COMPARATIVE EFFECTS OF TWO POPULATIONS OF *MELOIDOGYNE CHITWOODI* ON *TRITICUM AESTIVUM* AND *HORDEUM VULGARE*†

G. D. Griffin

USDA, ARS, Forage and Range Research Laboratory, Utah State University, Logan, UT 84322-6300, U.S.A.

ABSTRACT

Griffin, G. D. 1992. Effects of two populations of *Meloidogyne chitwoodi* on *Triticum aestivum* and *Hordeum vulgare*. Nematropica 22:65–74.

Wheat (*Triticum aestivum*) and barley (*Hordeum vulgare*) were evaluated under greenhouse conditions for responses to two populations of *Meloidogyne chitwoodi* from Utah and Idaho, U.S.A. Five cultivars of winter wheat, four cultivars of spring wheat, two cultivars of winter barley, and two cultivars of spring barley were included. Both nematode populations induced root galls and reproduced on all cultivars of wheat and barley. Nematode invasion reduced tillering and shoot and root growth. Head development was reduced or prevented on spring wheats and spring barleys. Nematode reproduction was greater on wheat than on barley and the greatest differences in reproduction were among cultivars of winter wheat. Significant differences between reproduction of, and plant damage caused by the two populations occurred only on winter wheat. The Utah population reproduced more and caused greater reduction in tillering than did the Idaho population.

Key words: barley, Columbia root-knot nematode, *Hordeum vulgare, Meloidogyne chitwoodi,* population dynamics, *Triticum aestivum,* wheat.

RESUMEN

Griffin, G. D. 1992. Efectos comparativos de dos poblaciones de *Meloidogyne chitwoodi* sobre *Triticum aestivum* y *Hordeum vulgare*. Nematrópica 22:65–74.

Se evaluaron las respuestas del trigo (*Triticum aestivum*) y la cebada (*Hordeum vulgare*) en un invernadero a dos poblaciones de *Meloidogyne chitwoodi*, provenientes de los estados de Utah y Idaho, U.S.A. Se incluyeron cinco cultivares de trigo de invierno, cuatro cultivares de trigo de primavera, dos cultivares de cebada de invierno, y dos cultivares de cebada de primavera. Ambas poblaciones indujeron la formación de agallas en las raíces y se reprodujeron en todos los cultivares de trigo y cebada. La infestación redujo tanto el ahijado como el crecimiento de raíces y tallos. El espigado resultó reducido o anulado en trigos y cebadas de primavera. Unicamente en el trigo de invierno se encontraron diferencias significativas entre tasas reproductivas y el daño causado por las dos poblaciones. La población de Utah se reprodujo más y afectó en mayor medida el ahijado que la población de Idaho.

Palabras clave: dinámica de poblaciones, cebada, *Hordeum vulgare, Meloidogyne chitwoodi*, nematodo agallador colombiano, trigo, *Triticum aestivum.*

INTRODUCTION

Wheat (*Triticum aestivum* L.) is grown in most of the major grain producing areas and provides 20% of the total food calories for the people of the world (13). About 240 million hectares of wheat are planted annually. Five million hectares of wheat are grown annually in the western United States (1). Wheat cultivars can be classified as winter wheat or spring wheat. Winter wheats require a period of low temperature for head set but generally are higher yielding than spring wheats. Spring wheats have an erect type

†Cooperative investigation by the Agricultural Research Service of the U.S. Department of Agriculture, and the Utah Agricultural Experiment Station. Journal Paper No. 4048.

of early growth in contrast to the prostrate growth habits of winter wheat seedlings. Winter wheats tiller readily, whereas spring wheats do not (3,11).

Barley (*Hordeum vulgare* L.) may have been the first plant cultivated and has the widest ecological range of the cereals (3). It is cultivated from the arctics to the equator, and to an elevation of 5 000 m (8). Once used mainly for human consumption, barley is now grown mainly for animal feed and malting. About 4 million hectares of barley are grown in the United States annually. Barley cultivars, like wheat, are classed as winter barleys and spring barleys. Winter barleys require vernalization for head set (18).

In the western United States, potato (*Solanum tuberosum* L.) is often rotated with wheat, and both crops are hosts of the Columbia root-knot nematode, *Meloidogyne chitwoodi* Golden, O'Bannon, Santo, & Finley (5,7,15,16). Sometimes potato is rotated with barley. About 0.2 million hectares of fall potatoes are grown in the intermountain and northwestern United States (1), and approximately 30% of the potato producing areas are infested with *M. chitwoodi* (7,15,16). *Meloidogyne chitwoodi* can greatly reduce marketable potato yields and is considered a serious problem.

The pathology induced by *M. chitwoodi* and other *Meloidogyne* spp. varies on cereals (4,10,12,14,17,19). Pathological races of *M. chitwoodi* have been found in Idaho, Utah, and Washington (7,16), based on presence or absence of the ability to reproduce on alfalfa. Populations also differ in their pathological effects on potato. This study was initiated to determine if *M. chitwoodi* populations that do and do not reproduce on alfalfa differ in their pathological effects on wheat and barley.

MATERIALS AND METHODS

Nematode inocula: Meloidogyne chitwoodi populations from potato fields at Beryl, Utah, and Ft. Hall, Idaho, were used in the study. The Utah population parasitizes and reproduces on alfalfa, and is more virulent to potato than the Idaho population (7); alfalfa is a nonhost for the Idaho population. Nematodes were reared on wheat cv. Nugaines in a temperature-controlled greenhouse at 24 ± 2 C. Eggs were collected by the NaOC1 method (9).

Cultivars included winter wheats Manning, Dusty, Daws, Wanser, and Nugaines, the spring wheats Fremont, Twin, Borah, and Fielder, the winter barleys Luther and Kamiak, and spring barleys Steptoe and Kombar.

Seeds were planted into plastic tubes (6 cm diam, 30 cm long) containing 540 cm^3 steam-sterlized Kidman fine sandy loam (coarse-loamy mixed mesic Calcic Haploxeroll; 85% sand, 8% silt, 7% clay; pH 7.1; 0.5% organic matter). Twenty-one days after planting, each plant was inoculated with the Utah or the Idaho population at the rate of 0, 2, 10, or 20 eggs/cm^3 soil. An egg suspension in deionized water was poured into four holes 10-cm deep in the soil around the hypocotyl base of each plant. Plants were arranged in a randomized complete-block design with 20 replications and were maintained in a greenhouse at 24 ± 2 C. Supplemental light for a 19-hr daylength was provided by high-output florescent lamps. Plants were watered daily and fertilized monthly with a complete nutrient solution.

All plants were harvested 96 days after inoculation. Tillers per plant, plant height, shoot and root dry weights, and root galling index (1 = no galling, 2 = 1–10%, 3 = 11–20%, 4 = 21–50%, 5 =

51–80%, 6 = 81–100% root tissue galled) were determined. Nematode eggs were extracted from each root system by the NaOCl method (9). Eggs were counted and the nematode reproductive index (Pf/Pi = final nematode population per plant/initial nematode population per plant) was calculated. Plants were not subjected to vernalization required for head set on winter wheats and barleys (2,3); hence, heads per plant, head length, and head dry weights were measured only for spring wheats and barleys. Each parameter measured was regressed against inoculum density. Differences between means were compared with the LSD at $P \leq 0.05$. The experiment was repeated. The data presented are the combined data of the two experiments.

RESULTS

Results of the two experiments were similar. Only effects that occurred in both experiments are discussed unless otherwise stated.

Winter and spring wheat: Winter wheat tillered more than spring wheat (Fig. 1). *Meloidogyne chitwoodi* populations from Utah and Idaho reduced tillering of all winter wheat cultivars and there was a significant negative correlation between tillering and nematode Pi ($r = -0.84$). The Utah population (MC1) reduced tillering more than the Idaho population (MC2) at inoculum levels of 2 and 10 eggs/cm^3 soil.

Plant heights of winter wheats Wanser, Nugaines, and Daws, and all spring wheat cultivars were reduced by both nematode populations. The greatest plant height reduction occurred on spring wheat at a Pi of 20 eggs/cm^3 soil. Both populations reduced shoot dry weight of winter and spring wheats; and there was a significant negative correlation between Pi and winter wheat shoot dry weight ($r = -0.78$). In winter wheats, reduced shoot dry weight resulted primarily from a reduction in the number of tillers per plant whereas in spring wheat, decreases in dry weight resulted from reduced plant height.

Both *M. chitwoodi* populations had similar effects on head set, head length, and head dry weights of spring wheat (Fig. 2). Heads per plant, head length, and head dry weight were reduced below those of uninoculated control plants at all Pi levels; the greatest reductions occurred at a Pi of 20 eggs/cm^3 soil. There was an inverse relationship between inoculum density and heads per plant ($r = -0.84$), and between inoculum density and head dry weight ($r = -0.81$). Head length was not significantly correlated with inoculum density ($r = -0.29$).

Both nematode populations reduced winter and spring wheat root growth (Fig. 3). The lowest spring wheat root weight occurred on Fremont, Twin, and Fielder. There was a direct correlation between Pi and root galling indices ($r = 0.85$). The greatest root galling indices occurred on winter wheats inoculated with 20 eggs/cm^3 soil.

Greatest nematode reproduction occurred at a Pi of 2 eggs/cm^3 soil (Fig. 3). The reproductive index differed several fold among winter wheat cultivars. On Nugaines and Wanser, reproduction by the Utah population (MC1) significantly exceeded reproduction by the Idaho population (MC2). Nematode reproduction did not differ among spring wheat cultivars.

Winter and spring barley: There were no significant differences between the two nematode populations for any parameter measured. Winter and spring cultivars tillered similarly and tillering was similarly suppressed by nematode

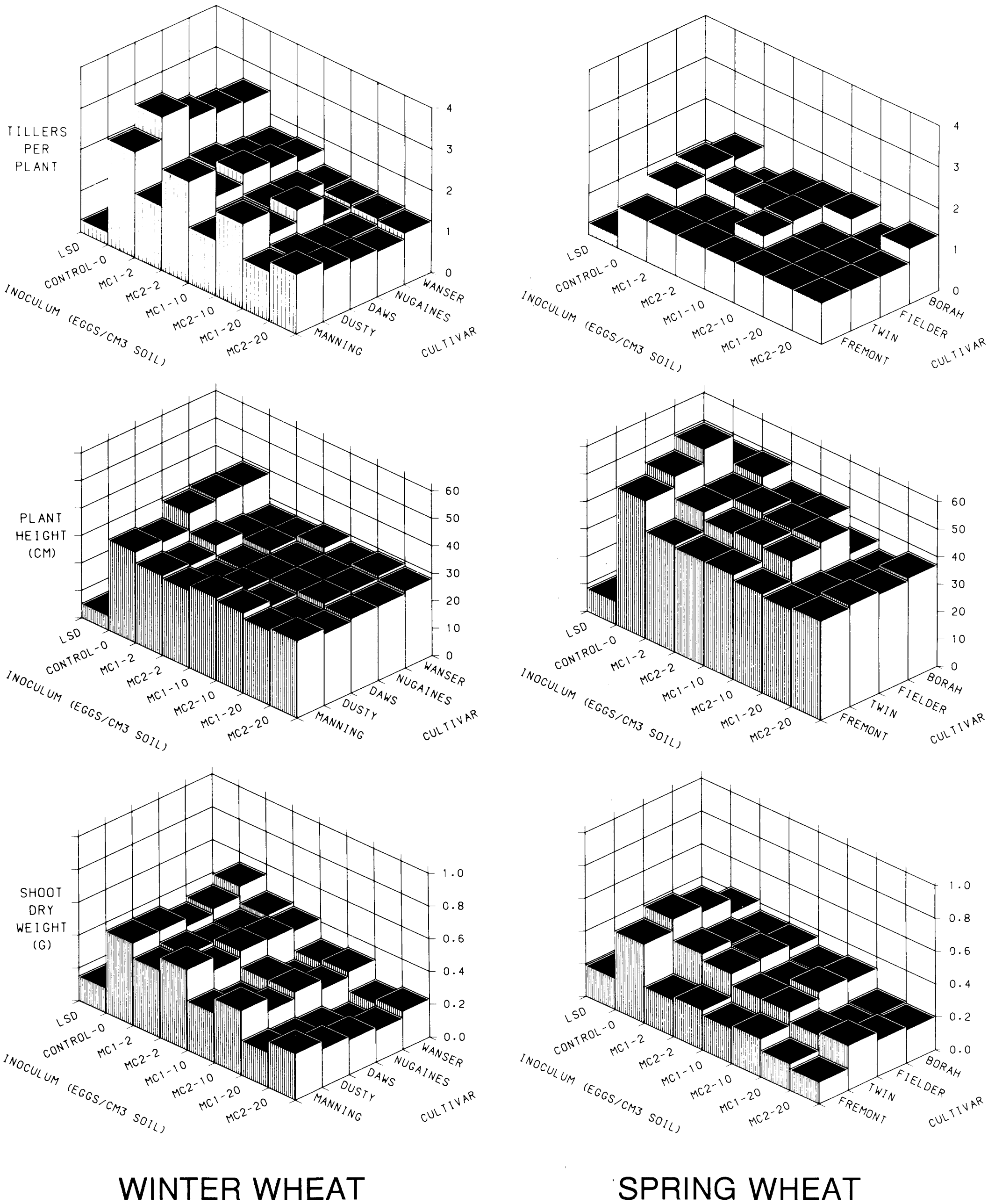

Fig. 1. Effect of a Utah population (MC1) and an Idaho population (MC2) of *Meloidogyne chitwoodi* on tillering, plant height, and shoot dry weight of winter and spring wheat cultivars in a greenhouse after 117 days at 24 ± 2 C.

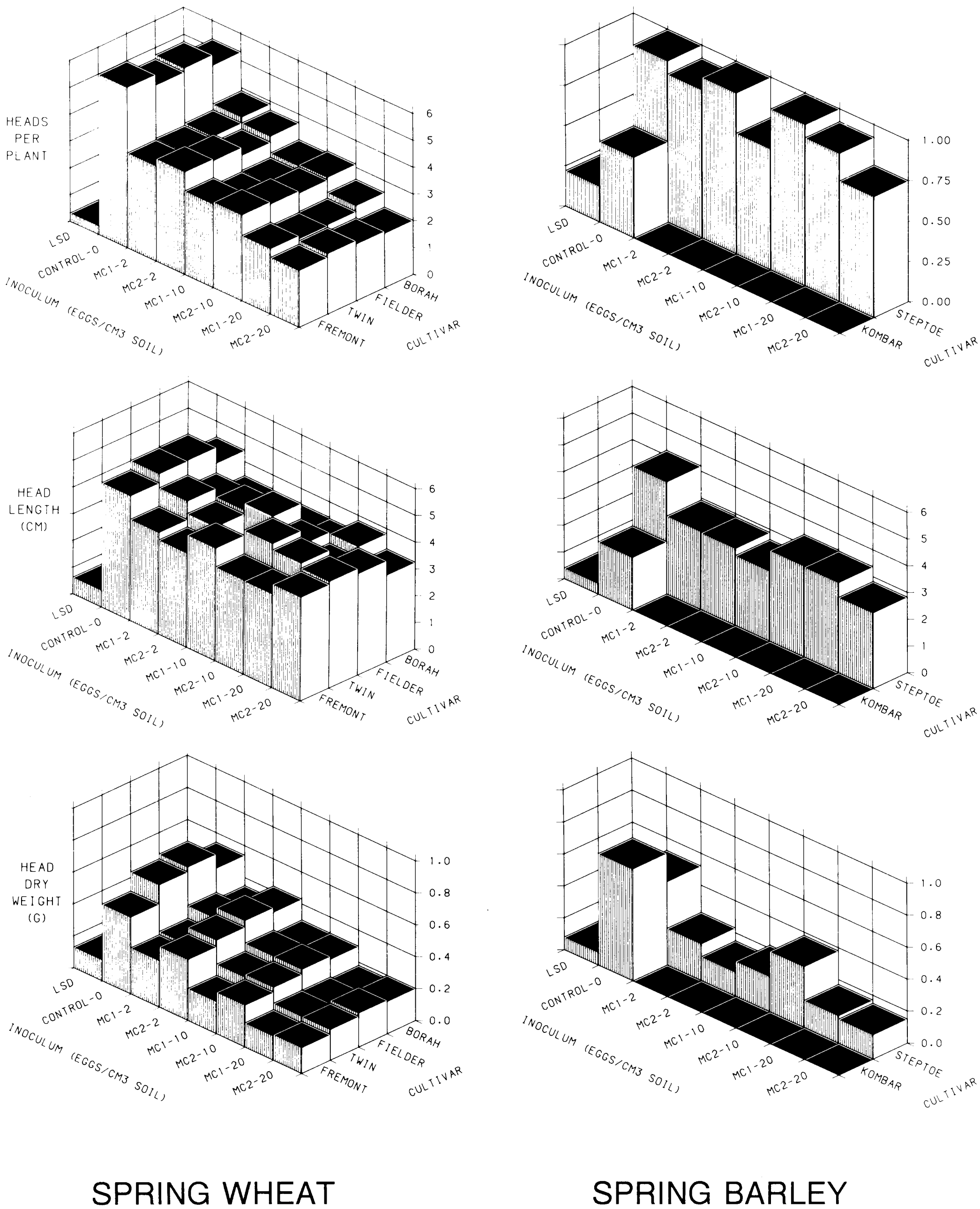

Fig. 2. Effect of Utah population (MC1) and an Idaho population (MC2) of *Meloidogyne chitwoodi* on heads per plant, head length, and head dry weight of selected cultivars of spring wheat and spring barley in a greenhouse after 117 days at 24 ± 2 C.

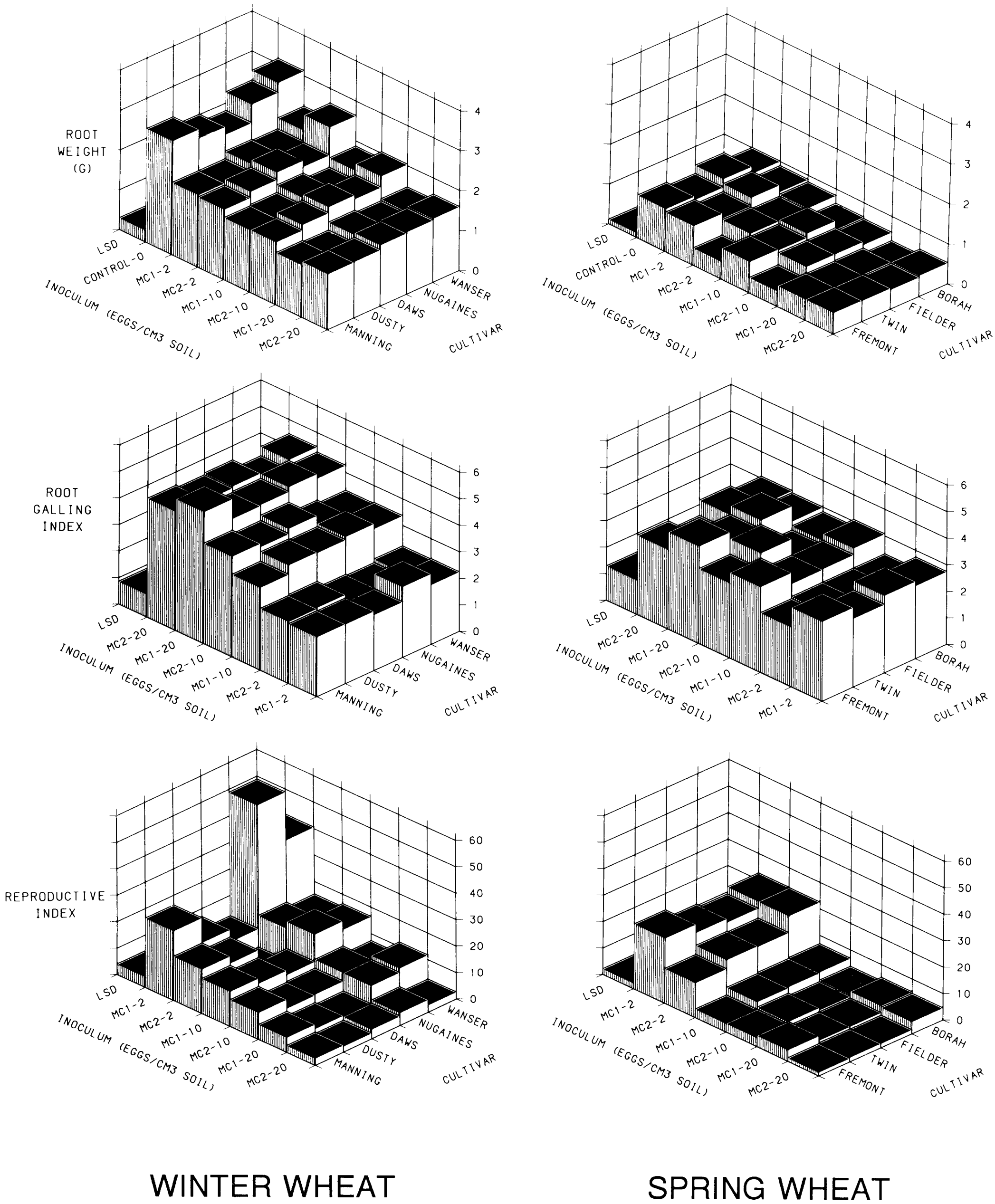

Fig. 3. Effect of a Utah population (MC1) and an Idaho population (MC2) of *Meloidogyne chitwoodi* on root weight, root galling index and nematode reproductive index on winter and spring wheat cultivars in a greenhouse after 117 days at 24 ± 2 C.

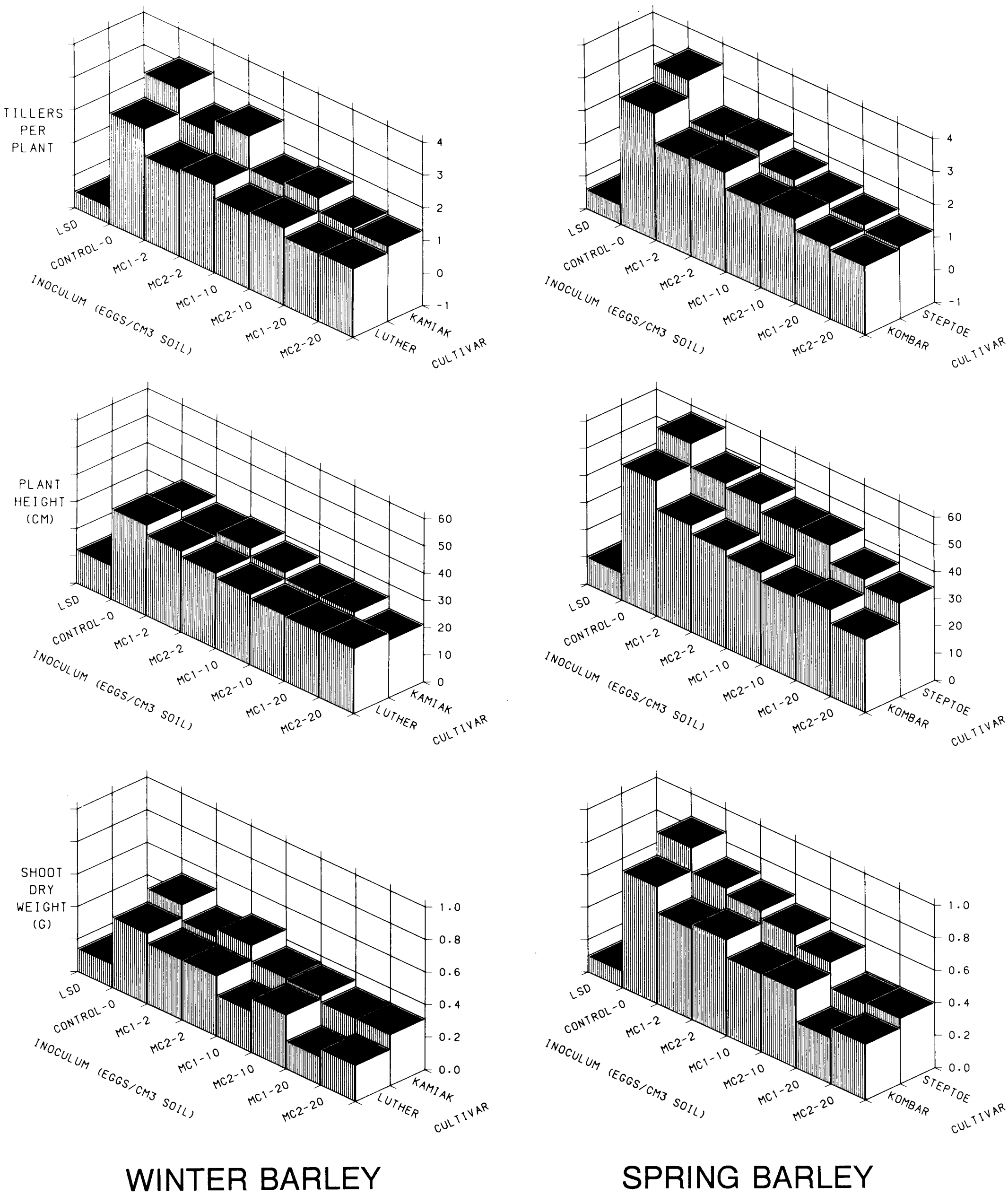

Fig. 4. Effect of a Utah population (MC1) and an Idaho population (MC2) of *Meloidogyne chitwoodi* on tillering, plant height, and shoot dry weight of winter and spring barley cultivars in a greenhouse after 117 days at 24 ± 2 C.

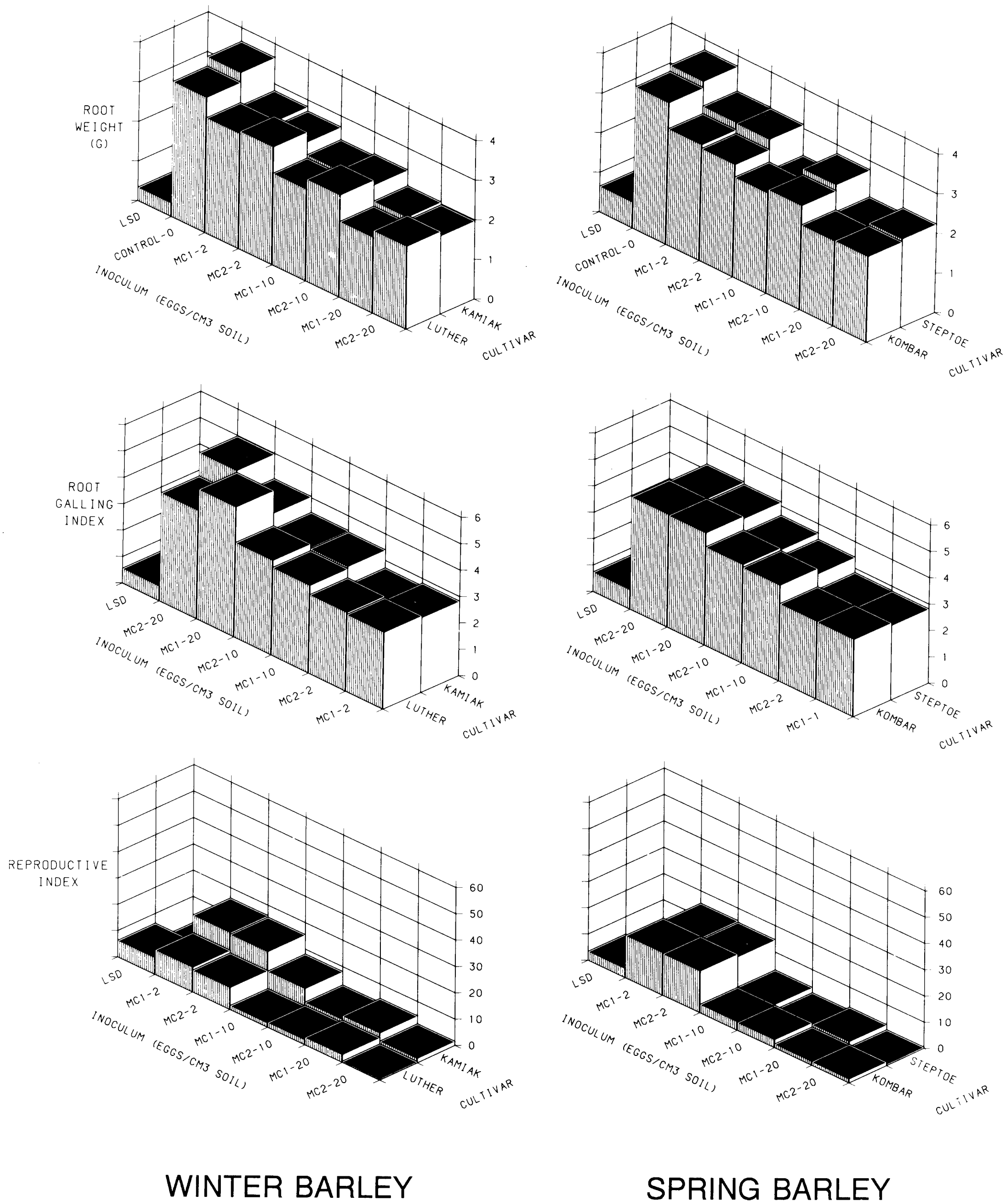

Fig. 5. Effect of a Utah population (MC1) and an Idaho population (MC2) of *Meloidogyne chitwoodi* on root weight, root galling index, and nematode reproductive index on winter and spring barley cultivars in a greenhouse after 117 days at 24 ± 2 C.

parasitism (Fig. 4). Tillering of both winter and spring barley was less affected than winter wheat was by inoculum density. Plant height of winter barley was not significantly affected by an increase in inoculum density; the greatest reduction in spring barley height resulted from inoculation with 20 eggs/cm³ soil (Fig. 4). Winter barley shoot dry weights were signigicantly reduced only at a Pi of 20 eggs/cm³ soil. All inoculum levels reduced spring barley shoot weight.

Nematode invasion reduced heads per plant, head length, and head dry weight of Steptoe spring barley; the head length and head dry weight of Steptoe were reduced at all inoculum levels (Fig. 2). Nematode inoculation prevented head set of Kombar spring barley. Unlike spring wheat, there is no significant correlation between inoculum density and the number of heads per plant ($r = -0.21$), or head dry weight ($r = -0.23$).

Root weights of winter and spring barley were reduced at all Pi levels, and the greatest reductions occurred at 20 eggs/cm³ soil (Fig. 5). There were positive correlations between Pi and the root galling index for winter barley ($r = 0.74$) and spring barley ($r = 0.88$).

Reproductive indices were greatest on winter and spring barley at a Pi of 2 eggs/cm³ soil (Fig. 5). Overall, the reproductive indices of both populations on barley were 54% less than on wheat.

DISCUSSION

Findings of this study agree with those of Nyczepir *et al.* (12), who showed that *M. chitwoodi* reduced grain yields of spring wheat cv. Fielder. Data from this study showed important varietal differences in the reactions of grain cultivars to *M. chitwoodi*. Similar differences may occur under field conditions. The Utah population used in this study is more aggressive on potato and alfalfa than is the Idaho population (7), and some aspects of wheat growth were affected differently by the two populations. The Utah population, for example, reduced tillering of winter wheat more than did the Idaho population. There were no differences between the dry shoot weights of plants inoculated with the two populations, apparently because plants can compensate for a reduction in tillering by increased tiller growth.

Meloidogyne chitwoodi differed in reproduction on wheat and barley, and different phenological stages of plant development were affected by the nematode invasion. Although there were little or no differences between the effects of *M. chitwoodi* on the different winter wheat cultivars, nematode reproduction differed appreciably among the cultivars. This agrees with the general observation that the effect of a pathogen on a plant and the effect of the plant on the metabolic activity and reproduction of a pathogen may be governed by different genetic variables (4,6). The wheat cultivars Nugaines and Wanser were much better hosts for the Utah population of *M. chitwoodi* than were Manning, Dusty, and Daws. Since the subsequent invasion and galling of roots and tubers of a succeeding potato planting would be affected accordingly, it will be valuable to verify the results of this study under field conditions to provide practical information for growers regarding the best choice of wheat cultivars used in rotation with potato.

LITERATURE CITED

1. ANONYMOUS. 1989. Agricultural Statistics. United States Department of Agriculture. United States Government Printing Office, Washington, D.C.

2. ARMAND, B., A. L. BLACK, A. B. FRANK, and E. H. VASEY. 1990. Agronomic characteristics of spring barley in the northern Great Plains. North Dakota Agricultural Experiment Station Bulletin No. 533. 47 pp.
3. BLAND, B. F. 1971. Crop Production: Cereals and Legumes. Academic Press: New York.
4. GRIFFIN, G. D. 1984. Nematode parasites of alfalfa, cereals, and grasses. Pp. 243–321 *in* W. R. Nickle, ed. Plant and Insect Nematodes. Marcel Dekker: New York.
5. GRIFFIN, G.D. 1985. Host-parasite relationship of *Meloidogyne chitwoodi* on potato. Journal of Nematology 17:395–399.
6. GRIFFIN, G. D. 1975. Parasitism of nonhost cultivars by *Ditylenchus dipsaci*. Journal of Nematology 7:236–238.
7. GRIFFIN, G. D., and S. V. THOMSON. 1988. The Columbia root-knot nematode, *Meloidogyne chitwoodi*, discovered in the State of Utah. Plant Disease 72:363 (abstract).
8. HUNTER, H. 1952. The Barley Crop. Crosby Lockwood and Son, Ltd.: London.
9. HUSSEY, R. S., and K. R. BARKER. 1973. A comparison of methods of collecting inocula of *Meloidogyne* spp. including a new technique. Plant Disease Reporter 57:1025–1028.
10. INSERRA, R. N., N. VOVLAS, J. H. O'BANNON, and G. D. GRIFFIN. 1985. Development of *Meloidogyne chitwoodi* on wheat. Journal of Nematology 17:322–326.
11. MARTIN, J. H., W. H. LEONARD, and D. L. STAMP. 1976. Principles of field crop production. MacMillan Publishing Company, Inc.: New York.
12. NYCZEPIR, A. P., R. N. INSERRA, J. H. O'BANNON, and G. S. SANTO. 1984. Influence of *Meloidogyne chitwoodi* and *M. hapla* on wheat growth. Journal of Nematology 16:162–165.
13. REITZ, L. P. 1967. World distribution and importance of wheat. Pp. 1–18 *in* K. S. Quisenberry and L. P. Reitz, eds. Wheat and Wheat Improvement. American Society of Agronomy: Madison, Wisconsin, U.S.A.
14. ROBERTS, P. A., S. D. VAN GUNDY, and H. E. McKINNEY. 1981. The effect of soil temperature and planting date of wheat on *Meloidogyne incognita* reproduction, soil populations, and grain yield. Journal of Nematology 13:338–345.
15. SANTO, G. S., J. H. O'BANNON, A. M. FINLEY, and A. M. GOLDEN. 1980. Occurrence and host range of a new root-knot nematode (*Meloidogyne chitwoodi*) in the Pacific Northwest. Plant Disease 64:951–952.
16. SANTO, G. S., and J. N. PINKERTON. 1985. A second race of *Meloidogyne chitwoodi* discovered in Washington State. Plant Disease 69:361 (abstract).
17. SANTO, G. S., and J. H. O'BANNON. 1981. Pathogenicity of the Columbia root-knot nematode (*Meloidogyne chitwoodi*) on wheat, corn, oats, and barley. Journal of Nematology 13:548–550.
18. SCHLEHUBER, A. M., and B. B. TUCKER. 1973. Culture of wheat. Pp. 117–119 *in* K. S. Quisenberry and L. P. Reitz, eds. Wheat and Wheat Improvement. American Society of Agronomy: Madison, Wisconsin, U.S.A.
19. THOMASON, I. J. 1962. Reaction of cereals and sudan grass to *Meloidogyne* spp. and the relation of soil temperature to *M. javanica* populations. Phytopathology 52:787–791.

Received: *5.VIII.1991*
Recibido:

Accepted for publication: *31.III.1992*
Aceptado para publicar: