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Effects of *Meloidogyne incognita* on Growth and Storage-Root Formation of Cassava (*Manihot esculenta*)[1]

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Abstract: Two-node cuttings of cassava cultivar SS4 were inoculated with 1,000 infective juveniles of *Meloidogyne incognita* at 1, 14, 40, 70, 88, and 127 days after planting (DAP). Plant growth and root damage were assessed at 150 DAP. *Meloidogyne incognita* significantly reduced the number of storage-roots formed in plants inoculated at 14, 40, 70, and 88 DAP and the total weight of storage-roots in plants inoculated at 1, 14, 40, 70, and 88 DAP, compared to uninoculated plants. Individual storage-root weight and plant height were not affected by *M. incognita*. Storage-root formation in cassava is initiated when plants are 1 to 2 months old. The results of this experiment indicate that, at this time, young cassava plants are most prone to root-knot nematode damage in terms of storage-root formation. The production loss caused by *M. incognita* to young SS4 plants was due to a reduction of storage-root number rather than a reduction in individual storage-root weight.

Key words: cassava, galling index, *Manihot esculenta, Meloidogyne incognita,* nematode, pathogenicity, storage-root formation.

Cassava (*Manihot esculenta* Crantz) is a major food crop in sub-Saharan Africa and throughout the tropics (Food and Agricultural Organization, 1989). Nematodes can cause yield losses of up to 87% in cassava (Caveness, 1982a). Root-knot nematodes have been identified as the main nematode species affecting cassava (Jatala and Bridge, 1990; Luc, 1968; McSorley et al., 1983). Depending on genotype, cassava cultivars react differently to root-knot nematodes (Diomande, 1982; Saka, 1982). In Uganda, *Meloidogyne* spp. have been observed on cassava, particularly in regions where crop rotation was not practiced and cassava was planted alongside root-knot nematode-susceptible crops (Makumbi-Kidza et al., 1998). Bridge et al. (1991) observed that little or no enlargement of storage-roots occurred where soils were severely infested with the nematodes, and Talwana et al. (1997) showed that high root-knot nematode densities at planting could lead to a complete failure of the cassava crop to establish.

The objective of this study was to determine the influence of *M. incognita* on the growth and storage-root formation of young cassava plants. Cultivar SS4, which is currently being distributed to farmers throughout Uganda (International Institute of Tropical Agriculture, 1998), was chosen as the test cultivar because of its high yield and resistance to cassava mosaic disease (Ssemakula et al., 1998).

Materials and Methods

The experiment was conducted in a screen house at the field research station of the International Institute of Tropical Agriculture in Sendusu, which is 25 km north of Kampala, Uganda. Pots were set up in a completely randomized design. Seven treatments, including six different plant ages at inoculation and an uninoculated control, were replicated 6 times. Pre-sprouted, two-node cuttings of cultivar SS4 were planted singly into polyethylene pots, each containing 1,000 g of a steam-sterilized mixture of sand and and topsoil (1 : 1 vol : vol). Treatments with nematodes were inoculated 1, 14, 40, 70, 88, or 127 days after planting (DAP). Aliquots of 1,000 freshly hatched juveniles suspended in tap water were pipeted into five 5-cm-deep holes equidistant around each plant. The nematode population used had been obtained from cassava

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grown in Masindi district, western Uganda, and subsequently reared on tomato (*Lycopersicon esculentum* cv. Hellfrucht); K. Kleynhans and M. Marais confirmed its identity as *M. incognita*. The experiment began on 3 April 1998 (DAP = 1) and ended on 31 August 1998 (DAP = 150), at which time storage-root number, storage-root fresh weight, root fresh weight, and plant height were recorded. Root galling was assessed using an index ranging from 0 to 5 (0 = 0, 1 = 1-10, 2 = 11-20, 3 = 21-70, 4 = 71-90, 5 = >90% of total root system galled) (Barker, 1985). The maximum daily temperature recorded during the experiment ranged from 29 to 37 °C.

Plant growth data were analyzed using the generalized linear model procedure of SAS (SAS Institute, Cary, NC), in which inoculation dates were taken as fixed effect and replicates as random effect. Least square means of treatments were separated using probability of difference options and individual treatments contrasted with the control.

Results

An average of 1.6 storage-roots was formed on uninoculated plants (Table 1). Storage-root number for plants inoculated at 14, 40, 70, and 88 days after planting was significantly reduced ($P < 0.05$) compared to uninoculated control plants. No significant reduction in storage-root number was observed for plants inoculated at 1 or 127 DAP. Individual storage-root weights were not different for inoculated and control plants; however, the total storage-root weight was significantly reduced for plants inoculated at 1, 14, 40, 70, and 88 DAP. With the exception of plants inoculated at 14 DAP, which had a mean root weight significantly higher than that of the control ($P < 0.05$), the root weights of inoculated plants did not differ. None of the inoculated treatments was significantly different from the control in height. The root-gall index of inoculated plants ranged from 1.5 to 4.8 (Table 1) and was highest for plants inoculated at 14 DAP.

Discussion

Nematode inoculation from as early as 1 DAP up to 88 DAP reduced the total weight of storage-roots, while inoculation from 14 DAP up to 88 DAP also reduced the total number of storage-roots formed. The results indicate that infection with *M. incognita* during the time of storage-root initiation was responsible for the reductions observed because storage-root formation in cassava is initiated when plants are 1 to 2 months old (International Institute of Tropical Agriculture, 1990). Once formed, cassava storage-roots are not normally infected by root-knot nematodes (Caveness, 1982b; McSorley et al., 1983). Therefore, in plants inoculated at 127 DAP, the number and weight of storage-roots formed were not affected. In these plants storage-root initiation had likely already been completed at the time the plants

TABLE 1. Effect of *Meloidogyne incognita* on storage-roots, roots, and plant height of cassava SS4 inoculated with 1,000 infective juveniles/plant, on six different intervals after planting (DAP).[a]

Plant age at inoculation[b] (days)	Storage-root number (n)	Individual storage-root weight (g)[c]	Total storage-root weight (g)	Root weight (g)	Height (cm)	Galling index[d] (0–5)
1	1.0	0.8	0.8*	6.5	22.0	4.0
14	0.4*	0.7	0.3*	9.0*	21.3	4.8
40	0.4*	0.8	0.3*	5.4	19.5	4.0
70	0.5*	1.6	0.9*	3.8	16.6	1.5
88	0.3*	2.2	0.7*	6.5	19.4	2.8
127	1.2	1.6	1.9	4.8	19.3	1.8
Control	1.6	1.7	3.2	6.0	21.3	0.0

[a] Numbers are means of 5 or 6 plants. Means in a column followed by an asterisk implies significant ($P < 0.05$) difference between the treatment and control.
[b] Plants consisted of pre-sprouted, two-node cuttings.
[c] The average weight of a storage-root per plant. Plants without storage-roots are not included.
[d] Where 0 = 0, 1 = 1–10, 2 = 11–20, 3 = 21–70, 4 = 71–90, 5 = >90% of total root system galled (Barker, 1985).

were infected. The reason that nematodes do not normally infect storage-roots was not investigated. The high galling index observed in plants inoculated at 1 to 40 DAP was expected because *M. incognita* was able to complete more life cycles in these plants than in the plants inoculated later. Our results demonstrate that yield loss in cassava is related to an inhibition of storage-root formation. This loss occurs in the absence of aerial symptoms or galling on formed storage-roots. The lack of knowledge about the possible importance of nematodes on cassava may be attributed to the mechanism of damage. The results are significant not only for breeding programs but also for integrated pest management strategies, which are important in Africa where cassava is inter-cropped with root-knot nematode-susceptible crops.

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