JOURNAL OF PLANT PROTECTION RESEARCH
Vol. 48, No. 3 (2008)

DOI: 10.2478/v10045-008-0035-4

ASSESSMENT OF YIELD LOSS OF ROSELLE (*HIBISCUS SABDARIFFA* L.) DUE TO ROOT-KNOT NEMATODE, *MELOIDOGYNE INCOGNITA* UNDER FIELD CONDITIONS

Ayodele Adesina Adegbite, Gideon Olubunmi Agbaje, Jimoh Abidoye*

RAJI, Omoniyi Olufunso ADEYEYE and Ganiyu Olatunde LAMIDI
Institute of Agricultural Research and Training, Obafemi Awolowo University, P. M. B. 5029, Moor Plantation, Ibadan, Nigeria

Received: November 9, 2007
Accepted: May 5, 2008

Abstract: Root-knot nematode *Meloidogyne incognita* (Kofoid & White) Chitwood is an economically important pathogen of many agricultural crops, and the frequency of occurrence, abundance and importance of this nematode in resource-poor agricultural production systems make control necessary. Field studies were conducted in 2004 and 2005 to determine yield loss of Roselle due to natural infestation by *M. incognita* using Carbofuran 3G at 2 kg a.i./ha and untreated as check. The yield of Roselle was found to be higher with the application of nematicide-Carbofuran 3G at 2 kg a.i./ha. The percentage increase over control was 48.7 and 40.8% in the years 2004 and 2005, respectively. A significant reduction in the yield of Roselle in untreated plots was mainly attributed to direct damage of the root system by the feeding of root-knot nematode *M. incognita*. Root-knot nematode population in carbofuran treated plots was significantly lower than in untreated check in the two years, also at harvest. In the check the nematodes multiplied many folds during the cropping season. High nematode population in the untreated check decreased plant growth and ultimately reduced the number of seeds and weight of seeds.

Key words: Roselle, yield loss, *Meloidogyne incognita*, root-knot nematodes, Carbofuran

INTRODUCTION

Roselle (*Hibiscus sabdariffa* L.) also called sorrel and Mesta, or Java jute originated in the West Indies and is a vegetable crop widely cultivated in tropical Asia, Australia, West and Central Africa (Tindall 1983).

*Corresponding address: talk2triple_a@fastmail.ca, ayo_sina521@yahoo.co.uk

Roselle is known under a variety of generic names such as *dah* in Cote d'Ivoire, *bisap* in Senegal, *Isapa* in Nigeria and *nsa* in Congo-Brazzaville (De-Lannoy 2001). Roselle is grown in all parts of Nigeria especially in the southwestern Nigeria conducive to root-knot nematodes. A number of plant parasitic nematodes have been reported to be associated with Roselle in Nigeria. Among these, root-knot nematode *Meloidogyne incognita* was greatly associated with the crop. This nematode constitutes a major constraint to Roselle production. Roselle varies in its susceptibility to *M. incognita*. Minton *et al.* (1970) reported that Roselle varied in root galling (scale of 1–4) from 1.8– 2.9 for *M. incognita*. Vawdrey and Stirling (1992) and Adeniji (1970) have also reported that several Roselle accessions are resistant to *M. incognita* and *M. javanica*. Symptoms of infection are the presence of root galls, excessive branching of roots and reduced root system. Poor germination and death of seedlings may be observed in cases of heavy infestations. Roselle yields were increased by as much as 2.5 t/ha in fields infested with *M. arenaria* and treated with ethylene dibromide, but no yield response to nematicide treatment was observed in soil infested with *M. javanica* (Minton and Adamson 1979). Adamson *et al*. (1975) reported that, because of the resistance of Roselle, it was an effective crop rotation for management of *M. incognita* and *M. javanica* on kenaf. Roselle is also likely to be effective in the management of *M. incognita* on cotton. In contrast, Heffes *et al*. (1991) reported that the Roselle (sorrel) cv. Red was severely galled and supported at least moderate levels of reproduction by race 1 of *M. incognita* population. Therefore it was felt desirable to report the yield loss of Roselle due to *M. incognita* for two consecutive years.

MATERIALS AND METHODS

Experiments were conducted in 2004 and 2005 on the same fields, at the Institute of Agricultural Research and Training, Obafemi Awolowo University, Moor Plantation, Ibadan, Nigeria, located at 3°54'E 7°30'N. Annual rainfall in this region is 1220 mm and the daily mean temperature is 28 ± 2°C. The soil is coarse loam, grayish brown in colour, friable, and is classified as Rhodic Harplustalf, series (USDA 1990). The experimental site had been cultivated previously for three years with okra [*Abelmoschus esculentus* (L.) Moench, cv. V35], which is susceptible to root-knot nematode. The experimental plots were naturally infested with *M. incognita* (about 430 and 375 juveniles per 250 cm^3 soil sample at planting, respectively. The identity of *M. incognita* was confirmed using perineal patterns, as race 2, as described by Eisenback *et al*. (1981). One Roselle variety (Roselle cv Purple) was used, obtained from the Industrial Crops Improvement Programme of the Institute of Agricultural Research and Training, Obafemi Awolowo University, Moor Plantation, Ibadan, Nigeria. The experiment was laid out in a randomized complete block design with four replications and plots measuring 6 x 5 m, each consisting of four rows. The field was ploughed and harrowed, and the seeds were planted on the prepared field. Plant spacing was 10 x 25 cm with five seeds planted per hole and after seeds germinated plants were thinned to one per hole. Carbofuran 3G was applied at 2 kg a.i./ha in planting hole as a single side dressing immediately after thinning. The seeds were not treated with pesticides. The choice of carbofuran was due to rapid metabolization and non-persistence, it does not contaminate food and is readily available in Nigeria. Like other carbamates it is metabolized rapidly in animals into less toxic and finally non-toxic metabolites and is non-toxic to vertebrates and higher animals. Weeds were removed manually at 4 and 8 weeks after planting. Basal application of fertilizers was carried out on the plots 2 weeks after planting using NPK fertilizer at a rate of 120 kg N, 50 kg of P_2O_5 and 50 kg K_2O/ha with no irrigation performed.

Soil samples were taken from the treatment plots before and after harvest and analyzed for nematode population counts, in order to determine the initial and final population of the nematodes (P_i and P_f). Ten soil core samples were taken from the plot at the depth of 20 cm and combined to obtain composite samples. Composite samples were taken to the laboratory in sealed plastic bags where they were stored at 10°C for 24 hours. The samples were then thoroughly mixed and 250 cm^3 soil sub-samples were prepared for nematode extraction using the tray extraction method of Whitehead and Hemming (1965). Ten weeks after planting, ten randomly selected plants per plot were carefully uprooted and the adhering soil washed off for assessment of root-galls using a stereoscopic microscope. Galling was assessed using a visual rating based on rating scale of Taylor and Sasser (1978) (Table 1). Eggs were extracted from roots and their amount estimated using the sodium hypochlorite method of Hussy and Barker (1973). Host status rating was determined using a rating scheme developed by Sasser *et al*. (1984) based on root gall index and reproductive factor (R), where $R = P_f/P_i$ (Table 2). At harvest, ten randomly selected plants, per plot were measured for the following parameters: plant height from the soil surface to the tip of top leaf, stem circuit measured using vernier calipers, days to maturity, number of seeds and seed yield (kg/ha). Data were subjected to analysis of variance and means separated using Duncan's multiple range test (Gomez and Gomez 1984).

Table 1. Scale for assessment of root-knot nematode galls or egg masses on roots (Taylor and Sasser 1978)

Number of galls or egg masses/plant	Gall index	Resistance ratings
0	0	Immune (I)
1–2	1	Resistant (R)
3–10	2	Moderately resistant (MR)
11–30	3	Moderately susceptible (MS)
31–100	4	Susceptible (S)
100+	5	Highly susceptible (HS)

Table 2. Resistance rating scale for root-knot nematode (Sasser *et al*. 1984)

Root gall index*	R-factor host efficiency**	Host status
≤ 2	≤ 1	Resistant
≤ 2	≥ 1	Tolerant
≥ 2	≤ 1	Hypersusceptible
≥ 2	≥ 1	Susceptible

*Gall index: 0 = no gall formation; 5 = heavy gall formation
** Reproductive factor: $R = P_f/P_i$, where P_i = initial population density and P_f = final population density

RESULTS AND DISCUSSION

The statistical analysis of the data revealed that performance of Roselle cv Purple treated with carbofuran 3G at 2 kg a.i./ha was significantly better over the years as compared to the control (Tables 4 and 5). The prophylactic effect of Carbofuran in increasing agronomic parameters have been demonstrated by Kinloch (1974, 1982), Adegbite and Adesiyan (2001). The decreasing agronomic parameters recorded for the untreated Roselle cv Purple was probably a result of the stunting action of root-knot nematode (*M. incognita*). The treated plants started flowering earlier than the untreated. Early flowering is very important because it affects the time of maturity and harvesting of plants. The yield of Roselle seeds was found to be higher with the application of nematicide-Carbofuran at 2 kg a.i./ha (Table 3). The percentage increase over the untreated control 48.7 and 40.8% in the years 2004 and 2005, respectively. A significant reduction in the yield of Roselle in untreated plots was mainly attributed to direct damage of the root system by the feeding activities of root knot nematode (*M. incognita*). Prasad and Ahmad (2002) reported a 40.1% yield loss of sunflower due to *Rotylenchulus reniformis* in New Delhi, India. Also, Prasad (1997) reported 33.1% yield loss of groundnut due to *M. arenaria* and *R. reniformis* found together in the field of Uttar Pradesh. *M. incognita* population (Table 3) in carbofuran treated plots was significantly lower than in the untreated plots in the two years, because, the nematode multiplied many folds during the crop seasons. High *M. incognita* population in the untreated control plots decreased the plant growth and ultimately reduced the flower size, number of seeds and weight of the seeds. The ovicidal effect of carbofuran is more effective in preventing penetration of nematodes into the root. This may suggest that carbofuran acts directly on the nematodes in the soil thereby preventing or limiting hatching of eggs and the movement of larvae into the root. This is in agreement with the work of Di-Sanzo (1973), Kinloch (1974, 1982), Adegbite and Agbaje (2007) and Adegbite and Adesiyan (2001). Prasad and Narayana (1999) reported that *M. incognita* could significantly reduce both the oil content and yield of sunflower by 40.3% in 3000J_2 of root knot in pot culture conditions.

Table 3. Avoidable yield losses of Roselle due to root-knot nematode (*Meloidogyne incognita*)

Treatment	2004	2005
Yield loss [kg/ha]		
Treated	1190.0 a	970.5 a
Untreated	610.0 b	570.8 b
SEm±	1.59	1.98
% Avoidable yield loss	48.70	40.80
Nematode population		
Initial	430.0	375.0
Control	772.4 a	1080.0 a
Treated with Carbofuran	119.0 b	196.7 b
SEm±	22.1	71.4

Means followed by the same letters are not significantly different at ($p < 0.05$) according to Duncan's Multiple Range Test

Table 4. Reaction of Roselle to field infestation by *Meloidogyne incognita* treated with Carbofuran in 2004

Treatment	Plant Height [m]	Stem circuit [cm]	Days to maturity	Number of seeds	Seed Yield [kg/ha]	R-Factor $R = P_f/P_i$	Gall index	Rating
Treated	2.5 a	4.27 a	120 a	4590 a	1190 a	0.55 a	1.5 a	Resistant
Control	1.95 b	3.10 b	135 b	3245 b	610 b	2.95 b	3.8 b	Susceptible
SEm±	0.27	0.58	7.50	673	1.59	1.2	1.2	

Means followed by the same letters are not significantly different at ($p < 0.05$) according to Duncan's Multiple Range Test

Table 5. Reaction of Roselle to field infestation by *Meloidogyne incognita* treated with Carbofuran in 2005

Treatment	Plant Height [m]	Stem circuit [cm]	Days to maturity	Number of seeds	Seed Yield [kg/ha]	R-Factor $R = P_f/P_i$	Gall index	Rating
Treated	2.4 a	3.50 a	120a	3590a	970.5 a	0.55 a	1.7 a	Resistant
Control	1.75 b	2.40 b	135b	2265b	570.8 b	2.95 b	3.8 b	Susceptible
SEm±	0.33	0.55	7.5	662.5	1.98	1.2	1.1	

Means followed by the same letters are not significantly different at ($p < 0.05$) according to Duncan's Multiple Range Test

In summary, the work confirms the suppressive effects of Carbofuran on Roselle nematodes and that without controlling the activities of root knot nematode (*M. incognita*) appreciable yield and income on Roselle cultivation will not be possible.

REFERENCES

Adamson W.C., Martin J.A., Minton N.A. 1975. Reaction of kenaf and Roselle on land infested with root knot nematodes. Plant Dis. Rep. 59: 130–132.

Adegbite A.A., Adesiyan S.O. 2001. Efficacy of Carbofuran (Furadan) on the performance of four nematode susceptible varieties of soybean [*Glycine max* (L.) Merrill]. Trop. Oilseeds J. 6: 11–23.

Adegbite A.A., Agbaje G.O. 2007. Efficacy of Carbofuran in control of root-knot nematode (*Meloidogyne incognita* race 2) in hybrid yam varieties in southwestern Nigeria. Electr. J. Environ. Agric. Food Chem. 6: 2083–2094.

Adeniji M.O. 1970. Reaction of kenaf and Roselle varieties to the root-knot nematode in Nigeria. Plant Dis. Rep. 54: 547–549.

Di-Sanzo C.P. 1973. Nematode response to Carbofuran. J. Nematol. 5: 22–27.

De-Lannoy G. 2001. Roselle. p. 418–421. In: "Crop Production in Tropical Africa" (R.H. Raemaekers, ed.). Directorate General for International Cooperation (DGIC), Ministry of Foreign Affairs, External Trade and International Cooperation, Brussels, Belgium.

Eisenback J.D., Hirschmann H., Sasser J.N., Triantaphyllou A.C. 1981. A guide to the four most common species of root-knot nematodes (*Meloidogyne* spp.) with a pictorial key. North Carolina State University and USAID, Raleigh, N.C., 48 pp.

Gomez K.A., Gomez A.A. 1984. Statistical Procedures For Agricultural Research, 2nd ed., John Willey and Sons, New York.

Heffes T.A., Coates-Beckford P.L., Hutton D.G. 1991. Effects of *Meloidogyne incognita* on growth and nutrient content of *Amaranthus viridis* and two cultivars of *Hibiscus sabdariffa*. Nematropica 21: 7–18.

Hussey R.S., Baker K.R. 1973. A comparison of methods of collecting eggs of *Meloidogyne* spp. including a new technique. Plant Dis. Rep. 57: 1025–1028.

Kinloch R.A. 1974. Response of soybean cultivars to nematicidal treatments of soil infested with *Meloidogyne incognita*. J. Nematol. 6: 7–11.

Kinloch R.A. 1982. The relationship between soil populations of *Meloidogyne incognita* and yield reduction of soybean in the coastal plain. J. Nematol. 14: 162–167.

Minton N.A., Adamson W.C. 1979. Control of *Meloidogyne javanica* and *M. arenaria* on kenaf and Roselle with genetic resistance and nematicides. J. Nematol. 11: 37–41.

Minton N.A., Adamson W.C., White G.A. 1970. Reaction of kenaf and Roselle to three root-knot nematode species. Phytopathology 60: 1844–1845.

Prasad D. 1997. Assessment of groundnut yield loss due to plant parasitic nematodes. Ann. Plant Prot. Sci. 4: 25–28.

Prasad D., Ahmad I. 2002. Assessment of avoidable yield loss of sunflower due to *Rotylenchulus reniformis*. Ann. Plant Prot. Sci. 10: 134–138.

Prasad D., Narayana R. 1999. Effect of *M. incognita* race 1 on the oil content of sunflower. Ann. Plant Prot. Sci. 7: 116–118.

Sasser J.N., Carter C.C., Hartman K.M. 1984. Standardization of Host Suitability Studies and Reporting of Resistance to Root-knot Nematode. North Carolina State University, Department of Plant Pathology, Raleigh, N.C. USA, 7 pp.

Taylor A.L., Sasser J.N. 1978. Biology, Identification and Control of Root-knot Nematodes (*Meloidogyne* spp.). A cooperative publication of North Carolina State University, Department of Plant Pathology and UDSAID, Raleigh, N.C. USA, 111 pp.

Tindall H.D. 1983. Vegetables in the Tropics. Houndmills Basingstake, Hampshire RG212X5, Macmillan Educational Ltd.

United State Department of Agriculture 1990. Soil Survey Staff Keys to Soil Taxonomy, SMSS, Technical Monograph Blackburg, VA.

Vawdrey L.L., Stirling G.R. 1992. Reaction of kenaf and Roselle grown in the Burkin River Irrigation Area to root-knot nematodes. Aust. Plant Pathol. 21: 8–12.

Whitehead A.G., Hemming J.R. 1965. A comparison of some quantitative methods of extracting small vermiform nematodes from soil. Ann. Appl. Biol. 55: 25–38.

POLISH SUMMARY

OKREŚLENIE STRAT PLONU KETMII *HIBISCUS SABDARIFFA* L. WYWOŁYWANYCH PRZEZ MĄTWIKA *MELOIDOGYNE INCOGNITA* W WARUNKACH POLOWYCH

Mątwik *Meloidogyne incognita* (Kofoid & White) Chitwood jest ekonomicznie ważnym patogenem wielu roślin rolniczych, a liczne występowanie i duże znaczenie w warunkach zaniedbań agrotechnicznych sprawia, że jego zwalczanie jest konieczne.

W celu określenia strat plonu ketmii *Hibiskus sabdariffa* L. (Roselle) wywoływanych przez tego szkodnika w latach 2004 i 2005 przeprowadzono badania na naturalnie zakażonych polach w Nigerii. Do zwalczania patogena stosowano Carbofuran 3 g w dawce 2 kg składnika aktywnego na hektar. Wzrost plonu *H. sabdariffa* w wyniku przeprowadzonego zabiegu wynosił w latach 2004 i 2005 odpowiednio 48,7 i 40,8%. Istotną redukcję plonu na nietraktowanych poletkach kontrolnych przypisywano głównie bezpośrednim uszkodzeniom systemu korzeniowego przez *M. incognita*. Populacja *M. incognita* na traktowanych Carbofuranem poletkach doświadczalnych była w obydwóch latach badań istotnie niższa niż w nietraktowaniej kombinacji kontrolnej, również w okresie zbioru. Na poletkach kontrolnych mątwik rozmnażał się wielokrotnie w czasie wegetacji, a liczna jego populacja była przyczyną ograniczenia wzrostu roślin, ilości nasion i ich masy.