

Pathological Reaction of Crested Wheatgrass Cultivars to Four *Meloidogyne chitwoodi* Populations¹

G. D. GRIFFIN AND K. H. ASAY²

Abstract: *Meloidogyne chitwoodi* populations from Tulelake, California; Ft. Hall, Idaho; Beryl, Utah; and Prosser, Washington, significantly ($P < 0.05$) reduced dry shoot weights of crested wheatgrass (*Agropyron cristatum* L., Gaertn. and *A. desertorum*, Fisch. ex Link, Schult.) cultivars Hycrest, Fairway, and Nordan in experiments conducted in a greenhouse and growth chamber. Shoot growth depression, root galling, and nematode reproduction indices were greatest ($P < 0.05$) on plants inoculated with 5,000 eggs/plant. Nematode populations from Tulelake, Ft. Hall, and Beryl significantly ($P < 0.05$) reduced the growth of the three grass cultivars at 15, 20, 25, and 30 C; the greatest reductions occurred at 20 and 25 C. There were significant differences in the virulence of the nematode populations at high (30 C) and low (15 C) soil temperatures. At 15 C, plant growth was reduced more by the Beryl and Tulelake than by the Ft. Hall population; whereas at 30 C, the Ft. Hall population was more virulent than the Beryl and Tulelake populations. Root galling and nematode reproduction were greater on plants inoculated with Beryl and Tulelake populations at 15 C than on plants inoculated with the Ft. Hall population, while the Ft. Hall population had the most pronounced effects at 30 C.

Key words: *Agropyron cristatum*, *Agropyron desertorum*, Columbia root-knot nematode, crested wheatgrass, resistance, reproductive index, root gall rating, susceptibility, temperature.

There are more than 155 million hectares of rangelands in the eight states of the Intermountain region which provide essential forage for livestock. In addition, these rangelands provide habitat for wildlife and have important recreational qualities. Unfortunately, only 14% of these rangelands are classified in good condition or are producing within 60% of their natural potential (17). In general, rangelands can be upgraded by better management or by replacing existing vegetation with improved grasses, forbs, and shrubs. Revegetation with superior forage grasses is a relatively economical and long-lasting means of improving depleted rangelands. Breeding programs to develop superior plant materials for this purpose have received increasing emphasis during the past decade (1-3).

Plant-parasitic nematodes can substantially reduce the longevity and productivity of perennial grasses on semiarid rangelands in the West (6). Several species of root-knot nematodes are associated with the growth of grasses (4,6,13,14). The Co-

lumbia root-knot nematode, *Meloidogyne chitwoodi* Golden, O'Bannon, Santo & Finley, is associated with several plant species, including grasses that have been developed for rangeland improvement (9,11,13). Races of *Meloidogyne* spp., including *M. chitwoodi* populations, have been differentiated (7,12,15). Soil temperature may affect the relationship between *M. chitwoodi* and plant growth (5,8,16).

The objective of this study was to determine the effect of different populations and inoculum levels of *M. chitwoodi* on the growth of crested wheatgrass (*Agropyron cristatum* L., Gaertn. and *A. desertorum*, Fisch. ex Link, Schult.) and the effects of temperature on the host-parasite relationship.

MATERIALS AND METHODS

Nematode inocula: *Meloidogyne chitwoodi* populations, taken from potato (*Solanum tuberosum* L.), near Tulelake, California (CA); Ft. Hall, Idaho (ID); Beryl, Utah (UT); and Prosser, Washington (WA), were used in greenhouse and growth chamber experiments. Populations were reared on wheat (*Triticum aestivum* L. cv. Nugaines) in a greenhouse to obtain inocula. Inoculum (eggs) was collected by a NAOCl method (10).

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² Nematologist and Research Geneticist, USDA ARS, Forage and Range Research Laboratory, Utah State University, Logan, UT 84322.

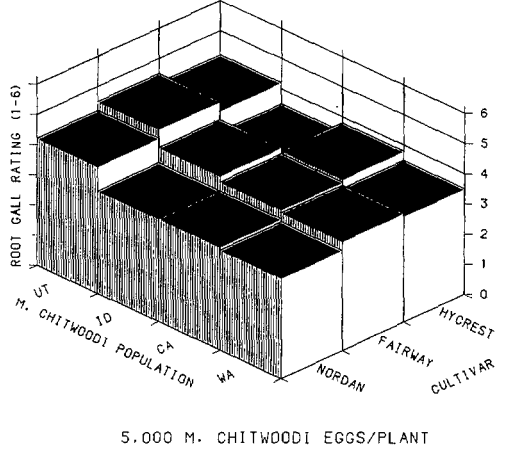
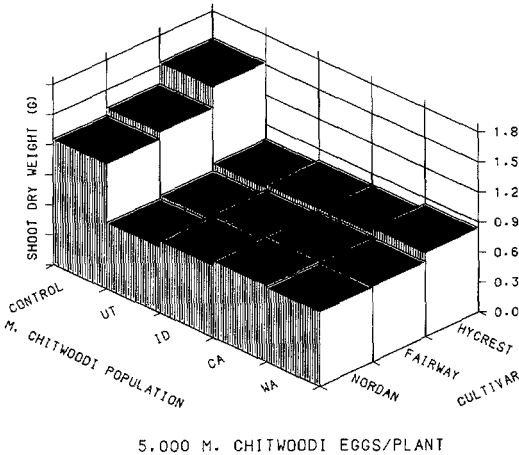
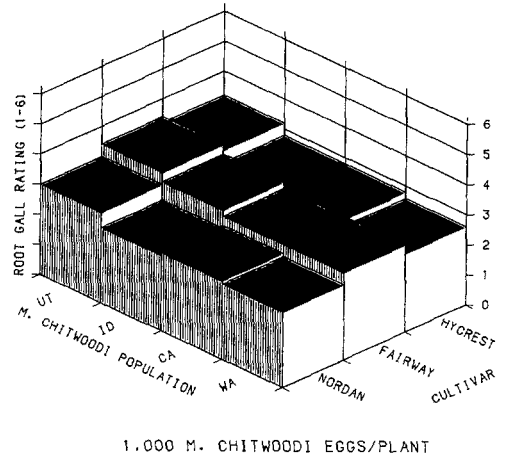
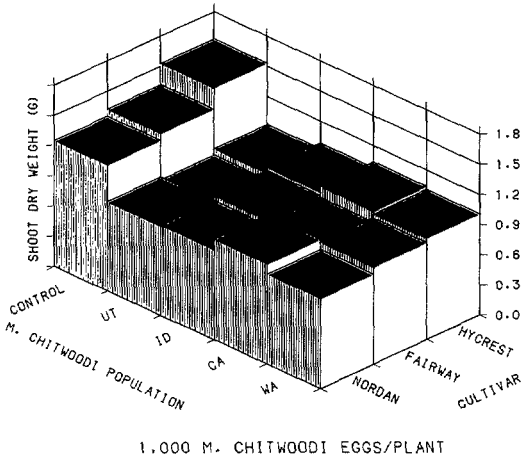


FIG. 1. Growth of three cultivars of crested wheatgrass at three inoculum levels of four populations of *Meloidogyne chitwoodi* in a greenhouse at 24 ± 3 C compared with uninoculated controls. LSD ($P < 0.05$) = 0.14 and 0.19 for differences in dry shoot weight among cultivars inoculated with the same nematode population, and 0.11 and 0.16 among nematode populations on the same cultivar, at Pi of 1,000 and 5,000 eggs and J2 per plant, respectively.

FIG. 2. Root galling of three cultivars of crested wheatgrass at two inoculum levels of four populations of *Meloidogyne chitwoodi* in a greenhouse at 24 ± 3 C (1 = no galling; 6 = 80–100% root tissue galled). LSD ($P < 0.05$) = 0.9 and 1.3 for differences in root galling indices among cultivars inoculated with the same nematode population, and 0.7 and 1.1 for differences among nematode populations on the same cultivar, at Pi of 1,000 and 5,000 eggs and J2 per plant, respectively.

Greenhouse experiment: Seedlings (2–5-mm radicle) of three crested wheatgrass cultivars (*Agropyron cristatum* × *A. desertorum* cv. Hycrest; *A. cristatum* cv. Fairway; and *A. desertorum* cv. Nordan) were planted into individual 6-cm-d plastic conetainers containing 540 cm³ steam pasteurized sandy loam soil (85% sand, 8% silt, 7% clay, pH 7.1). After 35 days growth, each seedling

was inoculated with either 0, 1,000, or 5,000 eggs of one of the four nematode populations. Eggs in an aqueous suspension of deionized water were poured into four holes 10 cm deep in the soil around the hypocotyl base.

Conetainers were maintained at a greenhouse temperature of 24 ± 3 C. Supple-

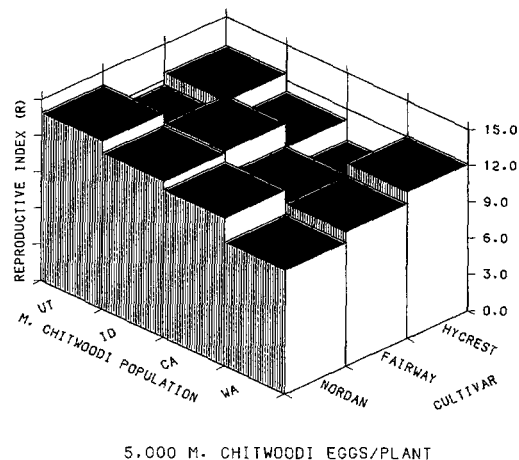
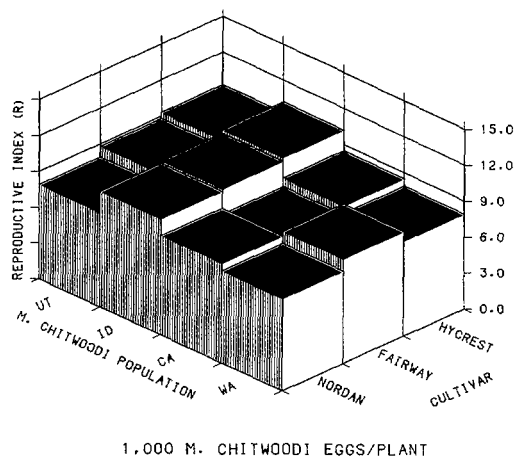


FIG. 3. Nematode reproductive index (R) (Pf/Pi) of two levels of inoculum of four populations of *Meloidogyne chitwoodi* on three cultivars of crested wheatgrass in a greenhouse at 24 ± 3 C. LSD ($P < 0.05$) = 2.8 and 3.4 for differences in reproductive index among cultivars inoculated with the same nematode population, and 3.2 and 3.8 among nematode populations on the same cultivar, at Pi of 1,000 and 5,000 eggs and J2 per plant, respectively.

mental light for a 19-hour daylength was provided by high-output fluorescent lamps. Treatments (one plant per container) were arranged in a randomized complete block design with 12 replications. Plants were watered daily and fertilized monthly. Shoots were clipped after 56, 112, and 169 days of growth. At termination of the experiment (169 days), total shoot dry

weights, root galling (1 = no galling; 6 = 80–100% root tissue galled), and the nematode reproductive index (final nematode population per plant/initial nematode population per plant) were determined (10) and data were recorded and subjected to analyses of variance.

Growth chamber experiment: Crested wheatgrass plants described in the greenhouse study were inoculated with the UT, ID, and CA nematode populations at 0, 1,000, or 5,000 eggs per plant. Temperatures were maintained at 15, 20, 25, or 30 C (± 1 C) and a 19-hour daylength was provided by high-output fluorescent lamps. Treatments were arranged in a randomized complete block with five replications. Shoot clippings were made at 56 days and 115 days (plant harvest). At termination of the experiment, plant weight and nematode galling and reproduction were obtained and analyzed as in the greenhouse studies.

RESULTS AND DISCUSSION

Greenhouse experiment: *M. chitwoodi* populations at both inoculum levels significantly ($P < 0.05$) reduced shoot dry weights of Hycrest, Fairway, and Nordan crested wheatgrass (Fig. 1). The greatest depression in shoot growth occurred on plants inoculated with 5,000 eggs per plant. The root galling and nematode reproduction patterns were correlated with the inoculum level (Figs. 2, 3); maximum indices were on plants inoculated with 5,000 eggs per plant.

Growth chamber experiment: The *M. chitwoodi* CA, ID, and UT populations significantly ($P < 0.05$) reduced the growth of the three grass cultivars at each of the four temperature regimes; the greatest shoot growth depression occurred on plants inoculated with 5,000 eggs per plant (Fig. 4). Population virulences were similar at all soil temperatures at an inoculum level of 1,000 eggs per plant, but differed at high and low soil temperatures at an inoculum level of 5,000 eggs per plant. At 15 C, shoot dry weight of plants parasitized by 5,000 eggs per plant of the UT and CA popu-

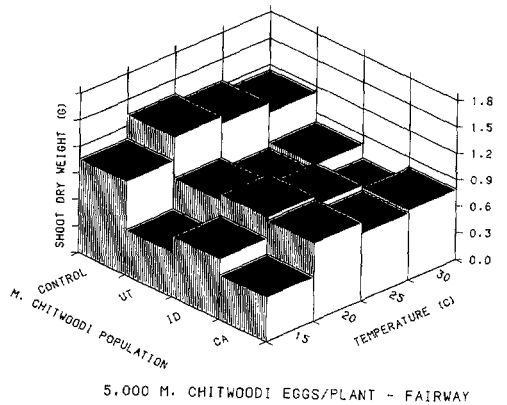
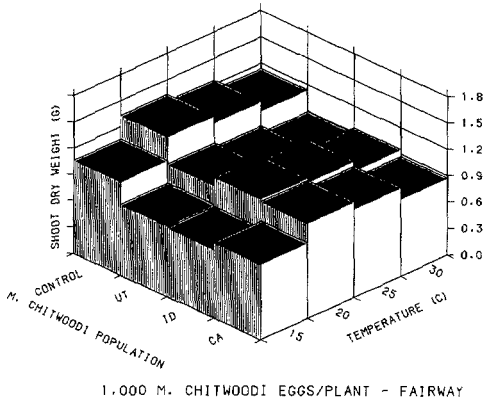
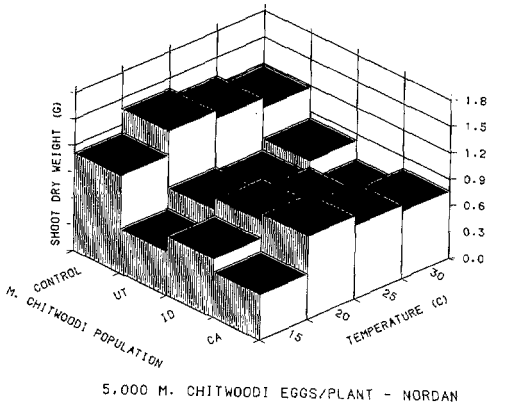
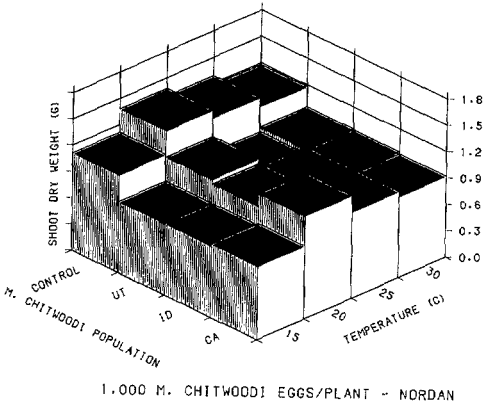
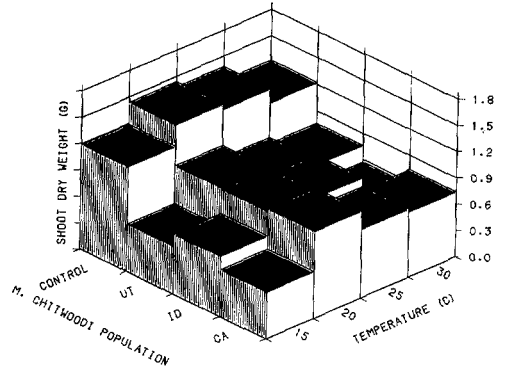
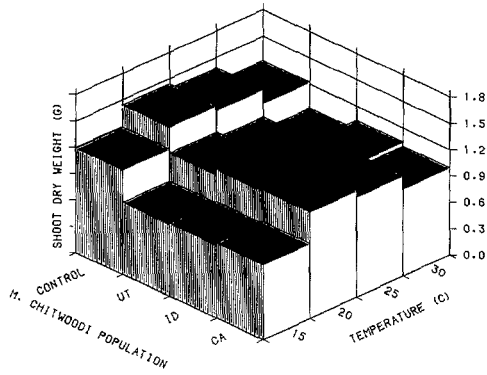


FIG. 4. Growth of three cultivars of crested wheatgrass at three inoculum levels of three populations of *Meloidogyne chitwoodi* at four different growth chamber temperatures compared with uninoculated controls. LSD ($P < 0.05$) = 0.14 and 0.24 for differences in dry shoot weight between cultivars at the same temperature and nematode population, 0.17 and 0.22 between temperatures for the same cultivar and nematode population, and 0.20 and 0.26 between nematode populations for the same temperature and cultivar, at Pi of 1,000 and 5,000 eggs and j2 per plant, respectively.

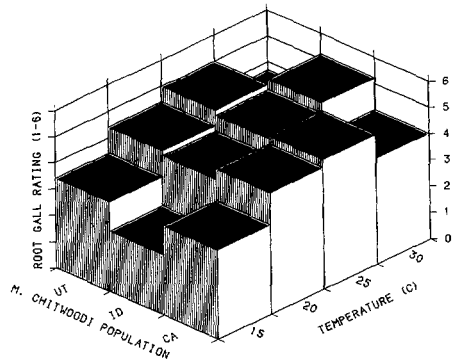
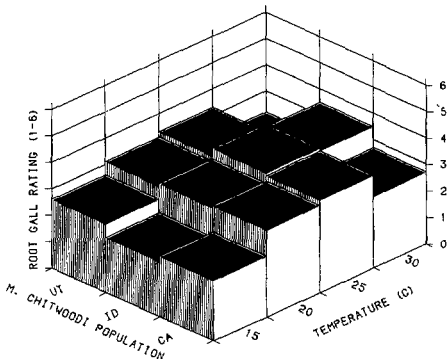
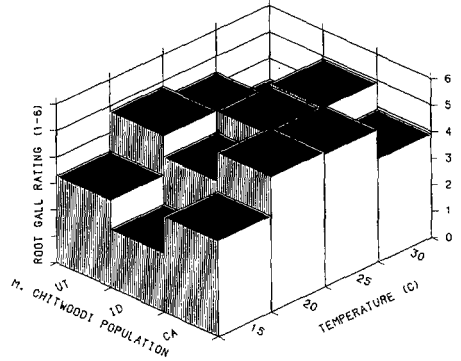
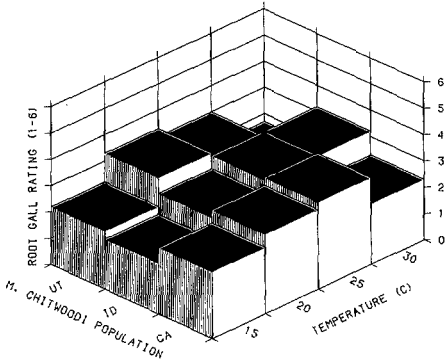
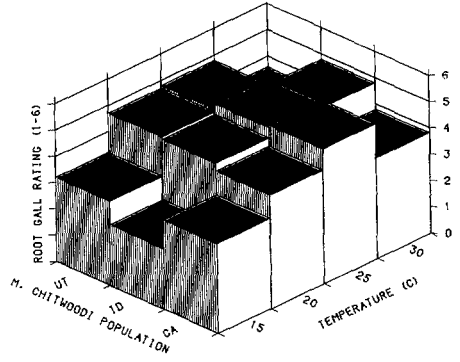
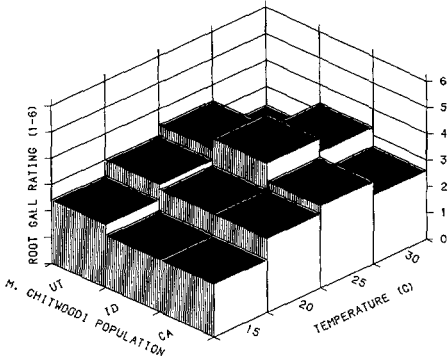


FIG. 5. Root gall rating (1 = no galling; 6 = 80–100% root tissue galled) of two inoculum levels of three populations of *Meloidogyne chitwoodi* on three cultivars of crested wheatgrass at four different growth chamber temperatures. LSD ($P < 0.05$) = 1.0 and 1.4, for differences in root galling indices between cultivars at the same temperature and nematode population, 1.6 and 1.8 between temperatures for the same cultivar and nematode population, and 2.0 and 2.3 between nematode populations for the same temperature and cultivar, at Pi of 1,000 and 5,000 eggs and J2 per plant, respectively.

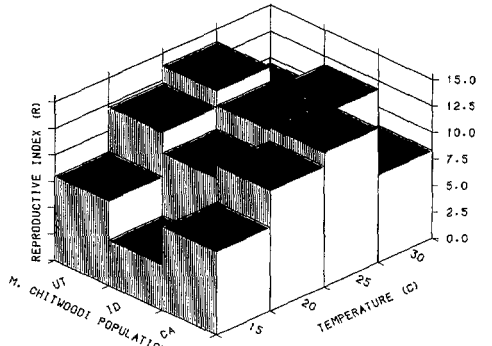
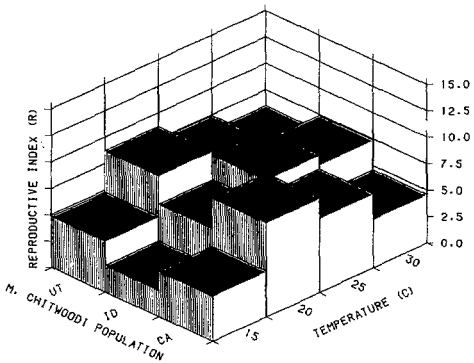
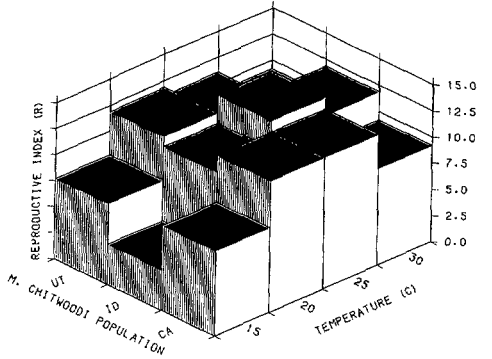
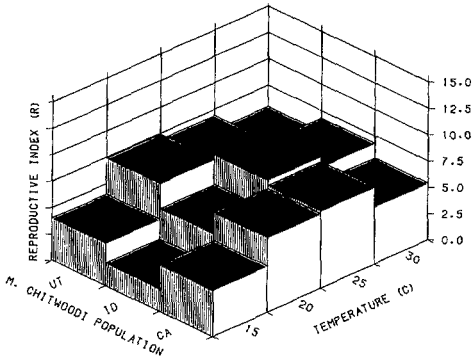
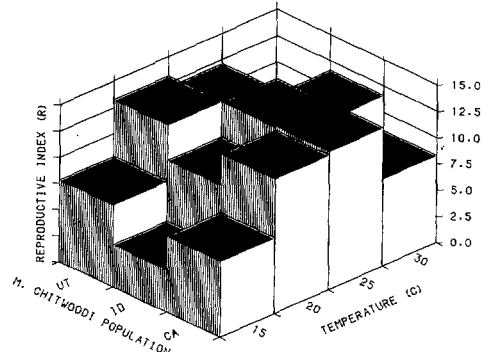
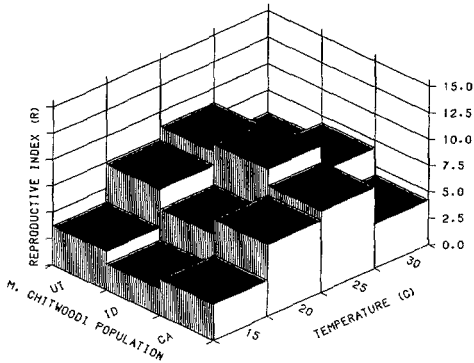


FIG. 6. Nematode reproductive index (R) (Pf/Pi) of two levels of inoculum of three populations of *Meloidogyne chitwoodi* on three cultivars of crested wheatgrass at four different growth chamber temperatures. LSD ($P < 0.05$) = 1.9 and 2.4 for differences in reproductive index between cultivars at the same temperature and nematode population, 2.8 and 3.3 between temperatures for the same cultivar and nematode population, and 2.6 and 2.9 between nematode populations for the same temperature and cultivar, at Pi of 1,000 and 5,000 eggs and J₂ per plant, respectively.

lations was reduced more than that of plants parasitized by the ID population; whereas at 30 C, 5,000 eggs of the ID population per plant caused the greatest reduction in shoot dry weight.

As with the greenhouse bench study, the root galling and nematode reproduction patterns were correlated with the inoculum level (Figs. 5, 6). The maximum root galling and nematode reproduction were on plants inoculated with 5,000 eggs per plant, and root gall ratings and nematode reproductive indices differed among the nematode populations. Galling and reproduction of the UT and CA populations were greater than those of the ID population at 15 C, whereas galling and reproduction of the ID population were greater than those of the UT and CA populations at 30 C.

Pathological differences in the virulence and reproduction of *M. chitwoodi* from different locations apparently reflect differences in environmental conditions. Data are not available on nematode reproduction (generations per year) of *M. chitwoodi* from Tulelake. There are, however, 2–3 nematode generations per year at Ft. Hall (5), and one generation per year at Beryl (Griffin, unpubl.). These differences could account for the adaptations of nematode populations to different soil temperatures. The uniform response to *M. chitwoodi* indicates these three crested wheatgrass cultivars are not resistant to *M. chitwoodi*. The genetic systems conditioning their host-parasite relationship are apparently not related to those factors affecting plant growth and environmental adaptability.

Meloidogyne chitwoodi can parasitize, reproduce and stunt the growth of crested wheatgrass, which is one of the most prevalent cool-season grasses on western rangelands. Identifying germplasm resistant to *M. chitwoodi* and incorporating the appropriate resistance factors into improved cultivars would result in valuable rangeland grasses for nematode-infested areas.

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