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Efficacy of aqueous extracts of *Aloe zebrina* Baker, *Capsicum annum* L. and *Melia azedarach* L. against *Aphis gossypii* Glover (Homoptera: Aphididae)

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Abstract

Low cotton yields in Zimbabwe are mainly caused by infestation by high numbers of insect pests, diseases, poor agronomic practices and poor season quality. Aphids cause considerable yield loss in cotton. Control methods implemented for aphids include cultural approaches, chemical and biological control and use of biopesticides. Synthetic pesticides used by farmers have problems of environmental contamination, toxicity to non-target organisms, resistance by pests and toxicity to humans among others. Plant extracts (PEs) are suitable alternatives to synthetic pesticides. Three aqueous PEs at 10 and 20%v/v application rates, distilled water (no spray) and acetamiprid were evaluated against aphids. The 3x2 factorial + 2 experiments were laid out in an RCBD in the field and CRD for laboratory experiments. Leaves of *Aloe zebrina* and *Melia azedarach* and *Capsicum annum* fruits were dried and ground into powder. Water extracts were prepared and used at 10 and 20%v/v and compared with synthetic insecticide and distilled water in the laboratory. In field evaluations distilled water was replaced by unsprayed plots. All three PEs had insecticidal properties against aphids. During laboratory experiments *C. annum* 20%v/v killed 64.75% aphids and *C. annum* 10%v/v killed 63.85% aphids and they were significantly ($p=0.007$) different from other treatments after correcting for mortality. An average of 80.3% and 72.2% aphids were controlled by *C. annum* 20%v/v and *A. zebrina* 20%v/v during field trial, these were significant ($p<0.001$). *A. zebrina* extracts had both repellence and contact toxicity against aphids. All the PEs are suitable alternatives to aphicides for aphid management.

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Introduction

Cotton production is subjected to various yield reducing factors which often lead to low productivity. These yield reducing factors include insect pests such as aphids (*Aphis gossypii*) which are capable of causing more than 40 % yield loss in Zimbabwe (Mubvekeri and Nobanda, 2012). Aphids compete directly with the cotton's reproductive systems for photosynthates and energy. It sucks sap from the phloem vessels (Godfrey *et al*., 2000). Aphids also secrete honeydew which attracts black soot mould that stains cotton fibre. The honeydew also causes sticky cotton during mechanical harvesting, ginning and processing (Hequet *et al*., 2007).

Use of natural pesticides is slowly gaining recognition (Singh and Saratchandra, 2005; Mazid *et al*., 2011). These pesticides are used as one option to address yield losses caused by pest attacks as well as reducing environmental contamination, human and animal poisoning, and high cost associated with the use of synthetic pesticides (Thalkappian and Rajendran, 2011). Overuse of synthetic insecticides can reduce predator and parastoid population, cause pest resurgence and development of insecticide resistance (Tholkappian and Rajendran, 2011). However, plant extracts have minimal toxicity to non-targeted organisms and degrade quickly in the environment (Munyima *et al*., 2004).

Several plants with pesticidal activities have been identified in Zimbabwe (Chitemerere and Mukanganyama, 2010). Evaluation of *Solanum incanum* and *Strychnos spinosa* by Madzimure *et al*. (2013) showed that the two extracts have acaricidal properties at 5 % w/v application against ticks. *Melia azedarach* extracts have shown substantial promise in insect control, mainly due to the presence of limonoids which have antifeedant activities against several pests (Castillo-Sanchez *et al*., 2010; Scapinello *et al*., 2014). *Capsicum annum* is known for its contact insecticidal activity against several insect pests. It contains capsaicin and dihydrocapsaicin which can repel as well as kill insects (Antonious *et al*., 2006). *Lippia javanica* and *Solanum delagoense* water extracts showed potential to suppress brassica aphids and tomato red spider mites when applied at 12.5 % and 25.6 % respectively (Muzemu *et al*., 2011). *Aloe vera* (a close species of *Aloe zebrina*) controlled Tetranychus cinnabaribus by its repellent action and contact toxicity (Meles *et al*., 2013; Zhang *et al*., 2013).

Unlike synthetic chemicals, plant extracts from *M. azedarach, C. annum* and *A. zebrina* are composed by a large mixture of biologically active substances (Attia *et al*., 2013). The extracts from these plant species have not been tested against cotton aphids in Zimbabwe. Crude extracts were preferred in this work so as to reduce production cost to the farmers and to reduce the need for sophisticated procedures and equipment to the resource limited farmers.

In this study, the pesticidal effects and residual activity of *M. azedarach, C. annum* and *A. zebrina* water extracts applied as foliar sprays against *Aphis gossypii* populations were investigated.

Materials and methods

The experiments were conducted at Cotton Research Institute (CRI) of the Department of Research and Specialist Services, Zimbabwe during the summer season of 2013-14.

Preparation of aqueous plant extracts

(a) Zebra leaf aloe, *Aloe zebrina* Baker.

The procedures for preparation of plant materials were modified from procedures followed by Mekuaninte *et al*. (2011). Succulent leaves of *Aloe zebrina* were collected from ARDA Sanyati, along Munyati river banks in December of 2013. They were oven dried at 80°C for 120 hours and were grounded into powder using mortar and pestle. The powder was sieved using a sieve with 500 µm aperture and the finely ground powder collected into a 1000 ml capacity beaker. The finely ground powder was kept in air tight jars and stored in the cold room (±10°C) to prevent microbial contamination until extraction day. During extraction day, 400 g of the powdered material was measured and mixed with two litres of distilled water in a three litres capacity conical flask.

The solution was manually shaken thoroughly for more than 1 hour and then left for 24 hours in the pesticide mixing room under room temperature, ±25.5 °C. After 24 hours, the extract was separated using fine muslin cloth and then filtered using Whatman filter paper 24 cm diameter to get rid of solid particles. The filtrate was collected into a two litre capacity conical flask. This was considered as the stock solution where the required treatment concentrations were made from. To prepare one litre of spray mixture with final concentration of 10 % v/v or 20 %v/v, 100 ml or 200 ml of stock solution was mixed with 900 ml or 800 ml of clean water respectively.

(b) Syringa tree leaves *Melia azedarach* L. and Chillies *Capsicum annum* L.

Syringa leaves were harvested in February 2014 at Cotton Research Institute farm. They were dried in the green house for 72 hours at 42 to 49 °C. Air dried chillies were obtain from a farm in Macheke district, Manicaland province. The dried syringa leaves and chillies (5 kg) were further processed using the same procedure as outlined under preparation of *Aloe zebrina* extracts.

Treatments and experimental design

The treatments tested were the three plant extracts at 10 and 20%v/v level of concentration against acetamiprid (50 SP) and distilled water/no spray. The laboratory experiments on efficacy of aqueous plant extracts on aphids had eight treatments laid out in a Complete Randomized Design (CRD) replicated 4 times. The field experiments on efficacy of aqueous plant extracts on red spider mites and aphids had eight treatments laid out in a Randomized Complete Block Design (RCBD) replicated 4 times.

Experimental procedures

Repellency test using the 'choice test'

Repellency effect was done following the choice test procedures outlined by Moawad and Al-Barty (2011). Repellency effect of two concentrations (10 and 20 %) of water plant extracts was tested. For each test, two leaf discs free from aphids were cut, from disinfested cotton plants and washed in running water and then swapped by cotton wool pieces to remove excess fluid and dry them. After that, one leaf was dipped for 5 seconds in the corresponding plant extract and put on blotting paper to remove excess liquid. Petri dishes (10 cm in diameter), have their bottoms lined with a moistened filter paper which was divided into two equal parts. Leaf discs dipped in treatment solution were placed in one side and untreated ones on the other side. Wingless aphids at mother stage individuals (eight 8 individuals in each test) were placed using a fine brush at the centre of the dish and left for 24 hours and then number of aphids in each side were recorded. Aphids which were found wandering in the lid were considered to be repelled by the treated leaf discs and thus were counted together with those in the untreated leaf discs. Percentage of repellency was calculated according to the following equation:

$$\text{Repellency \%} = \frac{(\text{No. of aphids in untreated area} - \text{No. of aphids in treated area}}{\text{Total numbers of aphids}} \text{x100}$$

Bioassay mortality test using the 'no choice test'

Aphid infested cotton leaves were collected from the field from plots which had never been sprayed with an aphicide. Solutions of 10 and 20 % v/v for aloe, syringa and chilly extracts and control treatments of distilled water and acetamiprid were prepared in separate beakers and appropriately labelled. Leaf discs from the most heavily infested portions of the leaves were punched with a union carbide leaf puncher of 22 mm diameter; aphids already parasitized or infested with pathogenic fungi were avoided. Selected discs were almost of equal level of infestation, excess aphids and adult aphids were carefully removed using a fine needle to remain with 25 nymphs almost at mother stage. The discs were dipped into test solution for five seconds and placed with lower surfaces upwards on absorbent paper which had been appropriately labelled. After the discs had sufficiently drained excess solution they were then transferred into 10 cm diameter Petri dishes lined with moistened filter papers, with lower surfaces upwards. One disc per treatment per Petri dish was used and each test was replicated four times.

The Petri dishes were appropriately labelled. The Petri dishes were left for 24 hours under room temperature (±25.5°C). An assessment of mortalities was made utilizing a hand magnifying lens (x 10 magnification). Aphids which were unable to make coordinated movement away from gentle stimulus with a fine paint brush were considered as dead (combination of dead and seriously affected). Mortality percentage was corrected in each case according to Abbott's formula (Abbott, 1925).

$$\% \text{ Corrected mortality} = \frac{(\% \text{ Survivorship of the CO} - \% \text{ Survivorship of the EXP}}{\% \text{ Survivorship of the CO}} x100$$

Where CO = control group and EXP = experimental group

Efficacy of APEs in the field

A field trial was conducted to determine the efficacy of the three APEs (10 and 20%) against aphids. Planting using variety CRI MS2 was done on 4 December 2013 on plots which consisted of five rows which were ten metres long replicated four times. The inner area of three rows by eight metres was taken as the sampling area. A pre emergence herbicide, Codal gold 412.5DC (Prometryn + S-Metolachlor) applied at planting and manual weeding were the methods of weed control employed.

The crop emerged on 9 December 2013 and thinning to one plant per station was done on 9 January 2014. Four sprays (treatment application) were done on 4 and 20 February 2014 and 4 and 20 March 2014. Pre-treatment aphid count data were recorded a day before each spray. Aphid counts were done on three plants randomly selected from the net plot and these leaves were tagged using white string, three plants per plot. Mortality assessments were done 24, 48 and 72 hours after spaying on the tagged leaves by counting the number of aphids remaining on the tagged leaves. Aphid counts were converted to percentage mortality using the following formula

$$\text{Percent pest mortality} = \frac{(\text{Pre treatment count} - \text{Post treatment count})}{\text{Pre treatment count}} \times 100$$

Seed cotton yield was measured per each sampling area.

Data analysis

The data was subjected to Genstat (14th version) analysis of variance (ANOVA) and mean separation was done using Fisher's protected LSD at 5 % level. Some date sets were transformed before analysis using $\log_{10}$.

Results

Repellency test (choice test)

There was no significant difference ($p > 0.05$) among treatment means (Table 1).

Table 1. Bioassay repellency effect of different aqueous plant extracts and control treatments on *Aphis gosspyii*.

Treatment	No. of pests introduced	Aphid on treated disc	Aphids on untreated disc	Percent repellence
A. zebrina 10% v/v	8	2.50	5.75	40.6
A. zebrina 20%v/v	8	2.75	4.75	25.0
C. annum 10%v/v	8	1.25	6.00	59.4
C. annum 20%v/v	8	2.75	5.25	31.2
M. azedarach 10%v/v	8	2.50	4.50	25.0
M. azedarach 20%v/v	8	2.75	5.25	31.2
Distilled water	8	3.00	5.25	28.1
Grand mean		2.50	5.25	34.4
P – value		0.432	0.934	0.800
LSD (5 %)		1.952	2.811	55.62
CV (%)		24.3	19.6	22.2

Mortality test using the 'no choice test'

The results revealed that there was highly significant difference ($p = 0.007$) among treatment means on the corrected percent mortality (Fig. 1 and Table 2). The control had no mortality whilst acetamiprid had the highest corrected percent mortality. *A. zebrina* and *M. azedarach* caused mortality which was comparable to the distilled water while *C. annum* 10% v/v and *C. annum* 20 % v/v extract were comparable to acetamiprid and there were no significant differences between the 10 % and 20 % v/v application rates of *A. zebrina, C. annum* and *M. azedarach* aqueous extracts.

Percent mortality (uncorrected) was 92.23 % in acetamiprid and was comparable with *C. annum* 10 % v/v and *C. annum* 20 % v/v. The lowest percent mortality was recorded in the distilled water and was significantly different (p = 0.004) from acetamiprid, *C. annum* 10 % v/v and *C. annum* 20 % v/v only. Mortality caused by *M. azedarach* 10 % v/v and *A. zebrina* 10 % v/v was not significantly different from *C. annum* 10 % v/v and *C. annum* 20 % v/v.

Table 2. Bioassay pesticidal effects of aqueous plant extracts and control treatments on survival of *Aphis gossypii*.

Treatment	No. of pests introduced	No. Dead	No. alive	Percent mortality	Percent survival	Corrected % mortality
A. zebrina 10 % v/v	25.0	10.75	14.50	47.50^{ab}	52.50^{bc}	32.16^{ab}
A. zebrina 20 % v/v	25.0	8.31	16.69	33.25^{a}	66.75^{c}	13.74^{a}
C. annum 10 % v/v	25.0	18.01	7.00	72.02^{bc}	27.28^{ab}	63.85^{bc}
C. annum 20 % v/v	25.0	18.18	6.82	72.72^{bc}	27.28^{ab}	64.75^{bc}
M. azedarach 10 %v/v	25.0	11.92	13.08	47.69^{ab}	52.31^{bc}	32.40^{ab}
M. azedarach 20 %v/v	25.0	9.65	15.35	38.59^{a}	61.41^{c}	20.64^{a}
Distilled water	25.0	5.65	19.35	22.62^{a}	77.38^{c}	0.00^{a}
Acetamiprid	25.0	23.06	1.94	92.23^{c}	7.77^{a}	89.95^{c}
Grand mean				53.3	46.7	39.7
P – value				0.004	<.001	0.007
LSD (5 %)				30.28	30.28	39.13
CV (%)				5.8	5.5	12.0

Means followed by the same letter in a column are not significantly different by LSD method at p = 0.05.

Significant difference (p < 0.001) among treatment means was recorded with regards to aphid survival (Table 2). The highest percent survival was recorded for the control and was not significantly different from *M. azedarach* 10 % v/v, *M. azedarach* 20 % v/v, *A. zebrina* 10 % v/v and *A. zebrina* 20 % v/v. The lowest survival was recorded in acetamiprid treatment and was comparable to *C. annum* 10 % v/v and *C. annum* 20 % v/v. There were no significant difference among *A. zebrina* 10 % v/v, *C. annum* 10 % v/v, *C. annum* 20 % v/v and *M. azedarach* 10 % v/v.

Efficacy of APEs in the field

Efficacy of various treatments on aphids

The results showed significant difference (p <0.05) for aphid mortality 24 and 48 hours after the first spray (Table 3). Percent mortality 24 hours after the first spray was significantly (p<.001) the lowest in no spray and was comparable with *C. annum* extract at 10 % v/v. The highest percent mortality 24 hours after the 1st spray was achieved after using acetamiprid which was not significantly different from *A. zebrina* 20 % v/v, *C. annum* at 20 % v/v and *M. azedarach* 20 % v/v.

Mortality a 48 hours was greatest for *C. annum* 20 % v/v and was not comparable with acetamiprid, *A. zebrina* (10 % and 20 % v/v), *C. annum* 10 % v/v and *M. azedarach* 20 % v/v. The no spray which was significantly (p=0.001) lower than all the other treatment means shows that the population of aphids multiplied in this treatment by having a negative percent mortality. No significance differences were recorded 72 hours after the first spray.

The results indicated that there was significant effect (p < 0.001) among treatment means 24 hours after the second spray (Table 4). Acetamiprid caused high mortality which was significantly different from all other treatments. The lowest mortality of 11.10 % was recorded for the control and was significantly different from all other treatments. *A. zebrina* 10 % v/v, *C. annum* 10 % v/v and *M. azedarach* 10 % v/v were not significantly different from each other while the 20 % v/v rates of the three extracts where comparable again. The lowest percent mortality was as high as 86.90 % (control) and 87.54 % (control) for 48 and 72 hours after the 2nd spray respectively but with no significance (p > 0.05) differences among treatment means.

Table 3. Bio-efficacy of aqueous plant extracts and control treatments against *Aphis gossypii* during the first spray.

Treatment	Initial aphid count	After 24h		After 48h		After 72h	
		Aphid count	Percent mortality	Aphid count	Percent mortality	Aphid count	Percent mortality
A. zebrina 10 % v/v	188.0	107.5	43.21^{bc}	97.2	47.97^{bc}	129.0	30.34
A. zebrina 20 %v/v	200.2	87.8	54.64^{cd}	67.0	67.31^{bc}	62.8	69.58
C. annum 10 %v/v	222.2	181.2	19.75^{ab}	114.5	48.01^{bc}	99.0	56.42
C. annum 20 %v/v	174.0	67.5	61.25^{cd}	37.8	78.61^{c}	35.5	79.41
M. azedarach 10 %v/v	157.8	101.0	34.47^{bc}	103.0	33.48^{b}	96.0	37.34
M. azedarach 20 %v/v	198.8	83.8	57.72^{cd}	94.5	51.63^{bc}	85.2	53.77
No spray	162.8	154.2	05.31^{a}	170.8	-08.66^{a}	153.5	05.37
Acetamiprid	210.8	47.5	78.64^{d}	54.2	76.07^{c}	52.8	76.74
Grand mean			44.4		49.3		51.1
P – value			<.001		0.001		0.175
LSD (5 %)			26.12		35.81		48.20
CV (%)			3.1		6.1		10.9

Means followed by the same letter in a column are not significantly different by LSD method at p = 0.05.

Acetamiprid recorded mortality for the assessment periods after the 3rd spray respectively and was not significantly different from *C. annum* 20 % v/v for all 3 cases ($p < 0.05$) (Table 5). After 24 hours, *A. zebrina* 10 % v/v, *C. annum* 10 % v/v, *M. azedarach* 10 % v/v and *M. azedarach* 20 % v/v were not significantly ($p < 0.001$) different from each other. Both rates of *A. zebrina* and *M. azedarach* were comparable at p = 0.05 after 24 hours. *M. azedarach* 10 % v/v at 48 hours after spraying recorded the low mortality as compared to the other plant extract rates.

Table 4. Bio-efficacy of aqueous plant extracts and control treatments against *Aphis gossypii* during the second spray.

Treatment	Initial aphid count	After 24h		After 48h		After 72h	
		Aphid count	Percent mortality	Aphid count	Percent mortality	Aphid count	Percent mortality
A. zebrina 10 % v/v	106.8	54.5	48.71^{b}	8.25	91.44	3.00	97.20
A. zebrina 20 % v/v	127.2	22.0	81.24^{c}	12.25	90.49	10.50	91.55
C. annum 10 % v/v	79.0	47.5	39.93^{b}	4.25	95.11	2.25	97.40
C. annum 20 % v/v	65.0	14.0	78.17^{c}	1.50	97.90	2.75	96.11
M. azedarach 10 %v/v	78.0	43.0	43.80^{b}	3.50	95.30	2.00	97.20
M. azedarach 20 %v/v	78.0	19.8	74.96^{c}	7.25	90.75	4.75	93.92
No spray	86.0	76.2	11.10^{a}	11.75	86.90	10.75	87.54
Acetamiprid	115.0	3.8	96.01^{d}	2.00	97.66	2.75	95.63
Grand mean			59.2		93.19		94.57
P – value			<.001		0.098		0.072
LSD (5 %)			10.23		8.029		6.825
CV (%)			11.7		5.9		4.9

Means followed by the same letter in a column are not significantly different by LSD method at p = 0.05.

The two rates *of A. zebrina* and *C. annum* 10 % v/v were not significantly different ($p < 0.001$) while the two rates of *C. annum* were comparable to each other and were not significantly different from *A. zebrina* 20 % v/v 48 hours after 3rd spray. Mortality assessment 72h after the 3rd spray reveals that *M. azedarach* (10 % and 20 % v/v), *A. zebrina* (10 % and 20 %) and *C. annum* (10 % v/v) were not significantly different ($p < 0.05$). Acetamiprid which recorded the highest mortality was not significantly different from *A. zebrina* (10 % and 20 %), *C. annum* (20 % v/v) and *M. azedarach* (20 % v/v). The no spray consistently recorded the significantly low mortality for 24, 48 and 72 hours after spray than all other treatments.

Table 5. Bio-efficacy of aqueous plant extracts and control treatments against *Aphis gossypii* during the third spray.

Treatment	Initial aphid count	After 24h		After 48h		After 72h	
		Aphid count	Percent mortality	Aphid count	Percent mortality	Aphid count	Percent mortality
A. zebrina 10 % v/v	190.2	105.2	45.13^{bc}	83.0	56.18^{c}	66.2	65.02^{bc}
A. zebrina 20 % v/v	214.2	81.2	62.00^{cd}	73.2	66.55^{cd}	74.0	66.78^{bc}
C. annum 10 % v/v	225.2	151.8	34.60^{b}	88.5	61.64^{cd}	106.5	53.16^{b}
C. annum 20 % v/v	186.5	47.5	75.23^{d}	37.8	79.84^{de}	45.0	76.09^{c}
M. azedarach 10 %v/v	173.2	85.2	49.01^{bc}	110.8	34.76^{b}	85.2	48.61^{b}
M. azedarach 20 %v/v	223.2	133.8	36.82^{bc}	92.8	58.11^{c}	71.2	67.64^{bc}
No spray	195.5	183.5	5.98^{a}	185.5	5.14^{a}	182.0	6.73^{a}
Acetamiprid	203.5	40.5	81.52^{d}	28.2	88.35^{e}	33.0	86.76^{c}
Grand mean			48.8		56.3		58.8
P – value			<.001		<.001		<.001
LSD (5 %)			25.22		20.03		26.63
CV (%)			2.9		2.5		3.3

Means followed by the same letter in a column are not significantly different by LSD method at $p = 0.05$.

Effects of different plant extracts on seed cotton yield

Results for seed cotton yield indicated that there were no significant differences among treatment means ($p = 0.795$) (Fig. 2). The different treatments did not influence seed cotton yield. The highest yield was obtained for *A. zebrina* (1456 kg) whilst the lowest yield was obtained from *M. azedarach* (1131 kg).

Discussion

Repellency test

The outcome of repellency test suggests that no one plant extract treatment has a net repellence against adult female aphids. This finding is in contrast with studies done on *C. annum* and *A. vera* by Antonious *et al.* (2006). They were able to demonstrate the repellence activity of capsaicin that, besides killing insects, can repel them. Zhang *et al.* (2013) showed that *A. vera* extracts controls female RSM by its repellence. Earlier on Meles *et al.* (2012) had even suggested that the bitter taste of aloe species is responsible for the repellence activity.

Mortality test

All the plant extracts killed a proportion of the test pests. This suggest that the three plant extracts contains substances which are either aphicidal, feeding deterrence or any other mode of action which can result in immediate death of the test pests. The high mortalities observed in *C. annum* 10 % (63.85 %) and *C. annum* 20 % (64.75 %) are in conformation with several other studies by several researchers such as Antonious *et al.* (2006) who found high (45 %) mite mortality from various species of Capsicum.

Efficacy of APEs in the field

Natural mortalities were observed in the treatment where no chemical was being applied. Natural mortalities can be caused by aging, natural enemies (REACH, 2013), migration to other plant parts and they can also be washed away by rainfall (REACH, 2013; Shivanna *et al.*, 2011; Melesse and Singh, 2012).

According to Melesse and Singh (2012) aphid populations increases when rainfall was reduced and the maximum temperature was increased. Randon *et al.* (2005) showed that lady bird beetles population increases with increasing aphid population and that the beetles are a good aphid mortality factor which can be utilized in IPM programmes.

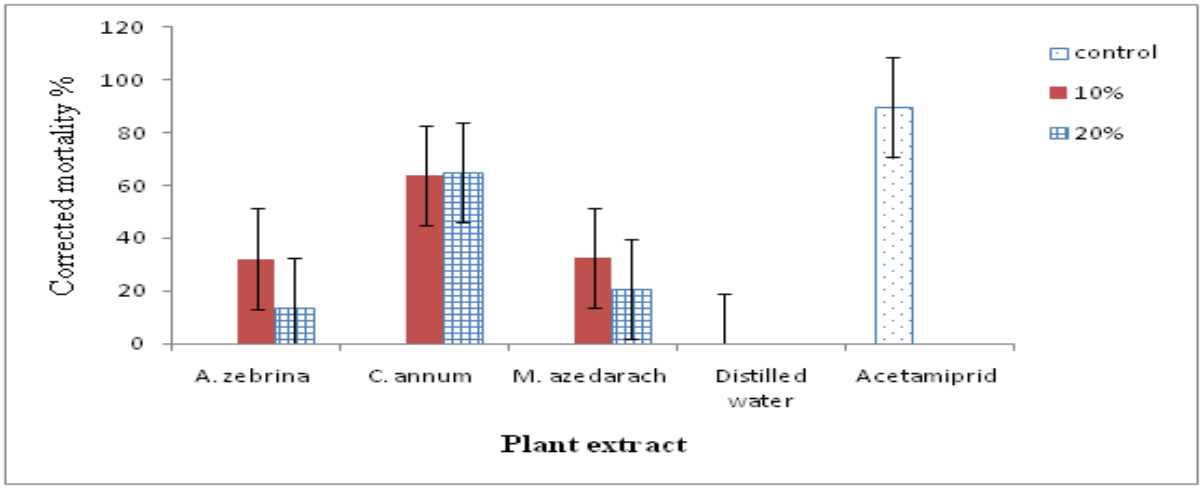

Fig. 1. Mortality effects of plant extracts on aphids.

In the current study *M. azedarach* 20 % controlled 67.64 % aphids on the 3rd spray and being comparable to the 10 % rate. These results are similar to Mekuaninte *et al.* (2011) where the syringa extracts from green and ripe fruits controlled cabbage aphids comparably. Mckenna *et al.* (2013) showed that syringa extracts reduces the population of citrus leaf miner *(Phyllocnistis citrella*) significantly. However, it is still to be found out whether the composition of Melia extracts extracted from leaves and those extracted from fruits (ripe or unripe) is similar. Different plant parts can have different types and quantities, of the active substances.

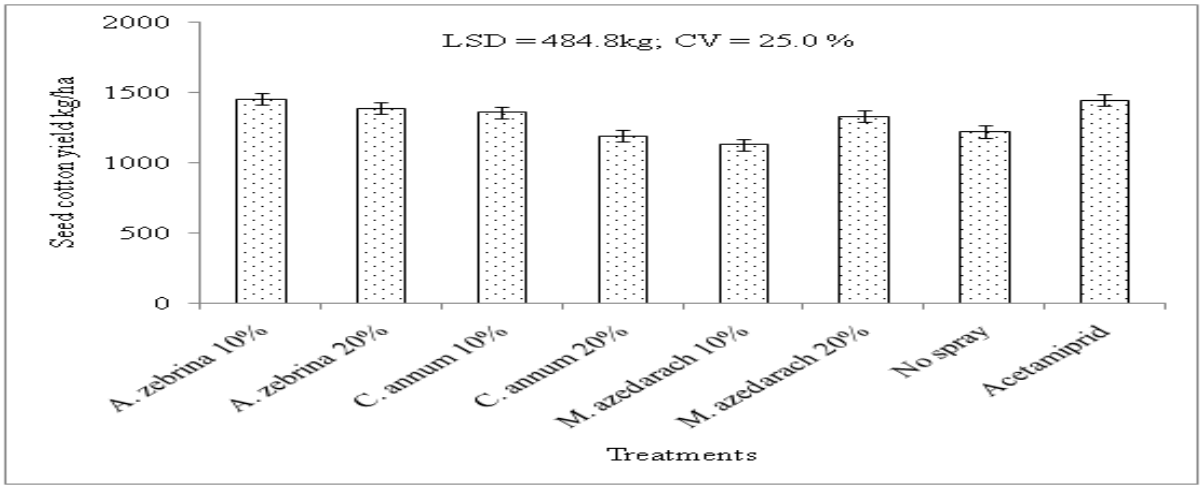

Fig. 2. Effects of different plant extracts on seed cotton yield (kg/ha).

The performance of *C. annum* extracts in this study is in contrast to that demonstrated by Oparaeke *et al.* (2005) where *C. annum* at 10 % did not significantly reduce the population of *C. tomentosicollis* and *Maruca vitrata* on cowpea.

This could be because the aphids used in this study and the pest species used by Oparaeke *et al.* (2005) are differentially susceptible to chilli extracts.

Promising results were also shown by *A. zebrina* in this work. Other species of aloe which have been studied also show insecticidal effects against aphids and other pests. *A. vera* extracts were shown to have larvicidal activity against first and second instars of *Culex salanarius* larvae (Verma *et al.*, 2013). In another study, Sarwar (2013), *A. vera* was able to keep the population of aphids to a minimum and overall pod damage was insignificant.

Excessive rainfall received at the site was responsible for lack of significance results for some sampling dates. Rainfall or sprinkler irrigation is known to be an important factor which can cause considerable aphid mortalities (Shivanna *et al.*, 2011; Melesse and Singh, 2012). The rainstorm which disturbed the fourth spray made it impossible to apply a further spray as most leaves were torn into pieces and aphids washed away. By the time the leaf area had improved temperatures were dropping such that no sufficient aphid population was built again. Temperature is known to be positively correlated with aphid population development (Wains *et al.*, 2010) low temperatures increases the developmental periods of nymphs from birth to reproductive state.

The use of botanicals is a step forward in the implementation of IPM programmes. Botanicals are environmentally friendly (Singh and Saratchandra, 2005).

Conclusion

Repellency activity of *C. annum, M. azedarach and A. zebrina* at 10 and 20 % v/v application rates and the control treatments were the same – moderately repellent. The three plant extracts caused high mortality on cotton aphids both in the laboratory experiments and field evaluation. The high rate of 20 % v/v of each extract was more effective in causing high aphid mortality than the lower rate of 10 % v/v of each extract.

C. annum 20 % v/v was most effective in causing high aphid mortalities than all other treatments. We recommended the use of *C. annum* 20 % v/v for management of cotton aphids. More work on repellency and mortality should be conducted and an HPLC must be done to quantify and the active principles in the three extracts.

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