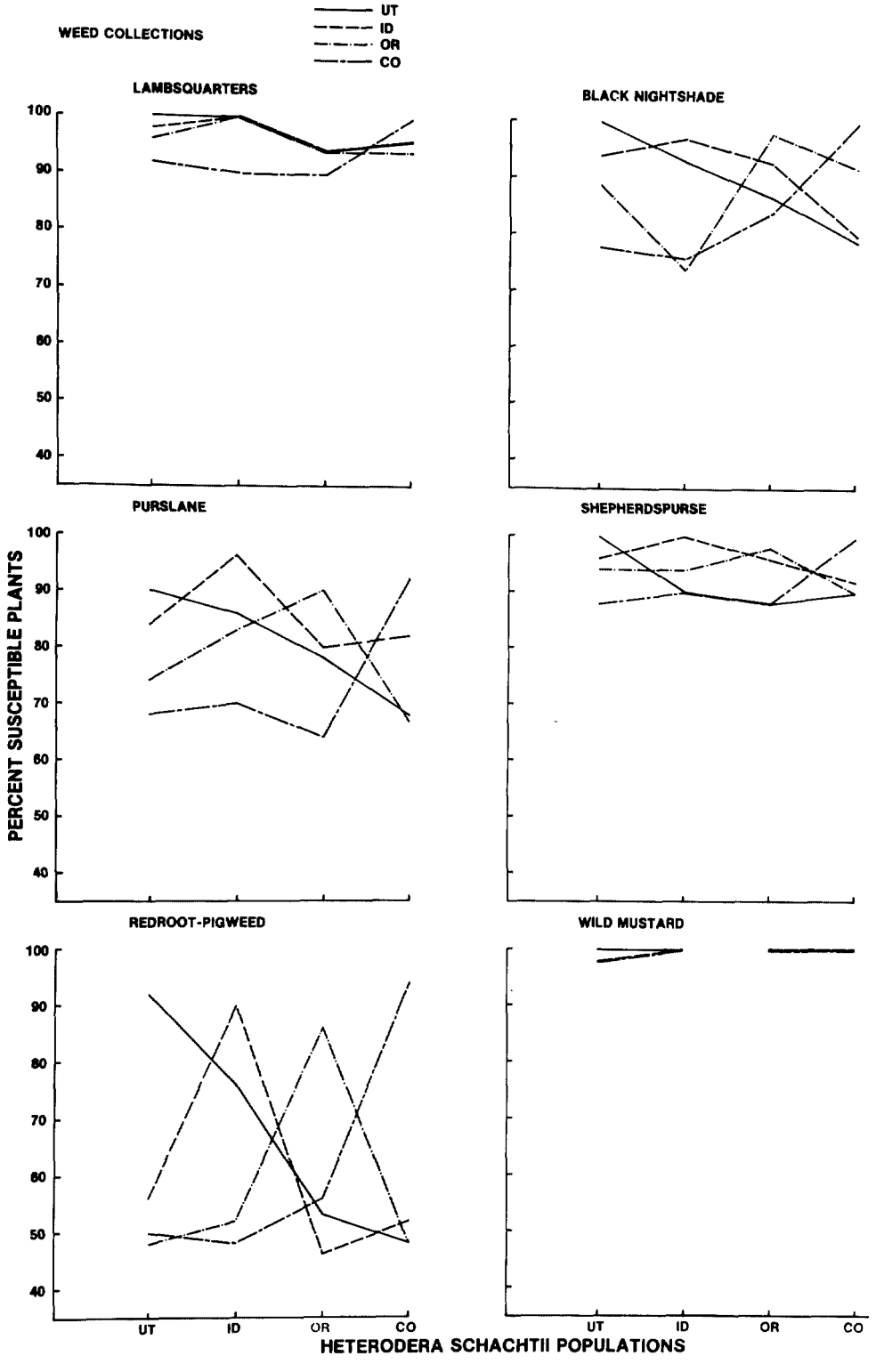


Fig. 1. Susceptibility of six weed hosts to *Heterodera schachtii*. Weed collection and nematode population collected from the same field.

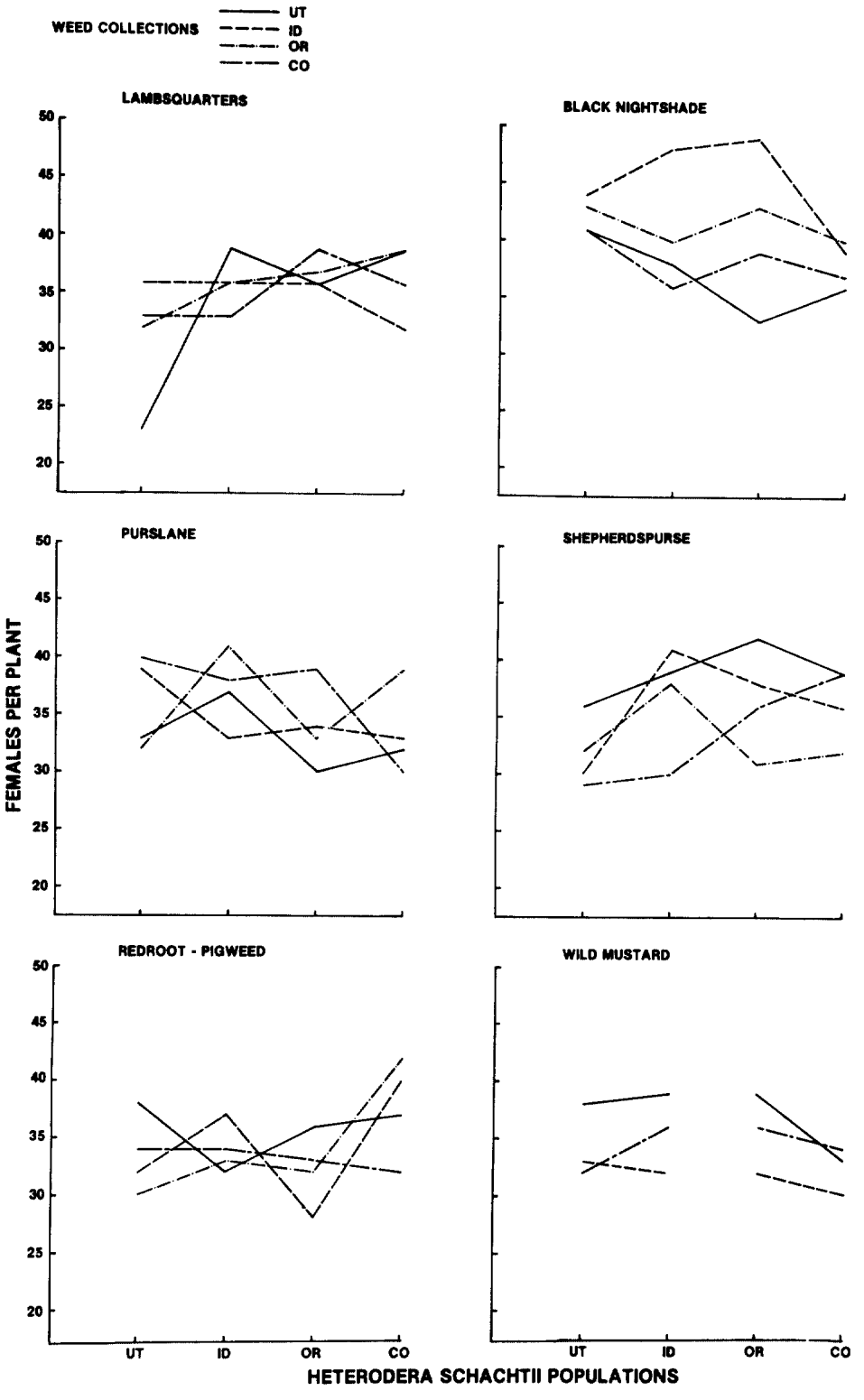


Fig. 2. Maturation (females per susceptible plant) of *Heterodera schachtii* on six weed hosts. Weed collection and nematode population collected from the same field (LSD, P, 0.05 = 13).

(Colorado, Idaho, Oregon, and Utah) geographic areas ($P = 0.05$). The greatest susceptibility for each weed, except common lambsquarters from Oregon, occurred when the weed and nematodes were from the same locality ($P = 0.05$). Colorado weeds were usually the least susceptible to nematodes from the other geographical areas, and weed collections were less susceptible to the Oregon nematode populations. The Utah and Idaho weed collections were generally the most susceptible.

There was a significant interaction ($P = 0.05$) between nematode populations and weed collections in numbers of nematodes that matured to females (Fig. 2). No definite pattern developed, however, in relation to the most suitable weed hosts as determined by female maturation. There was a great variability in relation of females per plant. This was especially true with common lambsquarters, while wild mustard was the most uniform host in relation to females per plant.

There were significant differences within some of the weed species in relation to female maturation ($P = 0.05$). There was also significantly greater numbers of females per plant ($P = 0.05$) on Colorado redroot-pigweed inoculated with a nematode population of the same locality than found on this host from Idaho inoculated with the Oregon nematode population.

Black nightshade appeared to be the best overall host for female maturation ($P = 0.05$). When all nematode populations and weed collections were combined, there was an average of 40 females per plant on black nightshade, 36 on shepherdspurse, 35 on common lambsquarters and common purslane, and 34 females per plant on redroot-pigweed and wild mustard.

No definite pattern ($P = 0.05$) developed in the ability of *H. schachtii* to reproduce (viable larvae per cyst) on any of the weed hosts regardless of weed or nematode origin (Fig. 3). Nematodes tended, however, to have greater reproductive capacity (larvae per cyst) on weed hosts with the highest percentage of susceptibility and not with the greatest number of females per plant.

A significant increase ($P = 0.05$) in soil temperature resulted in an increase in the percentage of susceptible redroot-pigweed of a Utah population to the different *H. schachtii* populations (Fig. 4). The percentage of susceptible plants of the Utah collection of redroot-pigweed varied from 35% when inoculated with the Idaho and Colorado nematode populations at 16 C to 100% when inoculated with the Utah nematode population at 28 C. The Utah nematode population showed the highest density values at all soil temperatures which agrees with the findings of the previous experiment where the most susceptible weed collections were found to be correlated to the nematode population from the same field.

The ability of *H. schachtii* to mature on redroot-pigweed was also affected positively by increasing soil temperature from 16 to 28 C (Fig. 5). Similar data were obtained in relation to the ability of *H. schachtii* to reproduce on redroot-pigweed (Fig. 6). The maximum number of larvae per cyst occurred at 28 C from the Utah and Idaho populations while the smallest number of larvae developed at 16 C. When redroot-pigweed collections from Utah (UT1, UT2), Idaho (ID1, ID2), and Colorado were inoculated with the UT1 *H. schachtii*, the percent susceptibility, females per plant, and larvae per cyst were greatest when weed and nematode populations were collected from the same site (Figs. 7, 8, 9). The greatest percentage of susceptible plants, females per plant, and larvae per cyst were always obtained when the UT1 weed collection was inoculated with the UT1 nematode population at 28 C, and were significantly greater ($P = 0.05$) than any of the other weed collections or soil temperatures. The most susceptible weed collections were the UT1 and UT2, while those from Colorado were the least susceptible.

DISCUSSION

This study confirms previous findings on the potential importance of weeds as *H. schachtii* hosts in sugarbeet production (6). Although there was great variability in the nematode to reproduce on weeds, weed hosts do play an important part in the population dynamics of *H. schachtii*. It is therefore imperative that growers be cognizant of the reproductive potential of weed hosts and

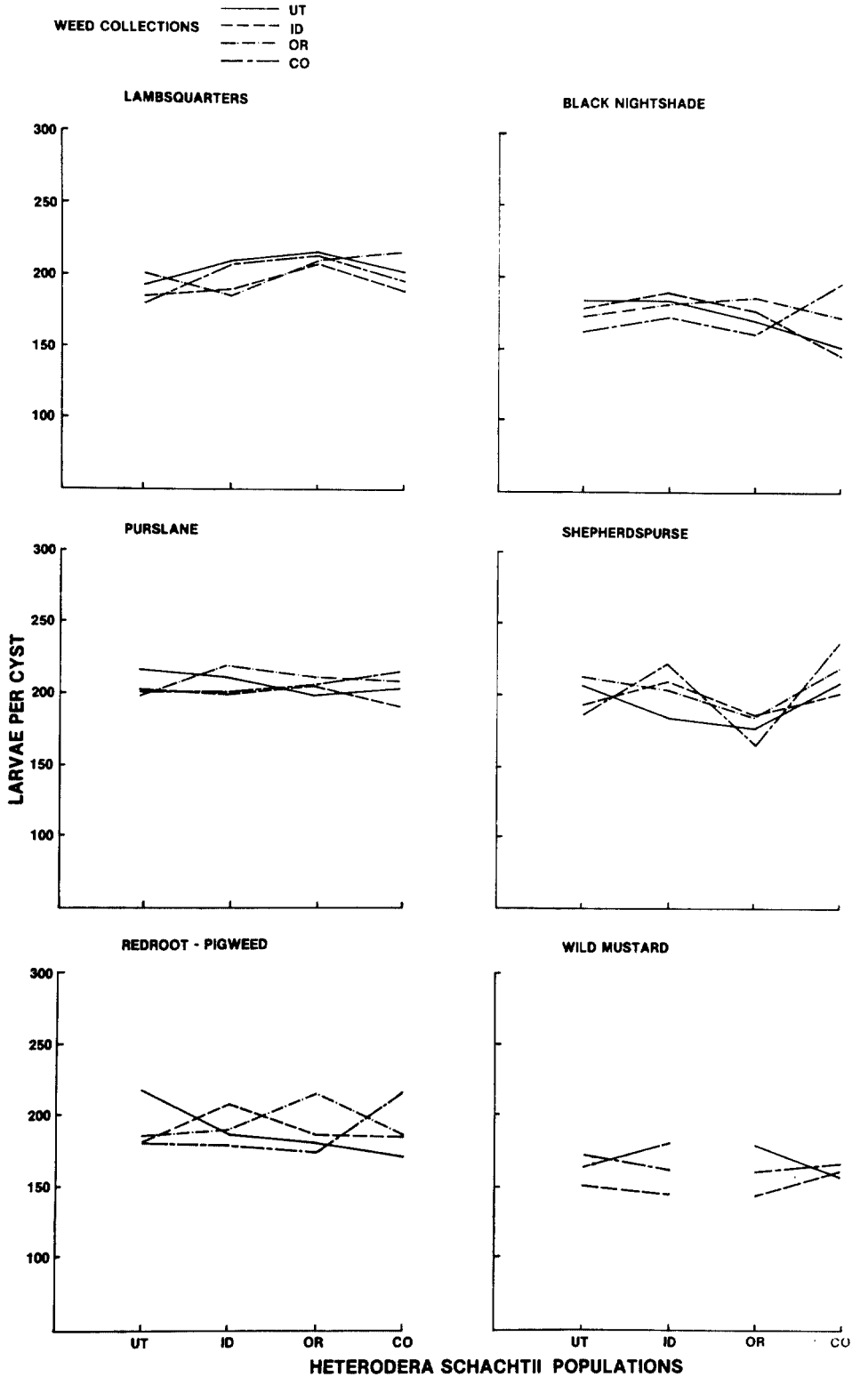
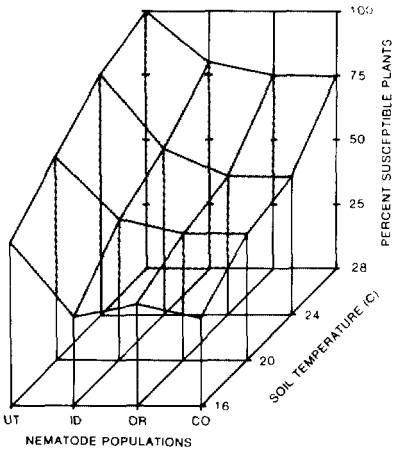
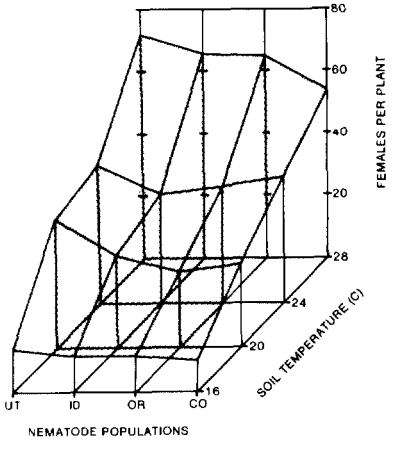


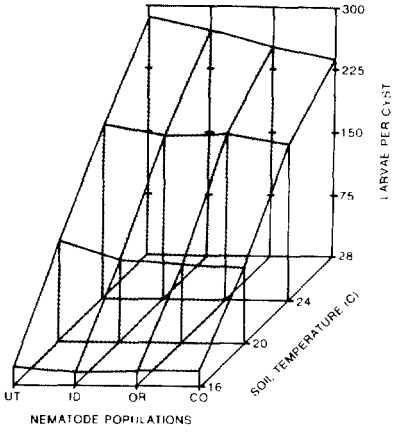
Fig. 3. Reproduction (larvae per cyst) of *Heterodera schachtii* on six weed hosts. Weed collection and nematode population collected from the same field (LSD, P, 0.05 = 40).


100
75
50
25
28
PERCENT SUSCEPTIBLE PLANTS
24
20
16
SOIL TEMPERATURE (C)
UT
ID
OR
CO
NEMATODE POPULATIONS

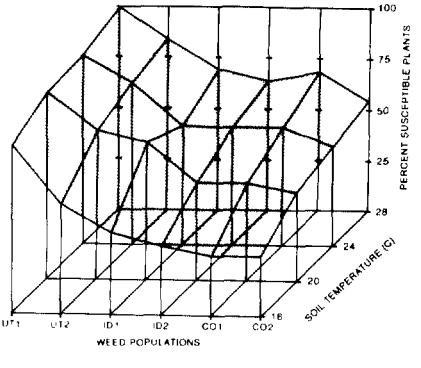
4.


80
60
40
20
28
FEMALES PER PLANT
24
20
16
SOIL TEMPERATURE (C)
UT
ID
OR
CO
NEMATODE POPULATIONS

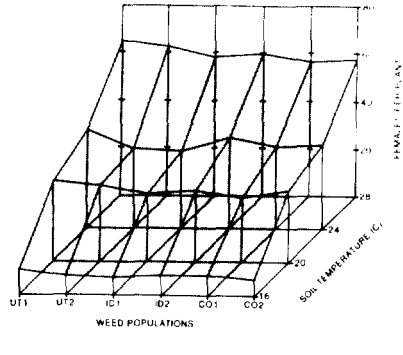
5.


300
225
150
75
28
LARVAE PER CYST
24
20
16
SOIL TEMPERATURE (C)
UT
ID
OR
CO
NEMATODE POPULATIONS

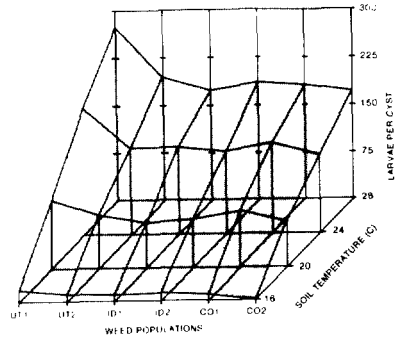
6.


100
75
50
25
28
PERCENT SUSCEPTIBLE PLANTS
24
20
16
SOIL TEMPERATURE (C)
UT1
UT2
ID1
ID2
CO1
CO2
WEED POPULATIONS

7.


UT1
UT2
IC1
ID2
CO1
CO2
WEED POPULATIONS

8.


225
150
75
28
24
20
16
SOIL TEMPERATURE (C)
UT1
UT2
ID1
ID2
CO1
CO2
WEED POPULATIONS

9.

include a proper weed control program in their sugarbeet production practices.

It appears from this study that genetic differences exist in both the weed host collection and the nematode population when geographically different collections and populations are compared. Golden and Shafer (3) refer to resistant and susceptible races of weeds to *H. schachtii* while Thorne (7) stated that differences in the susceptibility of weed hosts to *H. schachtii* may be due to nematode populations having adapted to different plants in different geographical areas. It appears that both observations are correct and genetic variability occurs in both weeds and in the sugarbeet nematode pathogen.

The results of this study also indicate that the greater the geographic separation, the greater the genetic differences between the weed collections with respect to nematode susceptibility. A greater percentage of weeds were most susceptible to nematode populations collected from the same field as the nematode population. One might suppose that the reverse would be true; i.e., that the longer the exposure of a given host plant to a given nematode population, the greater the chance of selection towards resistance. Such is the case of the natural selection of alfalfa cultivars (*Medicago sativa* L.) resistant to the stem nematode (*Ditylenchus dipsaci* Kuhn Filipjev). Alfalfa supposedly originated from the Middle East, and resistance of 'Lahontan' alfalfa to *D. dipsaci* came from 'Nemastan,' a strain of 'Turkestan' that was introduced into the United States from the Middle East (2). Also the potato (*Solanum tuberosum* L.), as well as germplasm resistant to the golden nematode, *Heterodera rostochiensis* (Woll.), originated in South America (5). However, in this study the reverse was found to be true. *H. schachtii* appear to have adapted to the physiology of the plant rather than the plant being able to develop resistance to the nematode. This may be due to nematode genetics for parasitism being more diverse than the diversity of the genome for weed resistance. Hence one may hypothesize that the nematode is the principle factor to consider and the greater the distance between locations, the greater the ecotypes between species to develop.

The difference as observed in this study may also be a result of there being usually two or more generations of nematodes and only one generation of the weed host produced during the growing season in most sugarbeet growing areas. This may tend to favor adaptation of the nematode. If we assume that the association of *H. schachtii* to certain weed hosts in the USA has been of a relative short duration and was introduced into and is not endemic to sugarbeet production (the first reported incidence of *H. schachtii* was in 1907), possible reversal of this data may be observed from fields with a longer nematode-weed association. Such reversal occurred in Europe where *H. schachtii* was first reported in 1859 (7).

Fig. 4. Effect of soil temperature on the susceptibility of a Utah collection of redroot-pigweed to four *Heterodera schachtii* nematode populations. The nematode populations were collected from redroot-pigweed collection fields (LSD, *P*, 0.05 = 13).

Fig. 5. Effect of soil temperature on maturation (females per susceptible plant) of four *Heterodera schachtii* populations on a Utah collection of redroot-pigweed. The nematode populations were collected from redroot-pigweed collection fields (LSD, *P*, 0.05 = 11).

Fig. 6. Effect of soil temperature on reproductivity (larvae per cyst) of four *Heterodera schachtii* populations on a Utah collection of redroot-pigweed. The nematode populations were collected from redroot-pigweed collection fields (LSD, *P*, 0.05 = 36).

Fig. 7. Effect of soil temperature on the susceptibility of six redroot-pigweed populations to a Utah population of *Heterodera schachtii* (UT1). The nematode population (UT1) and weed population (UT1) were collected from the same field (LSD, *P*, 0.05 = 18).

Fig. 8. Effect of soil temperature on maturation of *Heterodera schachtii* (females per susceptible plant) of a Utah population (UT1) on six redroot-pigweed collections. The nematode population (UT1) and weed collection (UT1) were collected from the same field (LSD, *P*, 0.05 = 16).

Fig. 9. Effect of soil temperature on reproductivity (larvae per cyst) of a Utah *Heterodera schachtii* population (UT1) on six redroot-pigweed collections. The nematode population (UT1) and weed collection (UT1) were collected from the same field (LSD, *P*, 0.05 = 36).

LITERATURE CITED

1. Anderson, R. N. 1968. Germination and establishment of weeds for experimental purposes. Geneva, New York: W. F. Humphrey Press.

2. Bolton, J. L. 1962. Alfalfa: botany, cultivation, and utilization. New York: Interscience Publishers.

3. Golden, A. M., and T. Shafer. 1958. Differential response of Heterodera schachtii and sugar beet nematode to selection of Chenopodium album. Plant Dis. Reptr. 42:184-187.

4. Raski, D. J. 1952. On the host range of the sugar-beet nematode in California. Plant Dis. Reptr. 36:5-7.

5. Smith, I. 1977. Potatoes: production, storing, processing. Westport, Connecticut: The Avi Publishing Company.

6. Steele, A. E. 1965. The host range of the sugar beet nematode, Heterodera schachtii Schmidt. J. of the A.S.S.B.T. 13:574-603.

7. Thorne, G. 1961. Principles of nematology. New York: McGraw-Hill Book Co.

8. Winslow, R. D. 1954. Provisional lists of host plants of some root eelworms (Heterodera spp.). Ann. Appl. Biol. 41:591-605.