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Lantana camara and *Tithonia diversifolia* leaf teas improve the growth and yield of *Brassica napus*

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Vegetable production is an economically viable enterprise in Zimbabwe. The most commonly grown leafy vegetable is *Brassica napus* (rape). The productivity of this vegetable is affected by poor soil fertility, with nitrogen being the most limiting nutrient. An experiment was carried out to evaluate the use of two invasive weeds *Lantana camara* and *Tithonia diversifolia* as leaf teas on harvestable biomass production of rape. The experiment was laid out as a randomized complete block design with six treatments that included different leaf tea concentrations. Leaf length was shortest (12.11 cm) on rape that did not receive any fertilizer application but was similar for all other treatments. Leaf widths of rape treated with leaf teas were not significantly different at three weeks after transplanting. At four weeks after transplanting, rape fertilized with ammonium nitrate and *T. diversifolia* (7.5 ℓ/week) had longest leaves. At five weeks after transplanting, rape that did not receive any fertilizer had the shortest leaves (12.79 cm) while ammonium nitrate gave the longest leaves. Highest rape fresh weight was from *T. diversifolia* (7.5 ℓ/week) and AN treatments. Treatments that did not receive any fertilizer consistently produced the lowest leaf length, width and fresh weight. The study showed that yield of rape from application of *T. diversifolia* (7.5 ℓ/week) was comparable to that of ammonium nitrate. Also, it is better to apply leaf teas than not to apply anything at all. Resource poor farmers who cannot afford to buy synthetic fertilizers could boost their rape production by using these leaf teas, and at the same time decelerate the spread of these weeds.

Key words: *Brassica napus*, leaf tea, *Tithonia diversifolia*, *Lantana camara*, smallholder farmer.

INTRODUCTION

In Zimbabwe, smallholder vegetable production is a fast growing enterprise due to increased vegetable demand from the rapidly growing urban population (Kuntashula et al., 2004; Chandiposha, 2007) and boarding schools. *Brassica napus* (rape) is one of the most commonly grown leaf vegetables (Turner and Chivinge, 1999). The vegetable is a cool season crop and its production is normally during the time of the year when temperature is low especially in autumn, winter and spring. However, poor soil fertility is one of the major biophysical constraints to increased productivity where nitrogen and phosphorus are the most severely depleted nutrients in many soils especially in sub-Saharan Africa (Sanchez et al., 1989; Sanchez, 1999; Jama et al., 2000). Compared to cereals, rape requires a higher amount of nutrients and available nitrogen (Rathke et al., 2005). Yield and nutrient uptake are highly dependent on nitrogen (N) fertility and peak yields occur with 120 to 180 kgN/ha (Jackson, 2000). As observed by Gachengo et al. (1999), the use of commercial fertilisers for vegetable production has generally been restricted to only a few farmers endowed with resources and high off-farm income. Inorganic fertilisers such as ammonium nitrate (AN) are at times inaccessible to smallholder farmers leading to reduced application rates or nothing being applied at all. Consequently, these farmers resort to use of traditional

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organic materials such as crop residues, livestock manure and tree leaf litter (Bradley and Dewees, 1993; Mafongoya et al., 2008). These resources are usually insufficient on most farms. Meanwhile unused, non-traditional organic resources are ubiquitous in smallholder farms. The commonest are the most unwanted *Lantana camara* and *Tithonia diversifolia* and utilization of these plants may help curb their spread.

L. *camara*, a fast growing shrub encroaching cultivated lands at an alarming rate, is labelled noxious in the Noxious Weeds Act of Zimbabwe (chapter 19:07). The plant is known to suppress the regeneration of neighbouring plants through allelopathic effects. The spread of *Lantana* is aided by the characteristic of its leaves which is somewhat poisonous to animals while its fruit is a delicacy for many birds which distribute the seeds (Fan et al., 2010). *T*. *diversifolia*, commonly known as Mexican sunflower, is an aggressive annual weed that grows to a height of about 2.5 m and is adapted to most soils (Sonke, 1997; Gachengo et al., 1999). It was probably introduced into Africa as an ornamental and is now widespread in Zimbabwe where it is found growing on waste lands, along major roads and waterways and on cultivated farmlands. The plant is very difficult to control especially during the rainy season because of its vigorous vegetative growth (Swift, 2000). Possible use of these plants for soil fertility improvement was generally explored. Both *L*. *camara* and *T*. *diversifolia* have the potential of being used as composts or green manures, especially supplying nitrogen as they both have high nitrogen content in their biomass (Mlangeni, 2010; Gachene and Kimaru, 2003).

Some studies reported that integrating *L*. *camara* trimmings with fertilizer, at 50% rates, resulted in higher maize yields than from either organic or inorganic resource (Kayuki and Wortmann, 2001). Similarly, green biomass of *T*. *diversifolia* applied either alone or in combination with fertilizer increased the yield of maize by 24 and 54%, respectively compared to plots which received no inputs (Party, 2010). However, there is a paucity of documented information on their use particularly as liquid fertilizers or leaf teas for vegetable production by the resource constrained smallholder farmers. Leaf teas are easier and quicker to prepare than composts. They have nutrients in mineral form and they can readily act as ‘straight’ fertilizers that have an important bearing on uptake by plants.

The objective of this study was therefore to assess harvestable biomass production of rape fertilized with leaf teas of *L*. *camara* and *T*. *diversifolia*.

MATERIALS AND METHODS

Study site

The study was carried out in January 2012 at Smaldeel Estate (20° 29’ 33.35’’ S and 32° 39’ 23.01’’ E), which is situated 47 km south east of Chipinge town in eastern Zimbabwe. Smaldeel Estate lies in Agro-ecological Region 1, which receives 1100 mm of rainfall per annum. In the November to April rainfall season it received 1445 mm. It is at an altitude of 1130 m above sea level, with a mean temperature range between 15 and 21°C, average relative humidity of 68 and average wind speed of 8 km/h over the past 10 years starting from 2011. The vegetation resembles a disturbed natural forest. There is abundant *L*. *camara* and *T*. *diversifolia* plants at Smaldeel Estate.

Soil sampling and analysis of *Lantana camara* and *Tithonia diversifolia*

A total of six random sampling points were selected where samples were collected from the 0 to 15 cm depth. The samples were thoroughly mixed to form a composite sample. A kilogram of the composite sample was collected and passed through a 2 mm sieve. The soil pH (0.01 M $CaCl_2$) was measured using a pH meter and electrical conductivity (1:5) soil to deionised water using a conductivity meter. Total nitrogen was determined using the method where total nitrogen in digested samples was determined colorimetrically (Anderson and Ingram, 1993). Available P was determined colorimetrically (Watanabe and Olsen, 1965). Exchangeable K, Na, Ca and Mg were determined after extraction with 1 M ammonium acetate solution, adjusted to pH 7 (Anderson and Ingram, 1993). A kilogram sample of each of *L*. *camara* and *T*. *diversifolia* fresh leaves were dried in the oven at 60°C for 48 h. Samples were ground and analysed for percentage of total N, P, K, Na, Ca and Mg using protocols outlined earlier.

Experimental design

A Randomized Complete Block Design (RCBD) with six treatments replicated three times was used. The site slope was the blocking factor. The six treatments used were as follows: No fertilizer applied, ammonium nitrate (commonly used rate of 100 kg/ha), *T*. *diversifolia* (5 ℓ/week), *T*. *diversifolia* (7.5 ℓ/week), *L*. *camara* (5 ℓ/week) and *L*. *camara* (7.5 ℓ/week).

Land preparation and transplanting

The land was first disced and seedlings of the cultivar Hobson (improved English giant rape) raised in the nursery were transplanted two weeks post emergence. The nursery was watered to field capacity before transplanting. Plot sizes were 3.3 × 1.2 m with the longer side perpendicular to the direction of the slope. A plant spacing of 30 × 30 cm with 30 plants per plot in three rows was adopted as it is commonly used by smallholder farmers.

Leaf tea preparation and chemical composition

T. *diversifolia* and *L*. *camara* leaves were obtained from the farm and prepared according to recommended methods (KATC and SCC, 2007; Altierri, 2001). Fifteen kilograms (15 kg) of fresh and tender leaves of *T*. *diversifolia* and *L*. *camara* were put into separate sacks. Each sack was put into a 200 ℓ drum with about 150 ℓ of water to maintain the required leaf tea ratio of 1:10. The mixtures were covered with hessian sacks to reduce volatilization and were kept in a shade. Mixtures were agitated once after every 2 days for 3 weeks to allow for mineralisation until the water had turned dark brownish green, an indication that most of the nutrients had dissolved into the water. Serial dilutions of ratio 2:3 (leaf tea to water) were done to reduce the tea concentration. Aliquots of 50 ml leaf tea were taken and analysed for macronutrients N, P, K, Na,

Table 1. Chemical composition of soil before planting rape.

Soil pH (0.01 $CaCl_2$)	EC (1:5) (uS/cm)	N (%)	P (ppm)	K (cmol/kg)	Ca (cmol/kg)	Mg (cmol/kg)	Na (cmol/kg)
5.5	72	0.024	4.5	0.87	3.54	0.99	0.16

Table 2. Foliar macronutrient content of *L. camara* and *T. diversifolia*.

Organic resource	N (g/kg)	P (g/kg)	K (g/kg)	Ca (g/kg)	Mg (g/kg)	Na (g/kg)
L. camara	25	8	21.6	12.8	4.1	0.1
T. diversifolia	35	9	38.6	17.8	4.0	0.2

Table 3. Leaf tea macronutrient content of *L. camara* and *T. diversifolia*.

Organic resource	N (mg/L)	P (mg/L)	K (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)
L. camara	68.54	0.04	435.56	91.56	61.78	7.98
T. diversifolia	95.20	0.28	602.22	69.44	41.11	8.44

Ca and Mg (Anderson and Ingram, 1993; Watanabe and Olsen, 1965).

Crop management

The site received high amounts of rainfall during the research period in summer and watering was not frequent. During drought periods, watering was done once in two days. Ammonium nitrate and leaf teas were applied in respective plots a week after transplanting. The leaf teas were applied by pouring onto the soil around the plant at weekly intervals. Tea rates of 5 ℓ/week per plant row translated to a rate of 500 ml/plant/week or 15 ℓ/plot/week and that of 7.5 ℓ/week per plant row to 750 ml/plant/week or 22.5 ℓ/plot/week. Watering was done prior to treatment application. Weeds were rouged whenever they emerged. A swath of 3 m bordering the experimental area was sprayed with Tamaron (methamidophos) to discourage locust attack. Other pests like aphids, cutworms and white grubs were controlled by using Karate (lambda cyhalothrin). Shallow cultivation was done to prevent soil capping thus improving infiltration of water, leaf teas and aeration. Ridges were maintained at low heights to avoid waterlogging in the experimental site.

Data collection

Data was collected from the net plot made up of ten plants in the middle row. Leaf length and leaf width were averages of the ten plants in a bed. Harvesting was done at 3, 4 and 5 weeks after transplanting. Each harvest involved removing all but three apical leaves. Fresh leaf mass was measured immediately. Yield was calculated from the mass of vegetable leaves per plot and expressed in t/ha.

Data analysis

An analysis of variance (ANOVA, F test) was carried out on the data from the RCBD using Genstat (6th edition). Differences between means were tested using least significant differences (LSD) at 5% significance level.

RESULTS

Chemical composition of soil, leaf and leaf tea

Soil chemical characteristics of the study area are presented in Table 1. Soil pH is medium acidity and soil electrical conductivity is generally low hinting at low levels of soluble salts. The total N is generally low indicating low N supplying power of the soil. According to Mashiringwani (1983), the available soil phosphorus is in the deficient range (7 to 15 ppm) while exchangeable K is in the rich range (>0.25 cmol/kg). Exchangeable Ca and Mg, though low, are relatively higher than in most communal areas of Zimbabwe (Shoko and Moyo, 2011; Chikuvire and Mpepereki, 2012). *T. diversifolia* had relatively higher nutrient content of N, P, K and Mg than *L. camara* (Table 2). *L. camara* had relatively higher levels of Mg and Na. The leaf teas displayed a disproportionate nutrient content pattern from that of the foliar. The leaf tea from *T. diversifolia* had higher levels of N, P, K and Na than that from *L. camara* (Table 3). However, the leaf tea from *L. camara* had relatively more Ca and Mg than that from *T. deversifolia*.

Effect of leaf tea on growth of *Brassica napus*

At 3 weeks after transplanting, leaf length was the same for all treatments except for the treatment where fertilizer was not applied that had the shortest leaf of 12.11 cm (Table 4). At 4 weeks after transplanting, leaf length was still significantly the shortest (17.59) in treatments that

Table 4. Effect of different fertilizers on leaf length (cm), leaf width (cm) and fresh weight (t/ha) of rape after 3, 4 and 5 weeks after transplanting.

Treatment	Leaf length (weeks)			Leaf width (weeks)			Fresh weight (weeks)		
	3	4	5	3	4	5	3	4	5
No fertilizer	12.11[a]	17.59[a]	22.21[a]	6.26[a]	10.41[a]	12.79a	0.812[a]	0.808[a]	0.908[a]
TD (5 L/W)	14.79[b]	20.35[b]	26.36[b]	7.5[b]	12.47[b]	18.37b	1.14[b]	1.41[bc]	1.661[ab]
TD (7.5 L/W)	17.07[b]	24.13[cd]	32.33[cd]	8.36[b]	15.48[c]	21.79c	1.45[c]	1.558[cd]	2.122[bc]
LC (5 L/W)	15.89[b]	20.81[b]	30.98[cd]	7.51[b]	13.41[b]	17.49b	1.055[b]	1.142[ab]	1.247[a]
LC (7.5 L/W)	14.95[b]	22.69[bc]	30.38[c]	7.95[b]	13.3[b]	19.84bc	1.256[bc]	1.167[abc]	1.593[ab]
AN	16.31[b]	25.59[d]	34.19[d]	9.95[c]	16.94[d]	25.26d	1.432[c]	1.864[d]	2.724[c]

Means followed by the same letter in a column are not significantly different ($P > 0.05$) using LSD test.
TD = *T. diversofolia*, LC = *L. camara*, AN = ammonium nitrate.

received no fertilizer. Whilst there was no significant difference between leaf length from treatments AN and *T. diversifolia* (7.5 ℓ/week), the former treatment had significantly longer leaves than those of treatment *L. camara* (7.5 ℓ/week). However, there was no significant difference between *T. diversifolia* (7.5 ℓ/week) and *L. camara* (7.5 ℓ/week). At 5 weeks, the leaf length from the treatment with no fertilizer continued to be the significantly shortest followed by that from *T. diversifolia* (5 ℓ/week). Leaf length from treatments AN, *T. diversifolia* (7.5 ℓ/week) and *L. camara* (5 ℓ/week) was similar. Conversely, that from AN treatment was significantly longer than from treatments with no fertilizer applied, *T. diversifolia* (5 ℓ/week) and *L. camara* (7.5 ℓ/week).

Widest leaves (9.95 cm) were recorded from the treatment AN while the treatment with no fertilizer had the narrowest leaves (6.26 cm) (Table 4). There were no significant differences in the leaf width of rape treated with leaf teas. At 4 weeks after transplanting, the leaf widths from treatments without fertilizer were significantly the narrowest (10.41 cm). Leaves from treatments AN were significantly the broadest of them all followed by those from treatment *T. diversifolia* (7.5 ℓ/week). Treatments *T. diversifolia* (5 ℓ/week), *L. camara* (5 ℓ/week) and *L. camara* (7.5 ℓ/week) had similar leaf width. At 5 weeks, significantly shortest (12.79 cm) leaves were consistently from the treatment that did not receive any fertilizer. The treatment with AN had the widest leaves (25.26 cm). Leaves were wider for *T. diversifolia* (7.5 ℓ/week) than for both treatments of *T. diversifolia* (5 ℓ/week) and *L. camara* (5.0 ℓ/week). The fresh leaf weight at 3 weeks after planting, from the treatment with no fertilizer, was significantly lowest (0.81 t/ha) (Table 4). Leaf weight from treatments AN and *T. diversifolia* (7.5 ℓ/week) were similar and significantly higher than those from *T. diversifolia* (5 ℓ/week) and *L. camara* (5.0 ℓ/week). At 4 weeks, there was no significant difference between fresh weight of leaves from the treatment with no fertilizer applied and *L. camara* treatments. Fresh leaf weight from treatments AN and *T. diversifolia* (7.5 ℓ/week) was similar but that from AN was significantly higher than weights from where no fertilizer was applied, *T. diversifolia* (5 ℓ/week) and *L. camara* treatments.

The trend of fresh leaf weight from treatments displayed in week 5 was almost similar to that observed in week 4. As fresh and dry weights are closely related, the cumulative dry matter yield of rape after three consecutive weekly harvests revealed that the treatment of AN and *T. diversifolia* (7.5 ℓ/week) were almost similar (Figure 1). The treatment with no form of fertilization yielded the least.

DISCUSSION

The soil is generally suitable for cultivation of rape with supplemental nitrogen and phosphorus. Higher nutrient content of *T. diversifolia* than *L. camara* is consistent with literature (Gachengo et al., 1999; Jama et al., 2000; Kwabiah et al., 2001). Consequently, the leaf tea from *T. diversifolia* was relatively more superior to that of *L. camara* with respect to supplying the much needed nitrogen and phosphorus. Treatments with no applied fertilizer consistently produced rape of the lowest leaf size as indicated by leaf length, width and fresh mass over the study period. Generally, addition of fertilizers either as AN or leaf teas showed a more positive response in growth over the control. This might be as a result of addition of fertilizers that increase and ensure the availability of nitrogen which determines assimilates accumulation in the rape leaf. Probably, high concentration of N, similar to observation by Trapani et al. (1999) on sunflower, increased the cell number and size and in overall increased the leaf size. A study by Jama et al. (2000) on maize confirmed similar results. However, it could be noticed at an early age that treatments with *T. diversifolia* leaf tea at 7.5 ℓ/week and AN had the highest potential to influence growth. The crop is likely to show a positive response to higher N rates.

Small differences especially in the fresh weight in the second and third harvests may be attributed to heavy rains that could have led to leaching of N and hence became unavailable for plant uptake. The season

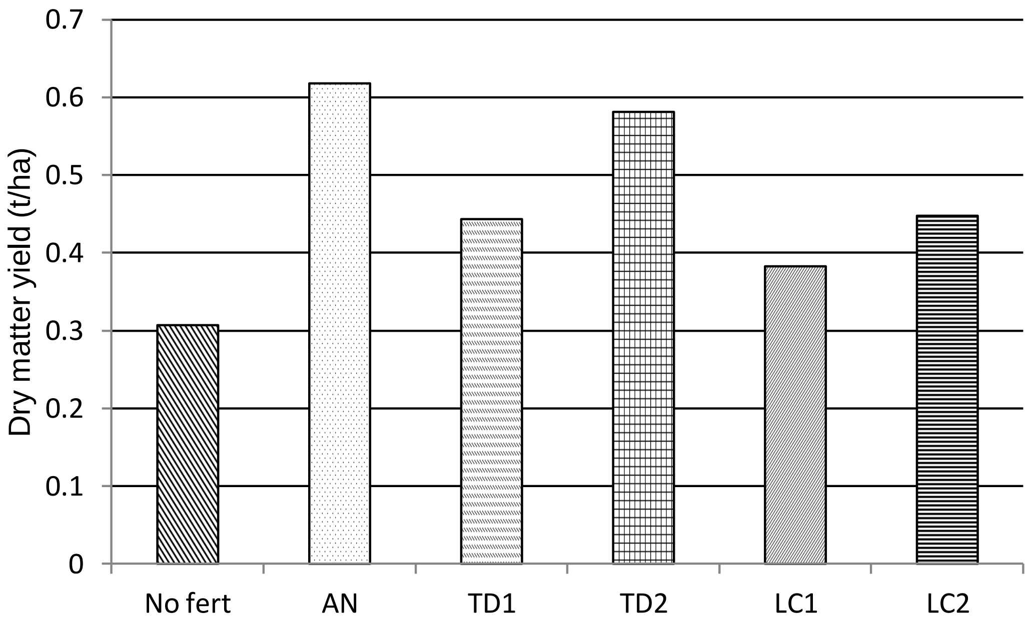

Figure 1. Cumulative dry matter yield (t/ha) of rape after three consecutive weekly harvests. Key: No fert = No fertilizer, AN = ammonium nitrate, TD1 = *T. diversifolia* (5 ℓ/week), TD2 = *T. diversifolia* (7.5 ℓ/week), LC1 = *L. camara* (5 ℓ/week), LC2 = *L. camara* (7.5 ℓ/week).

received higher normal rainfall amounts of 1445 mm. It might also be possible that volatilisation from the drums where the leaf tea was stored could have contributed to similarities of the leaf teas in terms of N content. The cumulative dry matter yield after three weekly harvests showed that the use of leaf teas is better than not fertilizing at all. *T*. *diversifolia* was apparently the better leaf tea than *L. camara* and the poor resourced farmers can alternatively utilize *T*. *diversifolia* at a higher concentration and attain similar results as those when ammonium nitrate is used. The application of leaf teas from these plants could help boost vegetable production while at the same time decelerates the spread of these invasive weeds. The trepidation of using *L. camara* due to presence of toxins such as putative hepatotoxin lantadene A is allayed by studies that revealed that *L. camara* biomass can be used, *inter alia*, as substrate for cultivation of edible mushroom, pesticide, antifungal agent to enhance crop yield and insecticide to control weevils in stored grains (Seema, 2011).

Conclusion

This study showed that generally, application of *T*. *diversifolia* at 7.5 ℓ/week was comparable to treatments with AN and there is scope for recommending it for use by smallholder farmers. *L. camara* at 7.5 ℓ/week though outperformed by *T. diversifolia,* can still be applied as it would be better than not applying at all. Spread of these invasive weeds can be curbed by exploiting them for soil fertility improvement due to their high N content. More research needs to be carried out on leaf tea formulation, storage and application in different soil types.

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