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Soil Incorporated Plant Residues and Nemacur affected Weed Population and Soil Nitrogen Dynamics in Asclepia Field

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Abstract

Field trials were conducted for two seasons in 2006 and 2007 to test the effect of *Tagetes patula*, *Lantana camara, Tephrosia vogelii, Azadirachta indica* and Nemacur on the growth of asclepiad, soil pH, and soil nitrogen as well as weed population dynamics. The experiment was replicated three times under complete randomized block design. Chopped plant materials were applied singly or in combination with nemacur. *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. *Tagetes patula* with nemacur reduced weed biomass between 33.6% and 36.6% while *L. camara* alone decreased the population density of *Oxalis cornulata* weed between 14% and 17% compared to the untreated control. The improvement of nutrient status of the soil and the control of weeds could have led to an improvement of yield characteristic of asclepias. A combination of *L. camara* with nemacur may be used instead of synthetic nematicides alone to control weeds and improve soil nutrient levels.

Keywords: *Azadirachta indica, Lantana camara, Oxalis cornulata, Tagetes patula, Tephrosia vogelii, Nitrogen Dynamics, Weed Population*

1. Introduction

Weed control is a continuous process in most horticultural crop fields. From planting time to harvesting, farmers must always keep weeds in check in order to achieve the target yields. Historically farmers have used single or combined operations such as hand hoeing, crop rotations and chemical applications among other available options in many agricultural operations. However, with the changes in health awareness and fuel prices farmers have been yeaning for low input process that can optically manage weeds. Methyl bromide which was extensively used for soil borne pests and disease control in horticulture has been phased out due to its emissions to the atmosphere as well as the toxic effects to the farmers and the environment, (McKenry et al., 1994; Kagai et al., 2012; and Culvert et al., 1998). The growing concern over the serious problems associated with chemical pesticides calls for sustained efforts to reduce pesticide and seek alternative pest control methods that are effective against target organisms, harmless to non- target organisms and are biodegradable. Among these alternative managing strategies is biofumigation. The process involves the use of biologically active compounds to manage weeds and other soil born pests. Apart from managing weeds, biofumigants can signifi-

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cantly alter soil biology and chemistry to the benefit of crops.

The concept of biofumigation was described by Kirkegaard and Sarwar (1998). Presently there are a number of herbaceous plants that can be utilized to improve plant protection and increase production (Kagai et al., 2012). Some herbs provide multiple uses that include medicine, pesticides and act as organic fertilizers. Where the herbs occur in abundance they can be used as natural pest control agents. The most common herbs in Kenya are lantana, tagetes, tephrosia and neem (Kagai, et al., 2012). Certain plants from the mustard family have also been used as biofumigants because of their ability to release inhibitory chemicals when grown as green manure and incorporated into the soil (Oloo, et al., 2009). Amended soils with fresh or composted organic matter also alter the physical, chemical and biological properties of the soil (Singh and Sitaramaiah, 1970). Changes in the soil temperature, pH, oxygen and nitrogen status have also been observed in amended soils (Brady and Weil, 2002).

Weeds are detrimental to the growth of ornamental plants and they also harbour pests. In addition, they compete for water, light and nutrients. Some weeds encountered in ornamental plant production include: common chick weed (*Stellaria media*), spotted spurge (*Chamaesyce maculata*) (Miller et al., 1975), wood sorrel (*Oxalis spp*) (Oloo et al., 2009), nutsedge (*Cyperus esculentus*) and crab grass (*Digitalia spp*) (Hall and Vandiver, 1991).

2. Materials and Methods

Experimental Site

The research work was conducted two seasons in 2006 and 2007 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 farm is in the Agro-ecological zone LH_I at an altitude of 1950 m above sea level. The mean annual rainfall during the research period was 1400 mm. The mean temperature range was between 14.8°-16.4° C. The soils are well drained, extremely dark reddish 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*

Planting seeds were obtained from Genesis Seeds Ltd, a breeder in Israel. The seeds were sown in ground beds ground beds in the greenhouse and 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 30 m long and 1m wide 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 apart 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.

Because Asclepias is a qualitative long day plant and requires 15-16 hours of light to flower (Halevy, 1999), cyclic lighting was done using normal 100-150 watt bulbs to provide 15 watts per square meter. The bulbs were placed 2.5 m above the canopy of the crop. Two layers of support wire were used to hold the crop with the first one placed 20 cm above the ground followed by another one at 40 cm above the ground to ensure that the flowering stem remained upright. Drip irrigation and watering was maintained on a constant schedule throughout the production cycle.

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) 75 gm/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

Organic soil amendments were incorporated in the soil five weeks before planting of flower seeds to allow decomposition to take place (Asirifi et al., 1994). The different plant materials were chopped into small pieces of about 2 cm and mixed with moist soil (Oloo et al., 2011). 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 the rate of150 gm/m^2 (Sharma et al., 1996). *Lantana. 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.

Organic matter and ash content were determined using the method by Bremmer, 1982. This method uses the ash content of the organic plant material. The sample is ignited slowly in a muffle furnace to a final temperature of 550^{o}C. The loss in weight represents the moisture and organic content of the sample, while the residue represents the ash (Anderson and Ingram, 1993). Critical C:N ratio was determined by the method described by Black, (1965). Organic carbon was determined by the sulphuric acid and aqueous potassium dichromate mixture.

The organic material and soil nitrogen content was determined using Micro-Kjeldah technique as described by Steyermark et al., (1958) and Bremmer, (1982) (Distillation and titration method). The nitrogen content of the soil was determined six weeks after incorporation of the plant material into the soil.

A quadrat with an area of 1 m^2 was used to randomly determine the distribution and identity of weeds under different treatments. The predominant weeds were mainly *Oxalis corniculata* and *Stellaria media*. Weed biomass was determined by clipping the shoots at the soil surface and weighing them to obtain their fresh weight. The shoots were then dried at 60° C for 120 hours to a constant weight.

Statistical Analysis

The data obtained was subjected to Analysis of Variance (ANOVA) at $P \leq 0.05$ 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.

3. Results

The soil analysis established moderate acidity (Table 1). The bases of sodium (Na) were adequately supplied while potassium (K) was low. The micronutrient manganese (Mn) was fairly adequate during the first season but excessive during the second season. Calcium (Ca), magnesium (Mg) and phosphorus (P) were excessive in the soil. Nitrogen (N) and carbon (C) were moderately supplied in the soil. The trace elements copper (Cu), iron (Fe) and zinc (Zn) were adequate in the soil in both seasons (Brandy and Weil, 2002).

Table 1

Fertility evaluation of soil before application of the treatments

Parameter*	Season 1	Season 2
pH	5.81	5.80
Sodium (%)	0.58	0.42
Potassium (%)	1.7	1.88
Calcium (%)	44.80	36.00
Magnesium (%)	4.02	3.25
Manganese (%)	1.42	2.36
Phosphorus (%)	30.18	15.43
Nitrogen (%)	0.80	0.95
Carbon (%)	2.01	1.99
Copper (ppm)	3.82	3.03
Iron (ppm)	49.87	44.82
Zinc (ppm)	26.65	28.56

*Soil analysis results of samples taken at 30 cm depth.

The Influence of Soil Amendments and Nemacur on Dry Weight of Weeds

Tagetes patula applied alone at the rate of 300 g/m^2 significantly reduced the weed dry biomass in season one, but not in season two. However, the highest reduction of 40% was observed when *T. patula* (150 g/m^2) was applied in combination with nemacur (20 g/m^2) in both seasons. A combination of *A. indica* and nemacur significantly enhanced the weed biomass compared to all other treatments (Fig. 1)

Effects of Soil Amendments on the Number of *Oxalis corniculata* and *Stellaria media*

The response of oxalis weed to the treatments was not consistent and varied with the treatments and season. For example, in the first season *L. camara* applied alone, *L. camara* + nemacur and *A. indica* + nemacur did not reduce the number of oxalis. However, these treatments had a significant reduction in the number of oxalis weed in the second season compared to the control. While plots treated with *T. vogelii* had the lowest number of oxalis in season two, those subjected to nemacur alone showed tendency to increase the number of weeds compared to the control (Table 2).

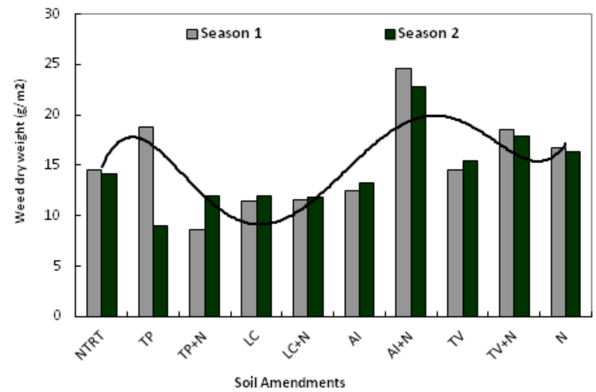

Figure 1: The influence of soil amendments and nemacur on fresh and dry weight of weeds

All treatments generally reduced the number of *Stellaria media* in both seasons except a combination of *T. vogelii* and nemacur. *Lantana camara* (5% w/w) + nemacur (20 g/m^2), *T. patula* (150 g/m^2) + nemacur (20 g/m^2) and *T. patula* alone consistently reduced the number of *Sellaria media* during the first and second seasons compared to the control (Table 2).

The Influence of Soil Amendments and Nemacur on Soil pH and Soil Nitrogen

The soil pH generally varied according to the type of organic plant material used and the combination with nemacur. The control plots had a consistent soil pH of 5.5 during the period of the study. A combination of *L. camara* and nemacur gave higher pH than all other treatments (Table 3).

The Influence of Soil Amendments and Nemacur on Soil Nitrogen

Nitrogen levels were significantly higher in amended soils than in the un-amended soils (Table 4). The concentration of nitrogen in the treatments was a reflection of the type of organic plant material used. *L. camara* alone gave the highest nitrogen concentration of nitrogen in both seasons. *L. camara*, a combination of *L. camara* with nemacur, a combination of *T. patula* with nemacur, *A. indica,* nemacur in a combination with *A. indica* and *T. patula* alone consistently increased the percentage of nitrogen in the soil during the first and second seasons. The percentage increase in nitrogen ranged between 30% and 170%.

Table 2

Number (m^{-2}) of *Oxalis corniculata* and *Stellaria media* after application of soil amendments

	Oxalis corniculata		*Stellaria media*	
Treatment	**Season 1**	**Season 2**	**Season 1**	**Season 2**
NO TRT	20.67 ab	32.67 a	24.67 b	28.67 a[1]
TP	16.00 b	20.00 bcd	11.33 e	11.33 de
TP + N®	17.67 b	16.33 cde	10.67 e	10.33 e
LC	14.33 b	17.67 cde	14.67 d	13.00 de
LC + N®	14.67 b	13.33 e	11.00 e	10.00 e
AI	17.33 b	21.67 bc	13.67 de	16.33 cd
AI + N®	13.33 b	15.00 de	13.67 de	14.67 cde
TV	16.00 b	13.67 e	19.00 c	19.33 bc
TV + N®	16.00 b	25.00 b	29.00 a	24.67 ab
N®	29.00 a[1]	20.33 bcd	20.00 c	15.33 cde

[1]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.

Table 3

Changes in Soil pH four and eight weeks after application of soil amendments

	Soil pH four weeks		**Soil pH eight weeks**	
Treatment	**Season 1**	**Season 2**	**Season 1**	**Season 2**
Control	5.55 d	5.56 b	5.53 ed	5.54 b
TP	5.76 b	5.75 b	5.83 b	5.80 b
TP + N®	5.72 bc	5.70 b	5.77 bc	5.72 b
LC	5.54 d	5.55 b	5.59 cde	5.57 b
LC + N®	6.21 a[1]	6.15 a[1]	6.27 a[1]	6.23 a[1]
AI	5.63 bcd	5.92 ab	5.75 bc	5.94 ab
AI + N®	5.58 cd	5.61 b	5.72 bcd	5.65 b
TV	5.52 d	5.54 b	5.54 de	5.53 b
TV + N®	5.49 d	5.70 b	5.56 de	5.55 b
N®	5.49 d	5.53 b	5.56 de	5.56 b

[1]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.

Table 4

Amount of soil nitrogen after application of soil amendments

Treatment	Season 1 (% N)	Season 2 (% N)
Control	0.95 c	1.00 d
TP	1.55 ab	1.68 bc
TP + N®	1.75 ab	2.00 b
LC	2.00 a	2.70 a
LC+ N®	1.79 ab	2.35 ab
AI	1.60 ab	1.75 bc
AI + N®	1.66 ab	1.79 bc
TV	1.35 b	1.30 c
TV + N®	1.40 b	1.43 c
N®	1.43 b	1.60 bc

[1]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.

4. Discussions

The density of *S. media* was significantly reduced in plots amended with *L. camara*. Lantana leaves and their leachates have been found to exert alellopathic effects in vitro and to a lesser extent in soil on seed germination, root elongation, and plant growth of many species (Casado, 1995; Sahid and Sugau, 1993). These amendments in the soil after leaching could have reduced the number of *S. media* weed seed germination. The results are also consistent with a study where it was shown that *L. camara* roots and shoots when incorporated into the soil reduced germination and growth of the milkweed vine (Kruse and Stranberg, 2000).

Soil amendments are known to influence a number of soil properties. In the present study, soil amendments were effective in regulating soil pH. Eight weeks after application of soil amendments, the control plots had a soil pH of 5.53 in the first season and 5.54 in the second season. In one study where mineral soils were amended with organic materials and sulfur in the field and in pots, plant growth was increased by all amendments and elemental sulfur (Li et al., 2006). In the control treatment, growth appeared to have been limited by high soil pH. For the sulfur treatment, a decrease in the soil pH with a concomitant increase of elemental sulfur probably stimulated plant growth. In the present study, plant growth response was probably related to both a decrease in soil pH and an improvement in soil physical conditions.

In this study, the amendments affected soil nutrient status. Lantana, tagetes and neem consistently increased nitrogen in the soil and had higher values compared to the control. It is most probable that the materials increased soil nitrogen content. This observation is consistent with the findings of MacRase and Mehuys, (2000) who stated that green manures increase nitrogen content in the soil to a certain percentage depending on plant material used. Green manures release humic acids and other acids which in turn unlock nutrients naturally present in the soil. The extra surface area provided by humus serves as a reserve for holding nutrients until they are needed by plants. This could explain why plant growth was enhanced in plots treated with soil amendment materials. Decomposition of the soil amendment materials could have provided an environment would be conducive for the biomass accumulation observed in most treatments compared to weeds from non treated plots. The results of a study conducted by 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. Nitrogen transformation in the soil produces residual acidity and perhaps account for some pH reduction associated with the organic materials (Li et al., 2006). Lantana architecture promotes accumulation of litter under the shrub, resulting into build-up of organic carbon and nitrogen (Sharma, 2007). Lantana also has higher leaf nitrogen (Rawat et al., 1994) which may favour faster litter decomposition in contrast to slower decomposition from other species. Higher N turnover rates enable lantana to perform better than other plant species (Rawat et al., 1994). The research evidence in this study confirms that a combination of *L. camara* with nemacur may be used instead of synthetic nematicides alone to control weeds and improve soil nutrient status.

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