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# Estimation of *Pelargonium sidoides* root damage by *Meloidogyne* spp.

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***Pelargonium sidoides*** **is a medicinal plant species indigenous to Southern Africa. Its roots are used for treating a variety of ailments in man and livestock. It is in great demand by local users and international pharmaceutical producers. Root-knot nematodes, *Meloidogyne* species, penetrate into the roots of plants in search of food and for reproduction locations, resulting in the formation of galls. They affect the plant's ability to absorb water and nutrients. *P. sidoides* plants, grown as part of a fertilizer trial, showed susceptibility to root-knot nematodes. Fifteen plots were replicated three times in a randomized complete block design with different levels of nitrogen, phosphorus and potassium. Ten plants per treatment were harvested eight months after planting, with the aim of developing a root-knot nematode rating chart. Each root system was assessed and ranked on a class of 0 to 10, with 0 representing no galls, 5 representing 50% infestation and 10 representing severe infestation. *Meloidogyne incognita* and *Meloidogyne javanica* were identified in the root samples. The sampled roots showed more than 50% infestation. It is recommended that the soil should be analyzed and treated accordingly, before planting *P. sidoides* to avoid root damage by root-knot nematodes.**

**Key words:** Medicinal plants, root-knot nematodes, nematode rating chart, *Pelargonium sidoides*, *Meloidogyne* spp.

## INTRODUCTION

*Pelargonium sidoides* DC is one of the estimated 3000 medicinal plant species that are regularly used in traditional medicine in South Africa (van Wyk, 2008). The species, which belongs to the Geraniacea family, occurs naturally in Lesotho, as well as the Eastern Cape, Free State, Northwest, Gauteng and Mpumalanga Provinces of South Africa (Brendler and van Wyk, 2008). *P. sidoides* is used for the treatment of several cold related ailments, in man and livestock, and there has been a great increase in demand for the plant for both local uses and by international pharmaceutical producers. The number of collectors and its rate of harvesting have increased in recent years (Lewu et al., 2006). The tuberous roots are the raw material for an important German phytomedicine used to treat acute bronchitis and infections of the upper respiratory tract, and a fully licensed medicinal product containing special extracts of *P. sidoides* root is now among the most widely bought self-medication products in Germany (Brendler and van Wyk, 2008).

The large and potentially damaging harvest of wild

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pelargoniums has raised a need for research addressing the development and implementation of sustainable harvesting practices and methods for effective cultivation of the species (White et al., 2008). Cultivation has been considered as a viable means of reducing the pressure on natural populations of *P. sidoides*, reducing the risk of their extinction (Lewu et al., 2010).

Root-knot nematodes, *Meloidogyne* species, which are among the world's major crop pests (Bridge and Page, 1980), belong to a relatively small, but important polyphagous group of roundworms and are distributed worldwide (Das et al., 2011). Root-knot nematodes are obligate endo-parasites, and need to penetrate the plant in search of food and for reproduction locations (Das et al., 2011). Root infection results in the formation of root galls which negatively affects the plant's ability to absorb water, nutrients and other essential elements from the soil, leading to poor plant growth and yield loss (Okeniyi et al., 2010; Ullah et al., 2011). It has been reported that root-knot nematodes can cause yield reduction of up to 85% in tomato (Esfahani, 2009). In yam (*Dioscorea* spp.), root-knot nematodes are also responsible for serious reduction in tuber quality and severe yield loss (Adegbite and Agbaje, 2007). The most important pests of geraniums, especially pelargoniums are, amongst others, soil-living larvae of various beetles, nematodes and termites (Weiss, 1997). Though *Meloidogyne* spp. have been frequently recorded on geraniums (Weiss, 1997; Dermane, 2002), this is the first report of root-knot nematode on *P. sidoides*.

Control methods such as chemical and biological control, and companion planting with nematicidal plants are some control actions used in the past (Weiss, 1997). *Meloidogyne hapla* on *Pelargonium graveolens* was successfully reduced by application of aldicarb, and the protection of the plants was reflected in the positive effect on plant height and number of branches per plant at harvesting (Doraswamy et al., 1979). Leaf extracts of *Bridelia micrantha*, *Mallotus oppositifolius*, *Hunteria umbellata* and *Citrus medica* had some nematicidal effects on *Meloidogyne incognita* (Okeniyi et al., 2010).

The galls or knots on plant roots caused by nematodes can be used to assess levels of root damage or nematode infestation by determining the extent of galling on the roots (Bridge and Page, 1980). Some rating schemes require detailed examination of roots and are not practical for field use, especially when a large number of plants need to be examined (Bridge and Page, 1980). The aim of this study was to develop a simple root-knot nematode rating chart for the estimation of root damage by *Meloidogyne* spp. on *P. sidoides*.

## MATERIALS AND METHODS

Two months old *P. sidoides* seedlings were obtained from a commercial nursery and transplanted in experimental fields at the Agricultural Research Council - Roodeplaat Vegetable and Ornamental Plant Institute (ARC-Roodeplaat VOPI), north east of Pretoria, South Africa (25°59'S; 28°35'E and 1 200 m.a.s.l.), in September 2010. Fifteen plots were replicated three times in a randomized complete block design for a fertilizer trial. Different levels of nitrogen, phosphorus and potassium were applied, with an untreated control where no fertilizers were applied. Nitrogen was applied as urea (46%) at 0, 120, 240, 340 and 360 kg/N $ha^{-1}$. Phosphorus was applied as superphosphate (10.5%) at 0, 60, 100, 140 and 160 kg/P $ha^{-1}$. Potassium was applied as potassium chloride (50%) at 0, 120, 160, 200 and 240 kg/K $ha^{-1}$. The plants were irrigated twice a week and 10 mm of water was applied per irrigation cycle. During the growing period, some plants showed signs of stunting and poor growth. At harvesting, eight months after planting, it was observed that the roots of most plants were infested with root-knot nematodes. Root samples were taken, twenty grams of which were sent to the nematology unit of the Agricultural Research Council's Plant Protection Research Institute, for identification of the nematode species.

To develop a root-knot nematode rating chart, 10 plants were harvested per plot and the roots were rinsed in clean tap water to remove the soil. A previously published rating chart (Bridge and Page, 1980) was adapted to assess and rank each root system on a class of 0 to 10. The classes were described as follows: 0 = no galling, 1 = few small knots that are difficult to find, 2 = clearly visible small knots, 3 = some large knots visible, 4 = large knots predominant, 5 = 50% of the roots infested with knotting on parts of the main roots, 6 = visible knotting on the main roots, 7 = majority of main roots are knotted, 8 = all the main roots are knotted, 9 = severe knotting on the main roots and 10 = all roots severely knotted, plants usually dead.

Ranking was done by calculating the average gall index per plot, which was determined by adding all the scores of sampled plants per plot and dividing the sum by the number of sampled plants per plot. Thereafter, the root-knot nematode index was calculated by adding the number of plants per class, in the three replicates and then dividing the sum by the number of plants sampled. The cut off points for the index were then determined statistically.

The frequencies observed in the 10 classes were subjected to the general linear model (GLM) technique with a logistic link function. The maximum likelihood estimators (Xbeta's) were calculated on an underlying scale (McCullagh and Nelder, 1989). These estimators, that are on an interval scale, were subjected to randomized block design analyses of variance, using SAS version 8.2 (SAS/STAT User's Guide, 1999). Shapiro-Wilk's test was performed to test for non-normality (Shapiro and Wilk, 1965). Student's t-LSD (Least Significant Difference) was calculated at a 5% significance level to compare treatment means. There was no evidence against normality, therefore no transformation was needed. The class cut off points or class limits were given at intercepts as in Table 1.

## RESULTS AND DISCUSSION

High population numbers of endoparasitic root-knot nematodes *Meloidogyne incognita* and *Meloidogyne javanica* were observed in the sampled roots of the *P. sidoides* plants. This is consistent with reports that nematodes are important pests of pelargonium and geraniums (Weiss, 1997; Dermane, 2002). Due to the infestation, no results relating to fertilizer requirements were obtained from the fertilizer trial.

The root-knot nematode index for *P. sidoides* plants across the different fertilizer treatments are shown in Figure 1. The figure shows that all the sampled roots

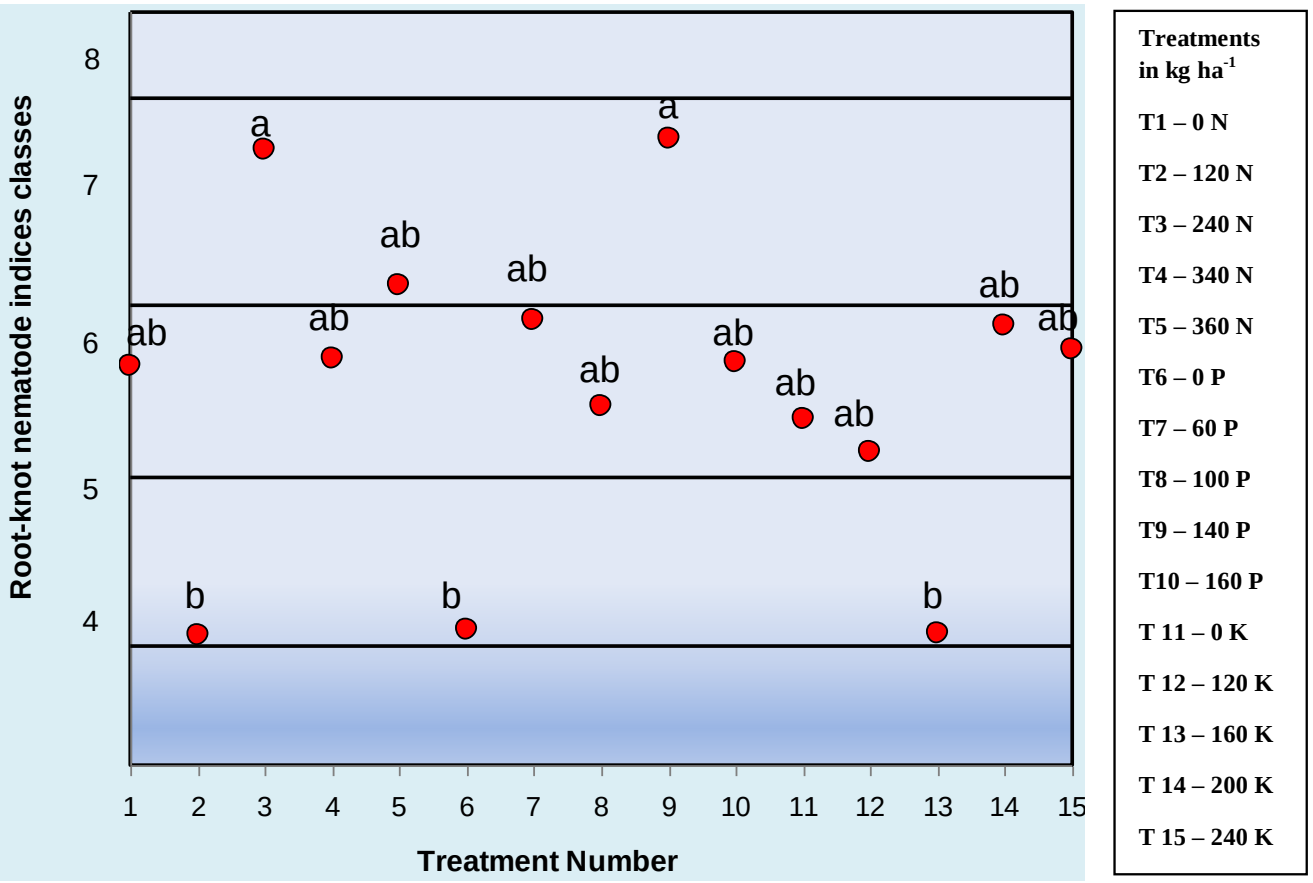


**Figure 1.** Root-knot nematode index class distribution as found for different fertilizer treatments on *P. sidoides*. Means with the same letters are not significantly different from each other.

**Table 1**. Class cutoff points or class limits for the degree of root knots on *P. sidoides*.

| Class | Lower limit | Upper Limit |
|---|---|---|
| 1 | - ∞ | -2.68 |
| 2 | -2.68 | -2.04 |
| 3 | -2.04 | -1.66 |
| 4 | -1.66 | -1.36 |
| 5 | -1.36 | -0.47 |
| 6 | -0.47 | 0.44 |
| 7 | 0.44 | 1.54 |
| 8 | 1.54 | 2.54 |
| 9 | 2.54 | 3.71 |
| 10 | 3.71 | ∞ |

were classed from five to seven on the rating chart, indicating a higher than 50% infestation of the root systems. Moderate to severe infestations of *M. hapla* have been reported on *P. graveolens* (Doraswamy et al., 1979). Significant differences were only observed between treatments three, nine and treatments two, six and thirteen. However, the significant differences observed between the treatments are probably due to root-knot nematode population distribution in the field and not fertilizer treatment.

Rating charts for estimating root damage or nematode infestation have been reported for other crops (Bridge and Page, 1980). Figure 2 shows the root-knot nematode rating chart that was developed for *P. sidoides* in this study. The severity of the rating increased from 1 up to 10, where the plants were usually dead.

## Conclusions

The results shows that *P. sidoides* is susceptible to severe root-knot nematode damage. It is therefore recommended that the soil be analyzed for nematode populations before planting, and be treated accordingly. Chemical control, biological control, companion planting with nematicidal plants and other cultivation practices, such as fallow cultivation or rotation with nematode resistant grasses, may reduce nematode infestation.

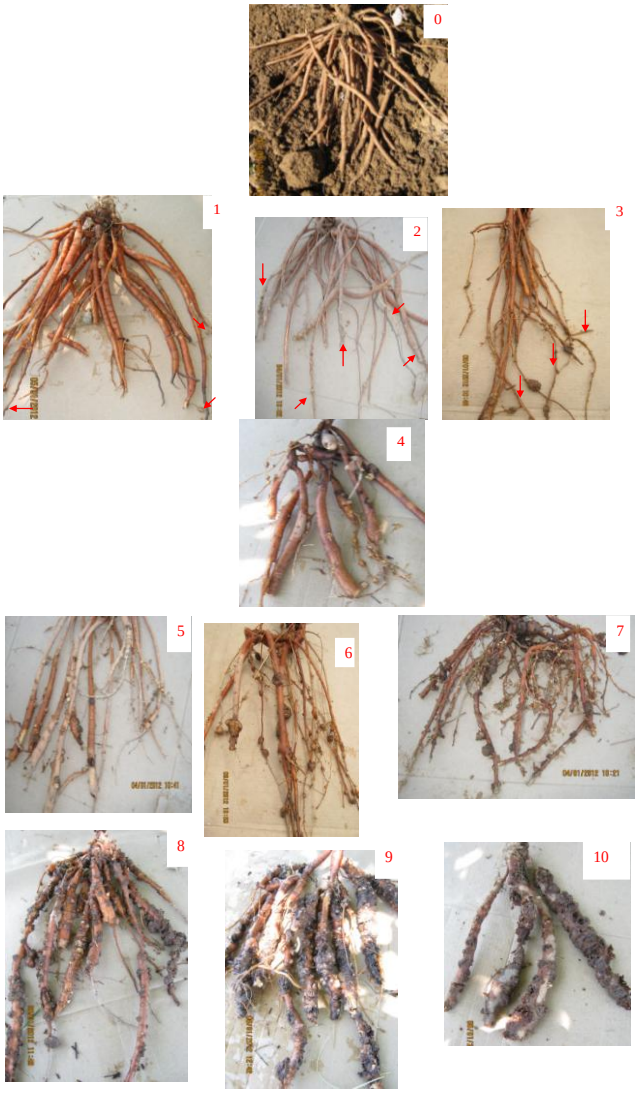


**Figure 2.** Root-knot nematode rating chart for *P. sidoides*. 0 = All roots are clean, no galling; 1 = few small knots, difficult to find; 2 = small knots only, but clearly visible; 3 = some large knots visible, but main roots are clean; 4 = large knots predominate, infestation starting on main roots; 5 = 50% of the roots are infested, there is knotting on parts of the main roots; 6 = visible knotting on main roots; 7 = majority of the main roots are knotted; 8 = all main roots are knotted; 9 = severe knotting on main roots, plant usually dying; 10 = all roots severely knotted, no root system, plant usually dead.

Since in the case of *P. sidoides*, it is the roots that are harvested, root-knot nematodes can affect yield significantly, thus making nematode control a critical part of production. The influence of root-knot nematodes on active compounds and biological activity of root extracts of *P. sidoides* is not known yet and needs to be investigated.

The rating method developed in this study will help growers to quickly identify the levels of infestation on *P. sidoides* roots, and thus estimate yield loss, by simply comparing the damage with the rating chart.

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