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Original Research

Efficacy of Botanical Insecticides against the Pea Aphid, *Acyrthosiphon pisum* (Harris) and Effect on Some of Its Natural Enemies on Field Pea in South Central Ethiopia

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Abstract

A field experiment was conducted at Kulumsa center of the Ethiopian Institute of Agricultural Research (EIAR) during September 2011 and January 2011 to assess the efficacy of botanical insecticides against the pea aphid, *Acyrthosiphon pisum* (Harris) on field pea (*Pisum sativum*) and their effect on the commonly associated natural enemies of the pest. Aqueous extracts of different parts of four plant species, namely pyrethrum flower (*Chrysanthemum cinerariifolium* Trev.), young leaves of Blue Gum (*Eucalyptus globulus* Labill.), neem seed (*Azadirachta indica* A. Juss) and matured leaves of Aloe (*Aloe pubescens* Reynolds), at two different concentrations (5 and 10%) were tested along with the standard insecticide Pirimicarb 50% WP and untreated check on pea aphid tolerant variety (Tegegnech) and susceptible variety (Mohanderfer). The experiment was laid out in randomized complete block design with three replications. The lowest and highest aphid population and damage level were recorded from the standard insecticide (Pirimicarb) and untreated plots, respectively. Aphid population and their damage in botanical treatments were intermediate between the standard and the untreated check. *Eucalyptus globulus* resulted in lower aphid population and damage level than the rest of botanical treatments. Similarly, the lowest and highest yield were recorded from the untreated and Pirimicarb treated plots, respectively. Differences between any of the botanical and Pirimicarb treatments were not significant for yield (P>0.05). Botanical treatments resulted in 0.51 to 0.81 tons/ha higher yield than the untreated check. This corresponds to a yield advantage of 21.1 to 33.5% over the untreated control. Aphid population in variety 'Tegegnech' was similar to that of the 'Mohanderfer' but damage severity was lower in 'Tegegnech'. The high rate (10 %) resulted in lower pest populations, less damage and higher yield than the low rate (5 %). Predation and parasitism were relatively high in the untreated plots, intermediate in botanical treated plots and low in Pirimicarb treatments suggesting that botanicals were safer to the natural enemies of the pest

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INTRODUCTION

Field pea (*Pisum sativum* L.) is a cool season food legume providing 21-25% proteins which substitute meat and other high protein animal products for resource poor farmers (Blaine *et al*., 2009). In Ethiopia, it is mainly produced in mid to high lands between 1800 and 3000 m above sea level, in the north, south, westand central parts of the country (MoA, 2007). Ethiopia ranks first in Africa and 9th in the world with a production volume of of 160 thousand metric tons (FAO, 1999). According to the Central statistical agency of Ethiopia, current production is estimated at 263 thousand metric tons (CSA, 2012).

Several biotic constraints limit the productivity of field pea in Ethiopia including insect pestssuch as pea aphid (*A. pisum*), African boll worm (*Helicoverpa armgera*), and pea weevil (*Bruchus pisorum*) and diseases such as powdery mildew (*Erysiphe pisi)*, Rust (*Uromyces pisi*), and Ascochyta blight (*Ascochyta pinodes*) (Asfaw *et al*., 1994). Pea aphid is the major constraint of field pea production worldwide. The problem of pea aphid is more severe in local cultivars reaching up to 90 to 100 % infestation level in several field pea production areas of Ethiopia (Asfaw *et al.,* 1994). Melaku (2002) reported a total crop failure in Zema valley of Gojam. Yield losses of 22 and 29% were reported from Holeta and Dembi areas, respectively (IAR, 1987) and a yield loss of 49% was reported on pea variety 'Mohanderfer' from Arsi Zone (Kemal, 1991).Insecticidal control is the only method that field pea growers in Ethiopia have been using to minimize the damage inflicted by this pest. Several drawbacks are associated with the use of pesticides in pea aphid management similar to sole dependence on chemical control of other crop pests (Rajinder and Ashok, 2009). Non chemical management options offer a sustainable alternatives and strengthen integrated pest management program. Plant based insecticides form an integral

component in nonchemical methods of pest management (Dodia *et al*., 2008).

Extracts from some plant species have been tested against the pea aphid in Ethiopia and resulted in varying level of control. These include the hot pepper (*Capsicum* sp.) (Melaku, 2004). Birbira (*Milletia ferruginea*) seed extract (Bayeh, 2007), Neem seed oil (*Azadirachta indica*) (Kemal, 2002). Several plant species with pesticidal properties reported elsewhere for pest control (Pavela, 2009) are abundant in Ethiopia. Among these are pyrethrum (*Chrysanthemum cinerariifolium* Trev.), blue gum (*Eucalyptus globulus* Labill.), and Aloe (*Aloe pubescens* Reynolds), This study was therefore conducted to assess the efficacy of aqueous extracts of different parts of these plant species in controlling the pea aphid and their effect on commonly associating natural enemies with the aim of strengthening pea aphid integrated pest management program (IPM).

MATERIALS AND METHODS

The study was conducted at Kulumsa Agricultural Research Center located at $8^0$00'-$8^0$02'N and $39^0$07'-$39^0$10'E , 2210 m.a.s.l in Arsi Adminstrative Zone of Oromia Regional State. The area is wet with 809 mm mean annual rain fall and maximum and minimum temperatures of 23.08 and 9.9 ^{0}C, respectively (Abayneh *et al*., 2003).

Collection and Preparation of Botanical Plant Materials

Botanical plants namely pyrethrum flower (*C. cinerariifolium*) and young leaves of Blue gum (*E. globulus*) were collected from the compound of Kulumsa Agricultural Research Centre. Neem seed (*A. indica*) was collected from Dire Dawa areaand matured leaves of *A. pubescens*, were collected from Dheera in Arsi Zone. The collected plant materials were thoroughly washed by sterile tap water and dried under diffused light in the laboratory by spreading them thinly on a plastic tray.

Extraction of Botanicals

The dried plant materials were powdered manually using sterile iron mortar and pestle. Aqueous extracts of botanicals were prepared in plant protection laboratory of Kulumsa Agricultural Research Centre by mixing 10 g powder of each botanical plant in 100 ml sterile distilled water. The mixture was allowed to stand for 48 hrs using 500 ml Erlenmeyer flask and shaken in between using shaker vibrating at 250 revolutions per minute. The solution was first filtered using bandage four times fold and squeezed and further filtered using 125mm filter paper and centrifuged at 500 revolutions per minute for five minutes.

The residual remained beneath the test tube was removed and this gave a 10% stock solution. The product was kept in a bottle of 500 ml capacity at room temperature in the laboratory until used. Five and 10 ml of this stock solution were taken and further diluted to desired concentration of 5 and 10% (Kemal, 2005; Pavela, 2009; Sharma and Gupta, 2009).

Experimental Design and Treatments

A randomized complete block design (RCBD) with three replications was used. Three factors, two pea varieties, pea aphid susceptible (Mohanderfer) and tolerant (Tegegnech) (Kemal, 2002), four botanicals and two rates (5 and 10%) of applications were used. The insecticide Pirimicarb 50% WP at recommended rate of 1 kg /ha and untreated control were included as checks. Plot size was six rows of 4 m length each with a spacing of 5cm between plants and 20 cm between rows. Spacing between plots and replications were 1 m and 2 m, respectively. The spray volume per plot was 90 ml which was determined by in situ calibration. Treatments were applied by taking 90 ml of each of the application rate (5 and 10%) per plot. One millilitre liquid soap was added as sticker before spray. Application was made using a hand held sprayer of 500 ml capacity with cone nozzle. The spray drift between adjacent plots was controlled by covering the plots using plastic sheet. Land preparation and planting were done in August and September 2010, respectively. Fields were irrigated twice weekly using flood irrigation. Weeds were controlled by hand weeding. Diamonium phosphate (DAP) was applied at the rate of 100kg per hectare at sowing. Urea was applied at 25kg per hectare at seedling stage once.

Data Collection

Pea Aphid Density and Damage

Procedure followed by Melaku (2004) was used to determine aphid population, incidence and damage severity. Prior to treatment application 20 plants from the central four rows of each plot were randomly selected and tagged at seedling. Each tagged plant tip was bent and well shaken to dislodge aphid population on to a tray prepared from carton plastered inside with white plastic sheet. Aphid population on the plant were examined and mechanically removed by hand and aphid population were counted.

Incidence was recorded by taking the ratio of healthy and infested plants of the 20 tagged plants. Percentage pea aphid damage was visually assessed on plot bases using a simple scoring system of 1 to 5 (1= no damage; 2= up to 25% damage; 3= 25-50% damage; 4= 50-75% damage and 5= higher than 75% damage) (Melaku, 2004).

Natural Enemy Population

Level of pea aphid parasitism was estimated twice at flowering and pod setting based on the number of mummified aphid as a proportion of total insect number from each 20 sampled plants. Population of the most common pea aphid predator, the ladybird beetle (*Adonia* spp.) were counted twice at flowering and pod filling stage from the 20 tagged plants per plot.

Data Analysis

Data were analyzed using the SAS statistical software (SAS, 2002). Data were checked for normality before subjecting to ANOVA and appropriate transformations were made as needed. ANOVA was carried out to analyze data on aphid population, pea aphid natural enemies, pea aphid incidence, pea aphid damage, yield and yield components. Significant means were separated by Student-Newman Keuls (SNK) at .05 significance level.

RESULTS

Interaction effects were not significant among the factors considered in the analysis. Hence data on treatments or levels of each factor (botanicals, rate of application and variety) are presented along with values (mean and standard error) of the standard and untreated checks (Tables 1 to 3).

Aphid Population

Significant variation between botanical species in aphid population was observed at flowering and pod setting stages only. At both stages, the lowest and highest aphid populations were recorded from the standard insecticide (Pirimicarb) and untreated plots, respectively (Table1). Among botanicals, *Eucalyptus* resulted in lower aphid population than the rest followed by aloe at flowering, and neem at pod setting. Both *Eucalyptus* and neem resulted in significantly (P<0.05) lower aphid number than pyrethrum at pod setting stage. At flowering stage, however, only *Eucalyptus* resulted in significantly lower aphid number than pyrethrum. Results obtained from *Eucalyptus* was in general comparable to the standard insecticide indicating its potential for use in the IPM of pea aphids on field pea. The high rate application resulted in lower aphid population than the low rate in all crop growth stages considered. However, differences were significant at pod setting and maturity stages.

Table 1: Pea aphid number per 20 plants at vegetative, flowering, pod setting and maturity stages of two pea varieties treated with four different botanicals at two rates (5 and10%) at Kulumsa

	Crop growth stages				
Treatments	**Vegetative**	**Flowering**	**Pod setting**	**Maturity**	**Mean**
Pyrethrum	332.67a	1495.8a	148.92a	205.17a	545.64a
Eucalyptus	379.25a	1045.8b	99.83b	178.00a	425.72a
Aloe	326.00a	1312.5ab	135.25ab	189.17a	490.73a
Neem	439.17a	1366.8ab	129.25b	185.75a	530.31a
Pirimicarb 50% wp	376.83±48.34	555±108.19	95±11.68	84.7±10.89	277.88±59.57
Water (control)	383.50±32.61	1866±394.08	240±38.46	320.7±52.85	702.55±164.68
Rates					
5%	373.17a	1414.4a	129.83a	237.17a	538.64a
10%	365.38a	1196.0a	126.79b	141.88b	457.51a
Varieties					
Tegegnech	456.67a	1306.6a	131.29a	193.5a	522.02a
Mohanderfer	281.88b	1303.9a	125.33a	185.54a	474.16a

Means within a column followed by the same letter (s) are not significantly different at 5% level of significance; Data were log transformed for ANOVA; Presented are actual values; means were separated using Student Newman Keuls multiple range test (SNK)

Aphid population recorded from 'Tegegnech' at vegetative stage was significantly higher than 'Mohanderfer' However, in all other crop growth stages, aphid populations in both varieties were similar without significant difference. Interaction effect was not significant either.

Incidence

Aphid incidence ranged between 58.33 and 84.17%. The lowest incidence of 58.33± 5.68% was recorded from the standard insecticide treatment followed by aloe (78.75%) and *Eucalyptus* treatments (79.17%), respectively (Table 2). Incidence in pyrethrum and neem treatments was similar to the untreated check. Differences between botanical species were not significant for aphid incidence. Similarly, incidence level was slightly higher in Tegegnech than in Mohanderfer but differences were not significant (P> 0.05). The high rate application resulted in significantly lower incidence (75.21%) than the lower rate (87.29) (Table. 2).

Table 2: Pea aphid incidence and damage level in two pea varieties treated with four different botanicals at two rates (5 and10%) at Kulumsa

Treatments	**Parameters**	
	Plant damage (%)	**Aphid incidence (%)**
Pyrethrum	73.33a	82.92a
Eucalyptus	58.75c	79.17a
Aloe	65.00b	78.75a
Neem	66.67b	84.17a
Pirimicarb 50% wp	1.17±0.77	58.33±5.68
Water (control)	83.33±2.98	84.17±3.84
Rates		
5%	73.33a	87.29a
10%	58.54b	75.21b
Varieties		
Tegegnech	61.25b	82.50b
Mohanderfer	70.63a	80.00b

Means within a column followed by the same letter (s) are not significantly different at 5% level of significance; Data were arcsine transformed for ANOVA. Presented are actual values; means were separated using Student Newman Keuls multiple range test (SNK's).

Damage Level

Damage levels varied significantly (P<0.05) among botanical treatments (Table 2). Eucalyptus with 58.70% damage performed better than the rest of botanical treatments. Damage level in neem and aloe was similar without significant difference between them. The lowest (1.17±0.77%) and highest (83.33±2.98%) damage levels were recorded from Pirimicarb treatment and untreated

control plots, respectively. On the other hand, damage level was significantly lower in Tegegnech (61.25%) than in Mohanderfer (70.63%). Differences were significant between the two rates with damage levels of 73.33 and 58.54% from 5 and10% rates, respectively.

Yield and Yield Components

Yield in tons per hectare ranged between 1.47 and 2.42 among treatments. Similarly, pods per plant, seeds per pod, thousand seed weight and average seed size ranged between 6.93 and 9.75, 2.81 and 4.16, 141.60 and 161.00gm, and 5.90 and 6.30 mm, respectively (Table.3). Differences between botanicals were significant for seed weight and size. Differences between botanical species for number of pods per plant, seeds per pod and yield were not significant. The lowest values for all yield and yield component variables were obtained from the untreated plot and the highest were obtained from Pirimicarb treatment with the exception of seed weight where the highest was recorded from aloe treatment (Table 3).

Values for botanical treatments were intermediate between the untreated and Pirimicarb treatments. Seeds appeared to be lighter and smaller in the untreated plot than the rest of the treatments as measured by thousand seed weight and size. All yield and yield component values were significantly lower in the untreated plot than Pirimicarb treated plots. Values in botanical treatments were generally intermediate between the untreated and standard checks without significant difference between them for all the variabless measured with the exception of seed weight. Seed weight in pyrethrum treatment was significantly lower than aloe treatment. Yields in Aloe, neem, *Eucalyptus*, and pyrethrum treatments were 0.81, 0.69, 0.62, and 0.51 tons per hectare higher than the untreated check (Table 3). This corresponds to a yield advantage of 33.48, 28.52, 25.63 and 21.08%, respectively over the untreated control.

Table 3: Yield and yield components in two pea varieties treated with four different botanicals at two rates (5 and10%), KARC, September 2010to January 2011.

Treatments	Yield and yield componnts					Mean
	Number of pods/plant	Seeds/pod	Grain yield(tons/ha)	Thousand seed weight(g)	Average seed size(mm)	
Pyrethrum	7.99a	3.53a	1.99a	146.9b	6.06b	33.29a
Eucalyptus	8.91a	3.78a	2.10a	151.67b	6.17ab	34.53a
Aloe	8.76a	3.98a	2.29a	161.00a	6.26ab	36.46a
Neem	8.63a	3.94a	2.17a	150.73b	6.34a	34.36a
Pirimicarb 50% wp	9.75±0.91	4.16±0.69	2.42±3.58	160.30±4.17	6.34±0.18	36.59±1.91
Water (control)	6.93±0.83	2.81±0.55	1.48±2.94	141.60±7.69	5.93±0.14	31.75±2.43
Rates						
5%	7.92b	3.47b	1.97b	150.02b	6.10b	33.89b
10%	9.22a	4.14a	2.30a	155.13a	6.31a	35.42a
Varieties						
Tegegnech	8.95a	4.28a	2.57a	157.62a	6.29a	35.94a
Mohanderfer	8.19a	3.33b	1.71b	147.53b	6.12b	33.38a

Means within a column followed by the same letter (s) are not significantly different at 5% level of significance; means were separated using means were separated using Student Newman Keuls multiple range test (SNK's).

Natural Enemy Population

Number of *Adonia* spp. recorded per plot (20 plants) ranged between 0.67 and 2.5 at flowering and between 0.67 and 4.50 at pod setting (Figure 1). The lowest and highest numbers at both stages were recorded from the standard insecticide and untreated controls, respectively (Figure 1). Differences between botanical species for number of *Adonia* spp. was not significant at flowering stage (P>0.05). At pod setting, *Eucalyptus* treatment gave significantly lower number of the predator than pyrethrum treatment. Predator numbers in aloe and neem treatments were intermediate between pyrethrum and *Eucalyptus* without significant difference between them. The low rate application resulted in higher number of *Adonia* spp. than the high rate both at flowering and pod setting stage. However, differences were significant at pod setting stage only (Figure 1).

Level of parasitism ranged from 1.17 to 3.50% at flowering and from 1.50 to 7.17% at pod setting stage as measured by the proportion of mummified aphids out of total aphids counted (Figure 1). Similar to level of predation, the standard insecticide and untreated controls gave the lowest and the highest parasitism level, respectively both at flowering and pod setting stages (Figure 1). Among botanical species, high level of parasitism was recorded from pyrethrum treatment followed by neem both at flowering and pod setting (Figure 1). The lowest was recorded from *Eucalyptus* treatment both at flowering and pod setting. Differences, however, were significant at flowering stage only. Similar to level of predation, parasitism was higher in the low rate of application than the high rate both at flowering (P>0.05) and pod setting (P<0.05).

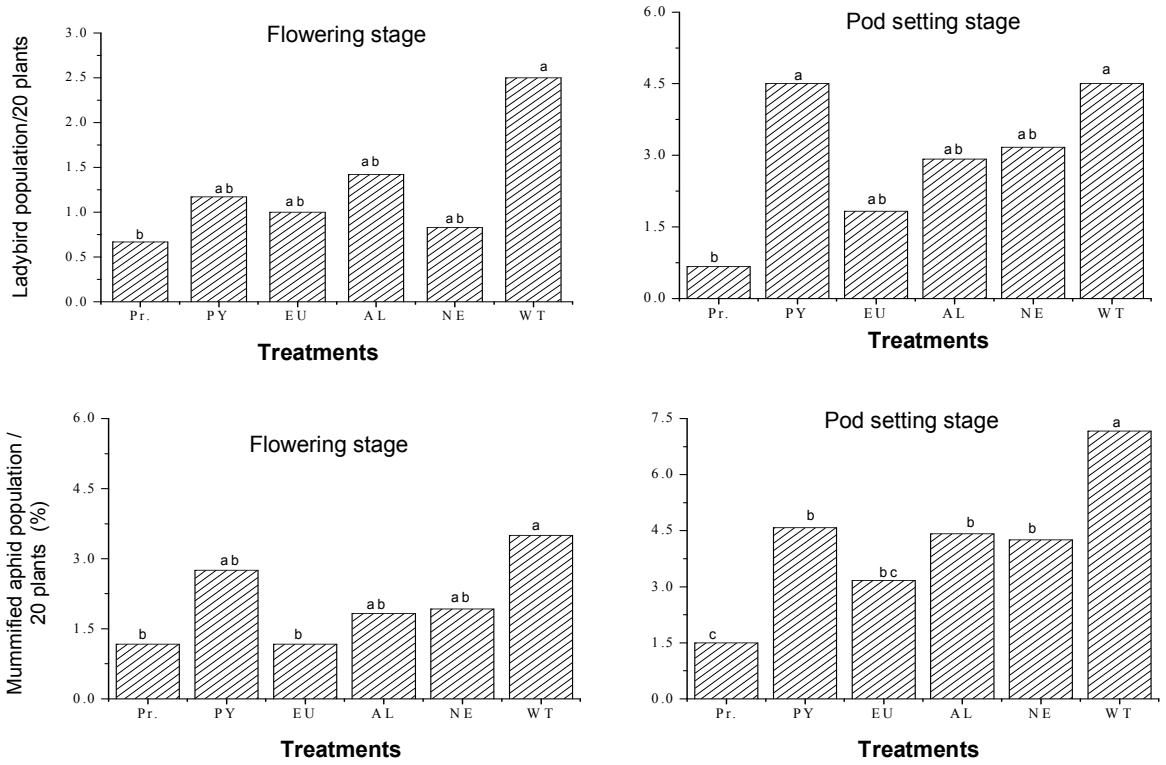

Figure 1: Mean ladybird beetle and mummified aphid population per 20 plants at flowering and pod setting stages treated with four different botanicals (Pr = Pirimicarb; PY = pyrethrum; EU = *Eucalyptus*; AL = aloe; NE = Neem; WT, untreated control);, means were separated using Students Newman Keuls test (SNK).

DISCUSSION

Results of the study showed that the 10% application rate or 100g/1liter of all botanicals tested was able to reduce pea aphid population and their damage on field pea. Studies in Egypt have shown that oil extracts from *Eucalyptus globulus* had a better performance than the organophosphate insecticide Dimethoate against piercing and sucking faba bean insect pests with minimal effect on associated natural enemies including the true spiders and minute pirate bug (Mousa *et al*., 2013). Mishra *et al*. (2012) also confirmed the pesticidal potential of *E. globulus* against the stored product insect pests , red flour beetle (*Tribolium castaneum*) and rice weevil (*Sitophilous oryzae*). The pesticidal characterstics of extracts from different parts of the neem tree, *Azadirachta indica* against several pests of crops are well documented (Schmutterer, 1990). Performance of pyrethrum, *Chrysanthemum cinerariifolium* Trev. was reported to be on par with --synthetic insecticide pyrethroid (Cypermethrin) in controlling field insect pests in ground nut in Nigeria (Frank *et al*., 2015). Aphid population recorded from 'Tegegnech' at vegetative stage was significantly higher than 'Mohanderfer' which agrees with earlier reports of Kemal (2002). Damage level was significantly lower in Tegegnech than in Mohanderfer despite higher aphid population in Tegegnech indicating the level of tolerance this variety exhibit against this pest which agrees with earlier reports of Kemal (2002).Quisenberry and Schotzko (1994) stated that tolerant plants do not inhibit pest population growth but harbor high pest population densities and give reasonable yield.

Aphid infestation with density of 1 to 3 per plant occurred about a month after planting which agrees with earlier observations of Kemal (1999) who stated that pea aphid population peaks 40 to 50 days after crop emergence coinciding with flowering and pod setting stages of the crop. The observed lower number of predators in the high rate of application than the low rate agrees with reports of Swaminathan *et al*. (2010). They reported a higher percentage (73.3%) of *Adonia variegata* (Goeze) mortality from a 10% neem seed kernel extract than a 5% neem seed oil which caused 65 % mortality. Predation and parasitism were relatively high in the untreated plots, intermediate in botanical treated plots and low in Pirimicarb treatment suggesting that botanicals are safer to the natural enemies of pea aphids. Both predation and parasitism were higher in the low rate treatment than the high rate.

CONCLUSION

This study found that 10% application or 100g/1liter of extracts from plant species, namely pyrethrum flower (*Chrysanthemum cinerariifolium* Trev.), young leaves of Blue Gum (*Eucalyptus globulus* Labill.), neem seed (*Azadirachta indica* A. Juss) and matured leaves of Aloe (*Aloe pubescens* Reynolds) botanicals was able to provide varying degree of protection on pea from pea aphid attack and safer to pea aphid natural enemies than the synthetic insecticide suggesting their potential in the integrated management of the pest (IPM). Their use in pea aphid IPM entails determination of the active substances present in them, improving its formulation and determination of optimum rate and frequency through further study. Although damage level in the tolerant

variety was less than in the susceptible variety used in this study, both aphid population and damage level were high in the tolerant variety too suggesting the need of identification of resistance sources from screening programs to get a more tolerant or pea aphid resistant variety.

Conflict of Interest

Authors declared no conflict of interest.

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