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# EFFICACY OF SELECTED PLANT BIOFUMIGANTS IN THE MANAGEMENT OF PARASITIC NEMATODES IN ASCLEPIAS (*Asclepias tuberosa* L.)

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**ABSTRACT**
Greenhouse based research to investigate the potential of using biofumigants in the management of nematodes was conducted at James Finlay's (K) Flowers-Kericho for two seasons during the months of June to October 2006 (first season) and November to March 2007. Chopped plant parts of *Tagetes patula*, *Lantana camara*, *Tephrosia vogelii* and *Azadirachta indica* were applied singly as soil amendment or in combination with nemacur in the plots that had *Asclepias tuberosa*. *T. patula* was applied at 300 g/m$^2$, *A. indica* at 150 g/m$^2$, *L. camara* at 10% w/w, and *T. vogelii* at 10% w/w. Organic plant materials were applied at half rate in combination with nemacur at 20 g/m$^2$. Nemacur treatment alone was applied at a full rate of 40 g/m$^2$. The experiment was laid in Complete Randomised Block Design replicated three times. The chopped plant materials were incorporated in the soil and left to decompose for four weeks. Nematode counts, and plant growth and flower characteristics were evaluated before and after application of soil amendment treatments. *L. camara* combined with nemacur reduced root knot nematodes count by between 79.8% and 82.6% while a single application of the same treatment reduced nematodes by 73.4%. Root galling was reduced by 79.3% when a combination of *L. camara* with nemacur was applied, while nemacur alone decreased galling by 89.6%. Nemacur or a combination of *L. camara* with nemacur led to an increase in plant height by between 22.7 cm and 26.5 cm respectively. *L. camara* with nemacur increased cumulative flower yield by between 78.6% and 83.6% compared to the untreated control. A combination of *L. camara* with nemacur may be used in place of synthetic nematicides alone to control nematodes and improve nutrient levels. This treatment combination gave the best control of nematodes, enhanced plant growth and significantly increased flower yield compared to all other treatments. The results from this study give cutflower growers alternative options to manage root-knot nematodes under greenhouse conditions.

**KEYWORDS:** Soil amendments, *Asclepias tuberose*, *Tagetes patula*, *Lantana camara, Tephrosia vogelii & Azadirachta indica.*

## INTRODUCTION

Flowers are grown in intensive cultivation including greenhouse production that contributes to accumulation of soil borne problems. The production of various flowers including asclepias is constrained by insect pests, weeds, nematodes and several diseases that build up in the soil leading to significant losses in yields and quality. Eradication of these noxious soil-born organisms is difficult; they may render an area unsuitable for the production of susceptible flowers and hence make soil disinfestations mandatory. The asclepias, also known as butterfly weed, performs well at an optimum soil pH of 6.2 and organic matter content of 2%. The soils should be well drained and deep to allow the expansion of the tuberous roots (Campbell, 1983). Asclepias (*Asclepias tuberosa)* belong to the family Asclepiadaceae (milkweed family), which is native to North America. Many plant products have been well known to be nematicidal in nature. This is attributed to the alteration in soil physical and ecological state by the materials or to the breakdown or decomposition by products. The species *Tagetes minuta, T. erecta T.patula* and *T. tenufolia* are the most common. Parasitic populations are dense in warmer climates and light, sandy soils harbor larger densities (Yepsen, 1984). Leaf chlorosis and wilting of *Asclepias tuberosa* followed by weak flowering or plant death has been reported in many commercial green houses (Tsror et al., 1997). Damage from nematodes not only occurs from feeding but also from interaction with other disease causing organisms that take advantage of wounds created by nematodes. Root lesion nematodes (*Pratylenchus spp*) affect development of asclepias, carnations, dahlia and greenhouse grown alstroemeria (Schnauber, 2003). Until recently, methyl bromide has been extensively used for soil borne pests and diseases control in the production of many fruit, vegetable and nursery crops. However, due to its emissions to the atmosphere as well as the toxic effects to the farmers and the environment, (Culvert et al., 1998), its use was phased out in developed countries by the year 2005 (UNEP, 2004). The use of soil amendments, cover crops, resistant varieties, flooding, soil solarization or bare fallowing can suppress nematodes and weed population build up (Miano, 1999). Sustainable control of nematodes and inhibition of damage to agriculture involves integration of preventive measures. The use of organic and/or in-organic soil amendments has been found promising in the control of plant parasitic nematodes (Miano, 1999). Organic soil amendments with low C:N ratios and high protein or amine-type nitrogen contents have been reported to be effective against root-knot nematodes (Rodriguez and Morgan-Jones, 1987). This was attributed to increased production of toxic compounds such as ammonia. The use of soil amendments is however limited by the large quantities needed to achieve effective nematode control (Miano, 1999). Some organic soil amendments have often resulted in phytotoxicity to plants. To overcome this problem, an optimum range of C:N ratio of 13:1 to 20:1 that balances phytotoxicity and nematicidal activity was suggested (Rodriguez-Kabana and Morgan-Jones, 1987). Most organic amendments have C:N ratios that fall outside this optimum range. Non chemical low input pest management systems exploit practices that minimize crop loss while requiring few additional inputs. A proactive integrated pest management (IPM) option creates a conducive environment (food, shelter) for the beneficial organism and hence lowers the carrying capacity of the green houses or field for the pest.

## MATERIALS AND METHODS

### Experimental site

The research work was conducted at James Finlay's flowers (K) Limited, Kericho District in Kenya. The site lies approximately at Latitude 0° 23'S and Longitude 35° 17'E. The mean temperature ranges between 14.8°-16.4° C. The soils are moderate to high in fertility. They are well drained, extremely dark redish brown, friable and slightly smeary clay with acid humic top soil (ando-humic NITOSOLS) (Jaetzold and Schimdt, 1993).

### Field production and culture of *Asclepias tuberosa*

Finlay's flowers obtained planting seed from Genesis Seeds Ltd, a breeder in Israel. The seeds were sown in ground beds in the greenhouse. The ground beds were treated with chopped plant materials (organic soil amendments), a granular nematicide (nemacur) or a combination of both. The size of each ground bed was 30m long and 1m width and was separated from other beds by a 50 cm path. The flower seeds were planted at a spacing of 20 cm by 20 cm on netting material at a population density of 125 plants/m$^2$.

The plants were irrigated by two micro irrigation tubes placed at 30.5 cm a part on the beds. Seedlings were fertilized using a feeding programme starting 4 weeks after planting. The plants were supplied with the following nutrients during different growth phases by fertigation.

i) Establishment: N-60, P-20, K-38, Ca-39, Mg-25, Fe-660, B-205, and Mn-200ppm
ii) Vegetative phase; N-105, P-20, K-126, Ca-70, Mg-34, Fe-660, B-205 and Mn 200ppm.
iii) Production phase; N-100, P-20, K-109, Ca-66, Mg-32, Fe-660, B-205 and Mn 200ppm.

### Treatment application

The treatments consisted of the following soil amendments applied alone or in combination with nemacur.

| Treatment number | Treatment/ Treatment combination |
|---|---|
| 1 | Control- Untreated (No TRT) |
| 2 | *Tagetes patula* (TP) 300gm/m$^2$ |
| 3 | *Tagetes patula* + Nemacur (TP+N) 75 gm/m$^2$ + 20 gm/m$^2$ |
| 4 | *Lantana camara* (LC) 10% w/w |
| 5 | *Lantana camara* + Nemacur (LC+N) 5% w/w + 20 gm/m$^2$ |
| 6 | *Azadiracta indica* (AI) 150 gm/m$^2$ |
| 7 | *Azadiracta indica* + Nemacur (AI+N) 75gm/m$^2$ + 20 gm/m$^2$ |
| 8 | *Tephrosia vogelii* (TV) 10% w/w |
| 9 | *Tephrosia vogelii* + Nemacur (TV+N) 5% w/w + 20 gm/m$^2$ |
| 10 | Nemacur (N®) 40 gm/m$^2$ |

The experiment was set up in a greenhouse naturally infested with a mixed nematode population of *Meloidogyne javanica*, *Pratylenchus penetrans* and *Meloidogyne incognita.* Fumigation or contact nematicides had not been used in the greenhouse for one year. The experiment was laid down in a complete randomized block design (CRBD). The plots measured 2.4 m by one meter separated by a 50 cm path. There were three replications.

Organic soil amendments were incorporated in the soil five weeks before planting of flower seeds to allow decomposition to take place. The different plant materials were chopped into small pieces of about 2 cm and mixed with moist soil. Nemacur was applied during planting. The organic soil amendments were mixed with soil at 300 gm/m$^2$ for *T. patula* (Chindo and Khan, 1990). Succulent leaves of neem were applied at 150 gm/m$^2$ (Sharma et al., 1996). *L. camara* and *T. vogelii* were incorporated in the soil at 10% w/w (Ogendo et al., 2003). Where the plant materials were combined with nemacur, rates of 5% w/w were used.

### Nematode sampling and extraction

For plant extraction, five plants were systematically sampled from each plot when the flowers were in full bloom. The nematodes were then extracted as per the method recommended by Alexander and Waldenmaier (2002). Soil samples for nematode extraction were taken prior to planting and harvesting. Fifteen soil cores, 15-20 cm deep were randomly collected from each plot with a standard 2.0 cm internal sampling tube. The extraction method was then adopted from Alexander and Waldenmaier (2002).

### Evaluation of Vegetative and flowering characteristics

Flower stems were harvested when 70-75% of the flowers in the terminal inflorescence had opened. Plant height (cm) was measured at intervals of seven days up to a maximum of 120 days after planting. At harvesting, the stems were classified into five grades which were: Grade 1 (60 cm and above), Grade 2 (50-59 cm), Grade 3 (40-49 cm), Grade 4 (30-39 cm) and Grade 5 (20-29 cm). The numbers of flowers in an inflorescence per stem were counted and the size of the flower head measured in centimeters.

**Galling index**

Sampling of infected and damaged plants was done for nematodes. A rating scheme of 0-10 developed by (Zeck, 1971) for evaluation of root-knot nematodes infestation, root infection and galling was used to quantify the level of damage by nematodes as follows:

0 Healthy root systems, no infection.
1 Very few galls, only detected on close examination.
2 Small galls, easy to detect.
3 Numerous small galls.
4 Numerous small galls and a few big galls.
5 25% of the root system severely galled and not functioning
6 50% of the root system severely galled and not functioning.
7 75% of the root system severely galled and not functioning.
8 No healthy root, plant still green.
9 Root rotting completely galled and plant dying.

**Statistical Analysis**

The data obtained was subjected to Analysis of Variance (ANOVA) at P ≤ 0.05 using PROC GLM (SAS version 8, 1999). Significantly different means were separated using Duncan's Multiple Range Test at 5% level of significance. The Univariate Procedure of SAS was used to check that the data were normally distributed before analysis. Data transformation was done for root galling index while all the other data met the assumptions of A NOVA and did not require transformation.

## RESULTS

**Counts of root-knot nematodes as influenced by the treatments**

The degree of control of root-knot nematodes was relative to the type of soil amendment used (Fig. 1). Although plots treated with nemacur at 40 g/m$^2$ resulted into the highest level of nematode control (79.8% to 82.6%), this was not significantly (P≤0.05) different from plots that received a combination of *L. camara* (5% w/w) and nemacur (20 gm$^2$). Used alone, *L. camara (*10% w/w) was the most effective among the soil amendments, achieving a nematode control of 54% to 58% over the plots where no amendments were applied (Fig 1). Nemacur had the same synergetic effect on the efficacy of *T. patula* as observed on *L. camara*, but not on the efficacy of *A. indica*

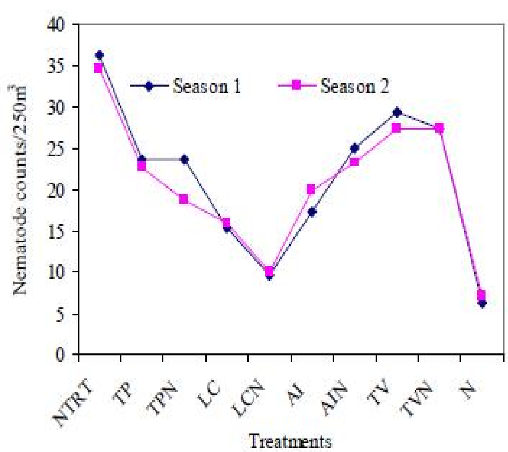


**FIGURE 1**. Count of root-knot nematode (second juvenile stage) in 250 cm$^3$ of soil sampled from different plots before treatment and after bed treatment (35 Days after treatment ) (No TRT-Control, TP-*Tagetes patula*, LC-*Lantana camara*, AI-*Azadirachta indica,* TV-*Tephrosia vogelii,* N®-Nemacur)

**Counts of Root-knot nematodes at flowering stage of *A. tuberosa***

Because of lack of significant differences in the number of nematodes in the two seasons, the data were pooled for analysis. Nemacur at 40 g/m$^2$, *L. camara* (5% w/w) + nemacur, (20 gm$^2$), *L. camara*, (10% w/w), *T. patula* (300 g/m$^2$) and *A. indica* (150 g/m$^2$) reduced root-knot nematode population by between 69% and 90% compared to the control (Fig. 2). The application of *T. patula* (150 g/m$^2$) + Nemacur (20 g/m$^2$), *T. vogelii* (10%w/w) and *T. vogelii* (5%w/w) + Nemacur (20 g/m$^2$) reduced root-knot nematodes by between 67% and 74% at the flowering stage of *A. tuberosa* compared to the control.

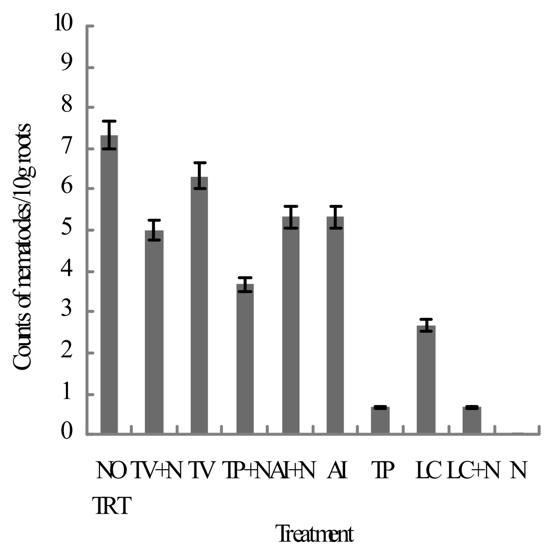


**FIGURE 2**. Influence of soil amendments and nemacur on the number of root-knot nematodes in 10 g roots at the flowering stage of *Asclepias tuberosa*. (No TRT-Control, TP-*Tagetes patula*, LC-*Lantana camara*, AI-*Azadirachta indica,* TV-*Tephrosia vogelii,* N®-Nemacur)

**Galling index**

The root-knot galling index of asclepias generally varied according to the type of organic soil amendment used and the amount of nemacur used in the combination. The reduction in galling index ranged from 0.0 to 0.58 compared to the control (Table 1). Nemacur alone or in combination (*L. camara* (5% w/w) + nemacur, (20 gm$^2$)) caused the greatest reduction in the galling index in both seasons.

**TABLE 1.** Influence of Soil amendments and nemacur on gall index

| | Gall index ( 0 – 10) 60 DAP | |
|---|---|---|
| Treatment | Season1 | Season 2 |
| NO TRT | 0.98a* | 0.98a |
| TP | 0.56c | 0.56c |
| TP+ N® | 0.58c | 0.32d |
| LC | 0.73b | 0.80ab |
| LC+ N® | 0.30d | 0.30d |
| AI | 0.69bc | 0.73bc |
| AI+ N® | 0.88a | 0.90ab |
| TV | 0.90a | 0.97a |
| TV+ N® | 0.93a | 0.80ab |
| N® | 0.00e | 0.16d |

*Means within a column followed by different letters are significantly different at $P \leq 5\%$ level of significance according to Duncan's Multiple Range Test.
Gall index 0 = no damage, 1 = few galls, 2-7 = small galls to big galls, 8 = no healthy roots, 9 = root rotting, completely galled and plant dying, 10 = plant and roots dead.
Data transformation (Log) was carried out before analysis because the mean and the standard deviation were not normall and independently distributed.

**Influence of soil amendments and nemacur plant height and biomass**

**Plant height:** At 120 DAP, nemacur (40 g/m$^2$), *L. camara* (5% w/w) + nemacur (20 g/m$^2$), and *T. patula* (150 g/m$^2$) + nemacur (20 g/m$^2$) increased plant height significantly compared to the control. The treatments increased plant height by 17.8 cm, 17.5 cm and 7.2 cm respectively in the first season (Table 2). During the second season, at 120 DAP, nemacur (40 g/m$^2$), *L. camara* (5% w/w) + nemacur (20 g/m$^2$ and *T. patula* (150 g/m$^2$) + nemacur (20 g/m$^2$) significantly increased plant height by 22.7 cm, 26.5 cm, and 12 cm respectively.

**TABLE 2.** The influence of soil amendments and nemacur on plant height and biomass (drwt/10 stems gm) 120 days after planting (DAP)

| | **Plant height (cm)** | | **Plant biomass** | |
|---|---|---|---|---|
| Treatment | **Season 1** | **Season 2** | **Season 1** | **Season 2** |
| NO TRT | 43.33cd* | 39.60cd | 10.95b | 21.77bcd |
| TP | 45.50cd | 45.90bcd | 10.70b | 23.30bcd |
| TP+ N® | 50.50b | 51.60b | 15.03b | 29.30abc |
| LC | 44.50cd | 42.20cd | 15.43b | 24.17bcd |
| LC+ N® | 60.83a | 66.10a | 26.33a | 34.40a |
| AI | 44.50cd | 42.20cd | 13.07b | 22.43bcd |
| AI+ N® | 41.17d | 40.20cd | 14.40b | 20.67cd |
| TV | 43.33cd | 37.53d | 11.53b | 19.03d |
| TV+ N® | 42.90cd | 39.77cd | 14.50 b | 19.83cd |
| N® | 61.17a | 62.28a | 21.03ab | 30.63ab |

*Means within a column followed by different letters are significantly different at $P \leq 5\%$ level of significance according to Duncan's Multiple Range Test. (No TRT-Control, TP-*Tagetes patula*, LC-*Lantana camara*, AI-*Azadirachta indica,* TV-*Tephrosia vogelii,* N®-Nemacur

**Cumulative flower yield as influenced by soil amendments and nemacur**

In the first and second seasons, *L. camara* (5% w/w) + nemacur (20 g/m$^2$) and nemacur (40 g/m$^2$) alone significantly increased cumulative flower yield (Fig 3). The two treatments increased the cumulative flowers yield by between 78% to 84% respectively within the two seasons of study.

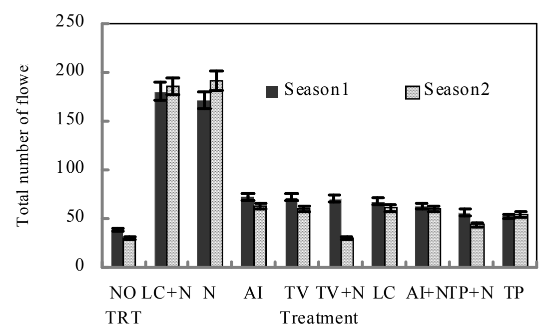


**FIGURE 3.** Cummulative flower yield of saleable stems harvested. No TRT-Control, TP-*Tagetes patula*, LC-*Lantana camara*, AI-*Azadirachta indica,* TV-*Tephrosia vogelii,* N®-Nemacur.

## DISCUSSION

Besides direct toxicity, soil amendments with plant materials act in a number of ways against plant-parasitic nematodes. For example, increased microbial activity in the soil amended with certain plant materials may enhance enzymatic activities, accumulation and decomposition of organic matter and also microbial metabolites which are deleterious to nematodes (Akhtar and Alam, 1993a).

The application of *L. camara* generally suppressed root-knot nematodes both in the first and second season. The combination of *L. camara* (5% w/w) and nemacur (20 $g/m^2$) was more effective than *L. camara* alone at 10% w/w. This could be due to the effect of chopped *L. camara* on soil properties (texture and moisture retention). Nematode reproduction and distribution has been found to differ with soil texture (Mateille et at. 1995). In one study, it was found that amendment of soil with *L. camara* caused soil suppressiveness to *Meloidogyne javanica* and produced marked changes to the fungal communities in the soil and endorhiza. It is likely that those fungal species, especially the endophytes that were reduced or specifically promoted by *L. camara* had a role in suppressing *M. javanica.* However, a role of toxic compounds produced by *L. camara* itself cannot be ruled out. *L. camara* is reported to produce unknown compounds of a polar nature that caused juvenile mortality of *M. javanica* (Ali et al., 2001). In that same study, *L. camara* added to the soil generally caused a strong reduction in nematode population density and root-knot nematodes of mungbean. Lantana was selected based on both field observations and historical references on the toxic nature of this species. Lantana has been observed to successfully inhabit citrus groves heavily infested with nematode populations. It is possible that root exudates and decomposing litter suppress the nematodes. Lantana produces allelopathic substances in its roots and shoots, potentially increasing its competitive ability (Sahid and Sagau, 1993). It is possible that soil amendment with lantana had increased surface area which allowed for better contact between the root-knot nematode and nemacur. The number of root-knot nematodes recovered from lantana amendment alone was less than those in the combination with nemacur probably due to rapid multiplication in organic matter. The trends from shoot evaluations were similar in both *T. patula and A. indica* amended soils. The shoot portions of several selected plant species including poinsettia (*Euphorbia pulcherrima*) and spotted spurge have been found to provide more mortality than root portions of the same species. These results are similar to those previously published about some of these species dealing mainly with insect pests (Prakash and Rao, 1997). Most observations on these plants noted that their pesticidal characteristics occur in the shoot and had activity against insect species. Organic amendments such as the biofumigants we tested probably improved tolerance of host and apparently reduced nematode populations (Dunn, 2006). In another study, *Brassica juncea* biofumigants applied at 3 and 4 $kg/m^2$ were effective in suppressing root knot nematodes and *Fusarium oxysporum f. sp. rosae* in greenhouse grown rose flowers (Oloo et al. 2009). In the present study, *L. camara, T. patula* and *A. indica* all showed root knot nematode suppression 35 days after treatment. There was a significant reduction in the number of root-knot nematodes in plots where *L. camara* was applied compared with the control. However a combination of *L. camara* and nemacur gave better results than *L. camara* alone. The results compare with the findings by Shaukat and Siddiqui, (2001) who concluded that addition of *L. camara* to the soil at 1% (w/w) significantly reduced *Meloidogyne javanica* population density in the soil and in the roots of mungbean, as well as subsequent root-knot infestation of mungbean. This confirms that suppression of nematodes was induced by organic amendment. The findings are also in agreement with the work undertaken by Ogendo et al. (2003) who reported a 75% reduction of maize grain weevils by *L. camara* and *T. vogelii*. Marigold roots release the chemical alpha-terthienyl, one of the most toxic naturally occurring compounds found to date. This compound is nematicidal, insecticidal, antiviral, and cytotoxic (Marles et al. 1992). The presence of alpha-terthienyl inhibits the hatching of nematode eggs (Siddiqui and Alam, 1988).

Nemacur suppressed root-knot nematodes to low levels compared to the plots with no treatment in both seasons (Fig 1.). The findings in this study indicated that nemacur was highly effective against root-knot nematodes. Fumigant nematicides provided good control of nematode population when application was followed by application of a non fumigant nematicide such as Cadusafos or Oxamyl (Giannakou et al., 2002). It has been pointed out that fumigant nematicides do not provide season long control of nematodes. There is synergistic effect when fumigants are applied in combination with other chemicals (Giannakou et al., 2002).

Generally, there were fewer root knot nematodes during the second season compared to the first season (Fig 1). This could be attributed to the prevailing weather conditions during. During the second season (week 20-35), temperatures and relative humidity were higher compared to the first season (week 1-15). Nematode densities are subject to conspicuous seasonal fluctuations. Some species are only found in certain seasons. In one study, Ploeg and Stapleton (2001) reported that temperature and amendment of soil with broccoli residues had synergistic effect on the infestation of melon plants by *Meloidogyne incognita* and *M. javanica.* An increase of temperature from 20°C to 25, 30 or 35°C dramatically reduced infestation and galling compared to that in unamended soils. Galling was reduced up to 79% in both seasons. In one study, *L. camara* added to the soil caused a strong reduction in nematode population density and root-knot of mungbean (Ali et al*.,* 2001). Nemacur generally reduced galling on asclepias roots 60 days after planting (DAP). The results of this study are consistent with a study on root-knot nematode control and tobacco yields in plots infested with *Meloidogyne incognita* (Broodie and Good, 1973). Treatments with the nonvolatile nematicides, Aldicarb, Mocap, or Nemacur gave greater nematode control than those on similar plots treated with volatile nematicides such as tetrachlorothiophene. In the study, *Azadirachta indica* alone (applied at 150 $g/m^2$) suppressed nematodes better compared to the control. Sharma et Al. (1996) found that neem cake applied at 1500 kg/ha reduced nematodes on tomatoes. Musabyimana et al., 2000 established that 60-100 kg/ha of neem seed powder was very effective against banana weevils and nematodes. Regardless of the treatment or the treatment combination in which neem was applied, there was a significant reduction in nematode population in comparison with untreated control (Table 3). However, the lowest nematode population was recorded when neem was applied alone. This gave a reduction of 52.3% compared to 31.2% reduction when neem was applied in combination with nemacur. Recently, much effort has been devoted to neem extracts as an alternative to synthetic pesticides. Neem extracts have been evaluated against various insect pests and nematodes. The efficacy of neem seed powder and neem cake against banana parasitic nematodes was demonstrated in screen house and outdoor tests (Musabyimana and Saxena, 1999). *Tagetes patula* (300 g/m$^2$) alone or *T. patula* (150 g/m$^2$) in combination with nemacur (20 g/m$^2$) reduced root galling significantly. In another study it was reported, sixty days after the start of the experiment the highest numbers of the second juvenile stage nematodes were extracted from tomato roots, and the fewest from *Tagetes spp*. Galls were seen only on roots of tomato and Scarlet Sophie, with average gall indices of 3.0 and 2.6, respectively (Ploeg and Maris, 1999). *T. patula* may not eradicate nematodes. However, it could provide a continuous suppression effect on nematode populations where it is grown every season before the actual crop is planted. This would suppress nematode populations over time as it happens in the presence of susceptible crops like vegetables and bedding plants. The soil amendments used in this research affected the growth of ascepedia. In both seasons of study, all the treatments that combined LC with N significantly increased the plant heights, plant biomas and Flower yield of the plant. In study, that was conducted to elucidate the relationship between soil conditions, growth and physiology of 3 highbush blueberries cultivars, Bahman et Al. (2004) observed that residual effects of P- or N- based on green manure or compost application increased crop production for one year and influenced soil properties several years thereafter.

The treatment (*L. camara* + nemacur) gave a biomass accumulation of 36.6% at 120 DAP compared to the control. The results of the study are consistent with an increase in the fresh weight of the shoots (+18.1%) obtained in soil when 0.5% *L. camara was* applied on mungbean (Shaukat and Siddiqui, 2001). Although mungbean growth was greater in *L. camara*-amended soils than in unamended soil, at higher concentrations of *L. camara* there was a noticeable reduction in plant growth (Table 4). *L. camara* is a well-known allelopathic plant containing a variety of phenolic acids (Narwal, 1996). Allelopathic plants applied at higher concentrations may produce phytotoxic symptoms. It is therefore advisable that before *L. camara* is applied under field conditions, optimal concentrations be determined to establish the levels toxic to the nematodes but not to the cropped plants, nor to any associated beneficial micro-organisms, such as those possessing biocontrol and growth-promoting properties. Nemacur alone or in combination with *L. camara* gave the highest cumulative flower yield. This was probably due to their greater suppression of both nematodes and weeds. It is probable that synergy between nemacur and *L. camara* could have increased their nematicidal effectiveness. In another study, a combination of nemacur/temik and pesticides (Treflon and Lorox) on Soyabeans cyst nematodes increased pod production and the number of nodules per plant. The number of the cyst nematodes in the field was reduced. It was also documented in the same study that nematicide and herbicide combination controlled Soyabean cyst nematodes with corresponding yield increases probably attributed to weed suppression as well. In the present study, there was a significant increase in the growth of asclepias, flower yield and quality on plots treated with *L. camara* 5% + nemacur (20 g/m$^2$) and nemacur (Fig 2). These results are consistent with the findings of Oduor-Owino and Waudo, (1994) who established that *Tagetes minuta* soil amendment increased tomato growth and fruit yield in a field infested with *Melodogyne javanica*.

This research confirms that *Lantana camara, Tagetes minuta* and *Azadirachta indica* in combination with a lower dosage of nemacur can effectively replace toxic and expensive chemicals in the management of parasitic nematodes under greenhouse conditions.

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