



## Original Research Article

### Allelopathic potential of *Lantana camara* for weed control in cowpea (*Vigna unguiculata* L. Walp)

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#### ABSTRACT

Smallholder farmers have challenges of weed control and mostly they use cultural control methods because chemical control with herbicides is usually costly. However, *Lantana camara* L. is known to be allelopathic to other plants hence a worthy candidate for biological control of weeds under cowpea production. A field study was conducted to determine the potential for *L. camara* to control weeds in cowpea at the University of Zambia Agricultural Experimentation Station. Leaves were harvested from two genotypes of *L. camara* (G1: Pink-flowered and G2: Orange-flowered genotypes) dried and pulverized to form a powder and applied at different rates (R0C: 0 kg ha<sup>-1</sup>, R1: 100 kg ha<sup>-1</sup>, R2: 200 kg ha<sup>-1</sup>, R3: 400 kg ha<sup>-1</sup>) using the following types of application: T0C: No application, T1: broadcasting, T2: incorporation in the soil and T3: spraying of soaked ground *L. camara*. The research was conducted at the University Of Zambia School Of Agricultural Sciences Field Station. The experiment was arranged in a split split-plot design with three replications. Weed population density and weed weight were reduced the most (38% and 12.5%, respectively) at the highest rate (R3: 400 kg ha<sup>-1</sup>) of *L. camara* application. The cowpea grain yield was higher ( $P < 0.05$ ) in fields treated with G1 (mean =876.90 kg ha<sup>-1</sup>) than for G2 (mean =672.10 kg ha<sup>-1</sup>). G1 increased cowpea grain yield by 36.04%. *Lantana camara* holds great potential to increase food security by reducing losses associated with weeds in cowpea.

#### Introduction

In many agricultural systems around the world, competition between crops and weeds is one of the major factors reducing crop yield and farmers' income (Ward et al. 2008). In cowpea production, weeds are a serious problem. When cowpea is left un-weeded, it can be completely smothered by weeds resulting in total yield loss. Weeds can cause greater yield reduction than all

the other pests and may lower quality of crop production (Ngalamu et al. 2014). Many strategies have been developed in order to control weeds including cultural, chemical, biological, mechanical and integrated weed control (Ngalamu et al. 2014). Although many smallholder farmers mostly use cultural control methods, such approaches are tedious and re-infestation of weeds is very rapid especially during the peak growing period. Chemical control with herbicides, though effective, is usually costly and sometimes unsafe to both human health and the environment (Mehdizadeh et al. 2019). Biological control of weeds has been achieved through the use of parasites, predators, or pathogens to maintain weed populations at a density lower than would occur without these natural enemies (Huffaker and Messenger, 2012; Van Driesche et al. 2008). Allelopathy has also been used to control weeds (Jabran et al. 2015). Many plants are known to have allelopathic effects, and some of these include *Asters*, *Sorghum bicolor*, *Triticum aestivum* and *L. camara* (Jabran, 2017). Despite being regarded as both a notorious weed and a popular ornamental garden plant, *L. camara* also has allelopathic properties that have been studied and exploited in weed management (Mishra, 2015). Lantana was found to inhibit the metabolism, germination and growth of susceptible plants (Mishra, 2015). *Lantana camara* therefore has potential for the control of weeds in a sustainable and environmentally friendly manner.

The objective of the study was to determine the effect of *L. camara* on weed control in cowpea production. More specifically, the study sought to compare effect of genotype of *L. camara* on weed control in cowpea, to identify the rate of application of *L. camara* on weed control in cowpea and to identify the effective rate and type of application for the control of weeds in cowpea.

## Materials and Methods

### *Study Site*

The research was conducted at the University of Zambia, School of Agricultural Sciences experimental station, falling between latitude 15° 23' 24" S and longitude 28° 19' 48" E, with an elevation of 1,260 m above the sea level. The station experiences tropical weather and falls under agro-ecological region IIa of Zambia, characterized by total annual rainfall between 800–1000 mm and annual temperature between 16°C–26°C. Soil texture grades from sandy loam in the top soil to clay loam in the subsoil.

### *Experimental Design and Treatments*

The leaves of genotypes of *L. camara* L. were room dried under ambient temperatures, milled using a mortar and pestle, sieved through a 0.1 mm sieve and the powder was weighed according to rates: Rate zero with cowpea (R0C): 0 kg ha<sup>-1</sup>, Rate one (R1): 100 kg ha<sup>-1</sup>, Rate two (R2): 200 kg ha<sup>-1</sup> and Rate three

(R3): 400 kg ha<sup>-1</sup>, equivalent, respectively. The experiment was conducted in three replicates in a split-split plot design with two genotypes (G1 and G2), four rates of application (R0C, R1, R2 and R3) and four types of application (Type zero with cowpea (T0C), Type one (T1): broadcasting, Type two (T2) incorporation in the soil and, Type three (T3): spraying of soaked ground *L. camara* powder) as main plot, sub plot and sub-sub plot factors respectively. The control was rate zero (R0C) with cowpea while the treatments (rate of application of *L. camara*) were applied in subplots as follows: i) 400 kg ha<sup>-1</sup> equivalent of dry powdered leaves of *L. camara*, ii) 200 kg ha<sup>-1</sup> equivalent of dry powdered leaves of *L. camara*, and iii) 100 kg ha<sup>-1</sup> equivalent of dry powdered leaves of *L. camara*.

Land preparation comprised of hand hoeing, after which raking was done to smoothen the tilth and flatten the land in readiness for planting. Cowpea (*Vigna unguiculata* L.) variety, Bubebe was planted on 26<sup>th</sup> February, 2018 at the rate of 25 kg ha<sup>-1</sup>. Spacing was 60 cm inter-row (with 30 cm on each side) with 15 cm and 2 cm intra row and depth, respectively. One seed was planted on each station. 300 kg ha<sup>-1</sup> of basal dressing fertilizer (Compound – D with a percentage of Nitrogen (N) 10: Phosphorus (P) 20: and Potassium (K) 10) was applied at planting on the 26<sup>th</sup> February, 2018 as recommended. Supplementary irrigation was given when there was no rainfall in week five and week six after planting using overhead irrigation. Plant protection was done using insecticides which included: i) Phorate with active ingredient phorate applied at 2 g per plant. Phorate was broadcasted in the second week after planting (7<sup>th</sup> of March, 2018) at recommended rate to protect the plants against insect pests and birds after germination. It controls insects as well as birds that feed on cowpea seedlings, ii) Thunder with imidacloprid and beta-cyfluthrin as active ingredients applied at 400 ml ha<sup>-1</sup> and iii) Ninja plus 5EC an emulsifiable concentrate containing five percent of Lamda-cyhalothrin applied at 400 ml ha<sup>-1</sup>.

Cowpea pods were harvested at physiological maturity, signified by pods turning yellow during the final stage of growth, and becoming brown and brittle when they reached maturity at a moisture content of 12%. Cowpea yield was done by removing mature pods by hand and they were packed in harvesting bags from the field to the Botany laboratory where they were allowed to dry completely. Cowpea was then threshed and the cowpea grain yield was weighed in plastic papers per plot to determine the effect of *L. camara* on weed control in cowpea.

#### *Data Collection and analysis*

Parameters measured were weed population density (WPD), weed weight (WW), crop stand (CS) and crop yield (CY). A 1 m<sup>2</sup> quadrant was used for sampling weeds around the research area as a baseline. A quadrant was thrown randomly in 15 different areas, three days before planting. The collected weeds per 1 m<sup>2</sup> quadrant were counted physically to obtain the weed population density and weighed using an electronic balance to determine weed weight. Identification of weeds was done in order to determine the types of weeds present per quadrant around the research area. Emergence count

was done by counting the number of cowpea seedlings in each row per plot in the second week after planting. All the cowpea seeds which were planted germinated. Crop stand was also done in the second week after planting. Cowpea pods were harvested at physiological maturity, signified by pods turning yellow during the final stage of growth, and becoming brown and brittle when they reached maturity at a moisture content of 12%. Cowpea yield was done by removing mature pods by hand and they were packed in harvesting bags from the field to the Botany laboratory where they were allowed to dry completely. Cowpea was then threshed and the cowpea grain yield was weighed in plastic papers per plot to determine the effect of *L. camara* on weed control in cowpea. Data analysis was conducted with ANOVA and treatment means were separated using LSD calculated at  $P \leq 0.05$  using GenStat 14<sup>th</sup> Edition.

## Results and Discussion

### *Effect of genotype of L.camara L. on cowpea grain yield*

There were significant differences ( $P < 0.05$ ) in cowpea grain yield between fields treated with the different genotypes of Lantana, rates of application and types of application (Table 1). All the interactions were also significant (Table 1).

**Table 1.** Analysis of Variance (ANOVA) for cowpea grain yield.

Source of variation	df	MS
Replication	2	539
Genotype (G)	1	1007334.00**
Error	2	1583.00
Rate (R)	3	946548.00***
G x R	3	151852.00***
Error	12	802.00
Type (T)	3	619394.00***
G x T	3	107095.00***
Rate x Type	9	41383.00***
G x R x T	9	25715.00***
Error	48	1282.00
Total		95

$P$  was calculated at  $P \leq 0.05$ . G: Genotype, R: Rate of application, T: Type of application, \*\* means significant at  $P = 0.01$ , while \*\*\* means highly significant at  $P < 0.001$ .

The cowpea grain yield was higher in plot treated with G1 (876.90 kg ha<sup>-1</sup>) than in those treated with G2 (672.10 kg ha<sup>-1</sup>). The difference in cowpea grain yield of genotype 1 over genotype 2 was 30.47% (Table 2).

**Table 2.** Means of cowpea grain yield (kg ha<sup>-1</sup>) responses on different genotypes, rates of application and types of application of *Lantana camara* L.

Genotype	Means (Kg ha <sup>-1</sup> )	Rate	Means (Kg ha <sup>-1</sup> )	Type	Means (Kg ha <sup>-1</sup> )
G1	876.90	R0C	533.90 <sup>d</sup>	T0C	579.60 <sup>d</sup>
G2	672.10	R1	724.30 <sup>c</sup>	T1	823.70 <sup>b</sup>
		R2	831.60 <sup>b</sup>	T2	732.40 <sup>c</sup>
		R3	1008.30 <sup>a</sup>	T3	962.30 <sup>a</sup>
LSD	34.940	LSD	17.810	LSD	20.780

Means within the same column followed by the same letter are not significantly different from each other at  $P \leq 0.05$ .

Both genotypes of *L. camara* were associated with higher cowpea grain yield as compared to control plots. This effect on cowpea yield could be attributed to the allelopathic effect of *L. camara* on weeds in treated fields, consistent with trends observed by Qasem (2006) who found that allelopathic plants release chemicals into the surrounding soil which prevent germination and competition from some other plant species (Ambika et al. 2003). Competition from weeds is one of the major factors reducing crop yield and farmers' income (Ward et al. 2008) and as such, reducing this competition is expected to result in increased yields. The genotype of *L. camara* with pink flowers (G1) decreased (by 64%) weed population density more than G2 and was associated with higher cowpea grain yield than the latter. This superiority of G1 over G2 in weed control could be that G1 produced more of the allelopathic chemicals than G2. Future studies should seek to verify the concentrations of allelopathic chemicals produced by the two genotypes of *L. camara*.

#### *Effect of rate of application of L. camara on cowpea grain yield*

Rate of application of *L. camara* had a significant impact on cowpea grain yield ( $P < 0.05$ , Table 2). Grain yield increased with increase in quantity of Lantana applied with R3 (400 kg ha<sup>-1</sup> rate) having the highest cowpea grain yield (1008.30 kg ha<sup>-1</sup>) and R0C having the least (533.90 kg ha<sup>-1</sup>, Table 2). These findings were in agreement with those by Mishra, (2015), who reported that, the high concentration of *L. camara* caused marked inhibition of germination and growth of weeds and eventually led to increase in yield as compared to the lower rates. The current study shows that smallholder farmers would get the most weed reduction and thus cowpea yields by using *L. camara* with pink flowers (G1), at the highest rate (R3: 400 kg ha<sup>-1</sup>), by spraying soaked ground *L. camara* (T3) to control weeds in cowpea. Type of application is discussed in the section below.

#### *Effect of type of application of L. camara on cowpea grain yield*

The type of application had an effect on cowpea grain yield. The findings of the study showed variation in plots treated with type of application on cowpea grain yield ( $P < 0.05$ ) (Table 2). Cowpea grain yield increased by 66% at T3 (962.30 kg ha<sup>-1</sup>) as it was compared to the control (579.60 kg ha<sup>-1</sup>) and it was also significant from T1 (823.70 kg ha<sup>-1</sup>). T3 was the most effective and it showed variation with T1. Soaked ground *L. camara* (T3) was more effective in that, it controlled more WPD which resulted to high yield. Similarly, other authors ascribed that yield losses caused by weeds alone in cowpea production can range from 25% to 76% (Adigun et al. 2014; Gupta et al. 2016; Osipitan et al. 2016; Ugbe et al. 2016). Contrary to the findings Marinov-Serafimov (2015), who suggested that weeds such as *L. camara* may also reduce crop yield by releasing allelopathic compounds into the environment. Soaked ground *L. camara* appeared to control more weeds maybe because grinding and soaking it made the allelopathic compound more readily available and diffusible to weeds than direct application.

#### *Variation of genotype, rate and type of application of L. camara on cowpea grain yield*

The highest cowpea grain yield was obtained from interaction of G1 at its highest rate (R3: 400 kg ha<sup>-1</sup>) with soaked ground *L. camara* (T3). In addition, the cowpea grain yield was significant different when G1, R3 and T1 was applied. In the case of G2, the highest yield was obtained from a combination of R3 and T1. Although it was higher, but it was still lower than what was obtained in G1 by 48.12% (Table 3).

**Table 3.** Effect of genotype, rate and type of application of *L. camara* on cowpea grain yield.

Genotype	Rate	Type of application			
		Cowpea grain yield (kg ha <sup>-1</sup> )			
		T0C	T1	T2	T3
G1	R0C	440.40 <sup>p</sup>	583.60 <sup>lm</sup>	550.30 <sup>mn</sup>	668.80 <sup>ij</sup>
	R1	657.10 <sup>jk</sup>	858.60 <sup>g</sup>	760.10 <sup>h</sup>	980.70 <sup>ef</sup>
	R2	496.40 <sup>nop</sup>	1026.10 <sup>e</sup>	952.30 <sup>f</sup>	1165.90 <sup>d</sup>
	R3	735.80 <sup>h</sup>	1350.08 <sup>b</sup>	1249.60 <sup>c</sup>	1554.70 <sup>a</sup>
G2	R0C	506.70 <sup>no</sup>	483.10 <sup>nop</sup>	454.10 <sup>op</sup>	584.20 <sup>lm</sup>
	R1	467.10 <sup>op</sup>	643.00 <sup>jk</sup>	602.70 <sup>k</sup>	824.90 <sup>g</sup>
	R2	616.00 <sup>jk</sup>	871.30 <sup>g</sup>	655.50 <sup>jk</sup>	869.50 <sup>g</sup>
	R3	717.70 <sup>hi</sup>	772.80 <sup>h</sup>	635.00 <sup>jkl</sup>	1049.70 <sup>e</sup>
LSD =		56.910			

*P* was calculated at  $P \leq 0.05$ .

The findings of the current study differ from what was noticed by Gantayet et al. (2014), where all the concentrations of leaf-litter dust of *L. camara* considerably reduced the yield efficiency of the

test crops compared with their respective control plants. It could be that allelopathic chemicals released by *L. camara* in the study targeted the weeds and not the crop as it was similar with observations by Wafaa et al. (2016). Weeds were mostly controlled where *L. camara* was applied as compared to where it was not applied (control) which eventually increased cowpea yield.

## Conclusion

The findings indicate that cowpea emergence and crop stand were not affected by *L. camara* and that *L. camara* reduced weeds in cowpea. G1 was more effective in that it increased cowpea grain yield by 36.04% than the G2 and the control (35.59%). However, different genotypes exhibited different effects in that G1 had better control resulting in significantly higher yield (876.90 kg ha<sup>-1</sup>) than both the control (533.90 kg ha<sup>-1</sup>) and G2 (672.10 kg ha<sup>-1</sup>) which were in turn significantly different from each other. WPD and WW were reduced the most at the highest rate of application (400 kg ha<sup>-1</sup>) or 14% aqueous extract of ground *L. camara* was found to be most effective. *L. camara* holds great potential to increase food security by reducing losses associated with weeds in cowpea.

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## Conflicts of Interest

No conflicts of interest have been declared.

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