Acyrthosiphon pisum (Harris) (Homoptera: Aphididae) infestation level and damage on grass pea, *Lathyrus sativus* L., in West Gojam, Ethiopia

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ABSTRACT

Once a minor pest, the pea aphid, *Acyrthosiphon pisum* has already become a major pest of grass pea (*Lathyrus sativus*), in Ethiopia, particularly in the northwestern region. The effect of two levels of chemical treatment on pea aphids and their natural enemies was investigated in a field experiment in Achefer, northwestern Ethiopia from September 2010 to March 2011. Plant height, plant density per 0.25 m^2, number of pea aphids and parasitoids per plant, ladybird beetles per plot, and finally grain yield per plot were recorded. Based on the results of the ANOVA, plant height was significantly different between treated and untreated plots especially after the vegetative stage. The density of the plant did not significantly vary between treatments ($P=0.99$). Pea aphid population significantly varied between treated and untreated plots and between the different growth stages of the crop ($P<0.0001$). many of the natural enemies of pea aphid, i.e., ladybird beetles and parasitoids, were recorded on untreated plots. Generally, natural enemies increased as number of aphids increased. Significantly more yield was obtained from treated than untreated plots but there was no difference in yield between doses. Yield and aphid density were inversely related and grain yield loss due to pea aphids increased as high as 82.4%. This loss is very high necessitating appropriate control measures.

Keywords: Food legumes, pea aphids, pest management, yield

INTRODUCTION

In response to an ever-increasing global demand for food and feed resources and the need to diversity modern cropping systems, the genus *Lathyrus* is receiving an increased attention by agricultural scientists (Asfaw Tilaye *et al*., 2006). Grass pea is the sixth most important pulse crop in Ethiopia (ECSA, 2010). Grass pea (*Lathyrus sativus* L.) is a food, fodder and feed crop belonging to the family Leguminosae (= Fabaceae), subfamily Papilionoideae, tribe Vicieae. *Lathyrus sativus* is a much branched, straggling or climbing, herbaceous annual, with a well developed taproot system (McCutchan, 2003). It is believed to have originated in South West and Central Asia It is a break crop in cereal rotations especially with wheat, barley and tef. It is predominantly grown under residual moisture (August-December) on black soil (Minale Liben *et al.*, 2006). It can grow at altitudes ranging from 1600 to 2700 m above sea level in the different parts of the country. It is mainly grown in the northwestern Ethiopia. It tolerates both drought and flooding rendering it an insurance crop for the subsistence farmer (Melaku Wale, 2004). It improves soil fertility by fixing atmospheric nitrogen in the soil.

Many insect pests including the pea aphid, African boll-worm and thrips attack grass pea. The pea aphid is temperate in origin (Blackman and Eastop, 2000), cosmopolitan in distribution (Hutchison and Hogg, 1985; Sullivan, 2008) and is a widespread insect pest of leguminous crops such as lentils (*L. culinaris*), field pea (*P. sativum*), grass pea

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(*L. sativus*) and faba bean (*V. faba*). It is widely distributed across North America and Europe, and successfully exploits various types of host plant (clover, alfalfa, pea and bean) (Norris and Kogan, 1980; Sharp and Andrade, 1994). The pea aphid adults are bright green, long-legged, and about 1/8 inch long. Pea aphids congregate in dense colonies along the stems, terminal shoots, and leaves. Heavy infestations cause plants to wilt and turn yellowish green. Honeydew secreted by aphids is usually abundant on infested plants (Pierce, 2013).

Like most aphids, the pea aphid displays cyclical parthenogenesis. The pea aphid's feeding sites are stems, terminal shoots and petioles of seedlings and, as the plant matures, flowers and pods (Jackai and Daoust, 1986). Aphids also affect crop yields indirectly by transmitting plant-pathogenic viruses (Atiri *et al*., 1984).

In Ethiopia, pea aphid is increasingly damaging food legumes and currently it is a key pest of grass pea, peas and lentil and a vector of viral diseases (Tebekew Damte and Mohamed Dawd, 2006).

Pea aphid is very commonly found in crops grown in mid-altitude areas (1800-2700 m above sea level) and remains the most damaging by direct feeding. The seriousness of the pest depends on agro-climatic (mostly temperature and rainfall) conditions that prevail during the cropping season. Their incidence diminishes to insignificance at higher altitudes, with cool temperatures and high rainfall (Kemal Ali, 2006).

Progress and achievements in biological control of insect-pest of tropical crops clearly show that the use of predators, parasitoids and pathogens for pest control, either by introduction from other sources or by exploiting those already in the area, has proven effective and economically beneficial. Coccinellids especially Hippodamia variegata plays an important role in aphid population regulation and are known to have the strongest impact on all aphidophagus insects (Kemal Ali, 2006).

Following the recognition of pea aphids as major production constraints on grass pea and field pea in northwestern Ethiopia, some aspects of the biology and ecology of pea aphids have previously been studied in Ethiopia on various legume crops in late 1990s and early 2000s (Melaku Wale *et al.*, 2000), but that did not include the present study area. Furthermore, the amount of yield loss, the abundance of the pest and also the relationship between pea aphid and their natural enemies has not been described in the study area. Therefore, the objective of the study was to assess pea aphid infestation level, their natural enemies and to determine the level of economic damage they cause (e.g. yield loss).

MATERIALS AND METHODS

Description of the study site

A field trial was conducted between September and March, 2010-2011, in South Achefer district, West Gojam, Amhara National Regional State, Ethiopia. The State is situated between $8^{0}45'$N to $13^{0}\ 45'$N latitude and $35^{0}\ 46'$E to $40^{0}\ 25'$E longitude and has an area of 170 thousand km^2.

The trial site, i.e., Durbete (Abchicli) area, which is the administrative town of South Achefer woreda is situated at $11^{0}25'32''$ N latitude and $36^{0}17'42''$ E longitudes. The physical characteristics of the study area (Achefer woreda) are an annual rainfall of 1450 mm to 1594 mm and a temperature of 25 to 29^{o}C and an elevation of 1500 to 2500 m a.s.1 (Achefer Woreda Agricultural Bureau, 2010).

Different crops such as tef, maize, sorghum, pea, bean, grass pea, etc. are cultivated on different soil types (i.e., red soil, brown soil, and black soil) in the area. Although all crops are attacked by a wide range of pests, legumes suffer most, particularly grass pea by pea aphids. Marwagra and other nearby kebeles (the study sites) are parts of Achefer Woreda kebeles which are found West of Durbete town.

Research Design

The trial comprised of three treatments, *i.e.*, untreated (i.e., 0 litre/ha), half dose treated (i.e., 0.6 litre/ha) and full dose treated (i.e., 1.2 litre/ha) with dimethoate 40% EC insecticide applied based on the company recommendation rate for beans, i.e. 1.2 litre/ha, in which we used one level below and one level above the company recommendation. It was laid out in a Randomized Complete Block Design (RCBD) replicated four times. The total number of plots was 12 from which data were recorded.

Field experiment

The field experiment was conducted under residual moisture. Planting procedures and other farm activities were largely traditional. The trial had a total area of 30 m × 30 m which was divided into smaller plots of 3 m × 3 m and 7 m away from the field margin. A distance of 1 m between plots and 1.5 m between replications was maintained. Using the RCBD design and the four replications, each treatment was applied on four plots, which gave a total of 12 plots. The treatments include no application, half dose and full dose of dimethoate insecticide developed to control aphids.

Data collection

Assessments from the field trial were done five times at various growth stages of the plant including seedling, vegetative, flowering, pod setting and maturity stages. Number of healthy aphids and parasitized aphids were counted on a random sample of 10 plants per plot, and number of ladybird beetles was recorded on plot basis. Plant height was recorded on a random sample of 10 plants per plot and plant density was counted on 0.25 m^2 area per plot. At harvest, grain yield was taken from each plot.

Data analysis

Plant height, plant density, aphid density, lady bird beetle and parasitism level, and grain yield, were analyzed based on treatments and growth stages as a sources of variation using ANOVA. Normality of each set of data and homogeneity of variance of groups of treatments were checked before analysis. Percent yield loss was calculated using yields obtained from controlled plots as a reference (benchmark). Correlation analysis was used to determine the relationship among variables such as plant height, plant density, aphid density, ladybird beetle, parasitoid population and grain yield. For mean separation, Tukey Honesty Significance Difference test (HSD) was used at α=0.05.

RESULTS AND DISCUSSION

According to the overall ANOVA, plant height significantly varied among insecticide application doses (treatments) and plant growth stages (*F=948.2,*

Table 1. Effect Tests of treatments on plant height

Source	DF*	Sum of Squares	F-Ratio	P-value
Treatment	2	5607.3	5.6	<.0001
Growth stage	4	2373713.8	3301.8	<.0001
Treatment*growth stage	8	6546.0	4.6	.0004

* Degree of freedom

P<0.0001, R^2=0.99). The interaction effect between doses and plant growth stages was also significant (Table 1).

Plant height was the same between treated and untreated plots at seedling, vegetative and flowering stages. However, at pod setting and maturity growth stages, untreated plants were shorter than the treated plants and there was no height difference between doses (Table 2). This indicates that as aphid density increased, the fluid of the plant sucked by aphids increased causing stunted growths of plants. This corroborates previous reports on alfalfa, in which feeding by pea aphids resulted in stunted plants, delayed cuttings, or even in death of plants (Barlow *et al.*, 2012; Pierce, 2013). According to Pierce (2013), when infestations are heavy, plants wilt, turn yellow-green and die.

Table 2. Effect of dimethoate insecticide application on plant height (mm) on grass pea at different growth stages in South Achefer, West Gojam, Ethiopia (2010/11).

	Spray dose levels		
Growth stages	Untreated (check)	Half dose	Full dose
Seedling	189.3g	189.3g	193.8g
Vegetative	324.5f	326.3f	331.8f
Flowering (50%)	453.0e	454.8e	453.5e
Pod setting	589.0d	627.0c	635.3c
Maturity	714.3b	766.5a	765.3a

Means followed by the same letter are not significantly different from each other according to Tukey HSD Test (P<0.05); mean plant heights were computed from 10 plants.

Plant density

The overall ANOVA showed that there were no significant difference in plant density among treatments and growth stages (*F=0.14, P<0.999,* R^2*=0.04*).

Aphid population

Based on the ANOVA results, aphid population significantly varied among treatments (*F=2690.9, P<0.000, R^2=0.999*). It significantly varied among pesticide application treatments (doses), crop growth stages and their interactions (Table 3; Figure 1).

The density of aphids significantly and steadily increased with crop growth stage only in untreated plots but not on treated plots (Table 4). At the vegetative and seedling growth stages, aphid density was the same among treatments. Generally, the untreated plots had more aphid density than treated ones. Using pirimicarb, an aphid specific insecticide, and systemic mode of action, low aphid density was reported earlier at Wondata area, close to Bahir Dar city (Melaku Wale, 2004). In the present study, half dose and full dose pesticide applications did not significantly vary from each other (Table 4). This means that we may use half dose to minimize pesticide costs. Aphid population was highest on untreated plots especially at pod setting and maturity growth stages (Table 4). Similar results were found in Wondata village, near Bahir Dar town (Melaku Wale, 2004).

Table 3. Effect Tests of treatments on aphid population

Source	DF*	Sum of Squares	F-Ratio	P-value
Treatment	2	10222940	5548.8	<0.0001
Growth stage	4	7990167	2168.5	<0.0001
Treatment + growth stage	8	16489708	2237.6	<0.0001

*Degree of freedom

Table 4. Effect of dimethoate application and crop growth stage on aphid density (number/10 plants) on grass pea in South Achefer, West Gojam, Ethiopia (2010/11).

	Spray levels		
Growth stages	Untreated	Half dose	Full dose
Seedling	5.5d	7.3d	6.5d
Vegetative	67.8d	64.0d	72.3d
Flowering (50%)	197.3c	8.3d	5.0d
Pod setting	1354.5b	67.3d	5.0d
Maturity	2879.8a	13.5d	5.0d

Means followed by the same letter are not significantly different from each other according to Tukey's HSD test (P<0.05); means were computed from 10 plants.

a) Treated plants (protected plots)

b) Damaged plants (control plots)

Figure 1. Comparisons of untreated and treated plots

Pierce (2013) has developed economic threshold for alfalfa. Alfalfa is one of the most suitable hosts for pea aphid. Based on that model, the economic threshold for grass pea is reached at pod setting, the time when there were over 100 aphids per plant. According to Pierce (2013), the economic threshold is set as follows: insecticide application is justified when counts in established alfalfa stands average 40–50 aphids per stem on plants less than 10 inches tall, or 70–80 aphids per stem on plants greater than 10 inches tall. The two crops are different and we cannot use exactly the same model. However, until we develop our own economic threshold, we may use the one developed for similar crops such as alfalfa.

Ladybird beetle population

According to the overall ANOVA, the density of ladybird beetles was highly significant among treatments ($F=11.2$, $P<0.0001$, $R^2=0.8$). Effect test also showed the same result (Table 5). Spray treatment levels (doses), crop growth stages and their interactions were significantly different (Table 5).

The density of ladybird beetles were more in untreated plots than treated plots especially at vegetative and flowering growth stages. The number of ladybird beetles was high at vegetative and flowering growth stages, *i.e.*, 5 and 9.5 ladybird beetles per plot, respectively (Table 6). Generally, as the growth stage increases, the number of ladybird beetles decreases. Because of their mobility, insecticide application in neighborhood plots disturbs them and may avoid even unsprayed plots. Most farmers apply insecticide after crop flowering. That is why as the growth stage increases, the number of ladybird beetles decrease even on untreated plots (Table 6).

Table 5. Effect Tests of treatments on ladybird population

Source	DF*	Sum of Squares	F-Ratio	P-value
Treatment	2	64.3	14.0	<0.0001
Growth stage	4	167.6	18.3	<0.0001
Treatment*growth stage	8	126.5	6.9	<0.0001

*Degree of freedom

Table 6. Effect of dimethoate application and crop growth stage on ladybird density per plot on grass pea in South Achefer, West Gojam, Ethiopia in 2010/11.

	Spray levels		
Growth stage	Untreated	Half dose	Full dose
Seedling	0.3cd	1.3bcd	2.0bcd
Vegetative	5.0b	3.0bcd	4.0bc
Flowering (50%)	9.5a	1.5bcd	1.8bcd
Pod setting	1.5bcd	0.0d	0.0d
Maturity	1.5bcd	0.3cd	0.0d

Means followed by the same letter are not significantly different from each other according to Tukey's HSD Test (P<0.05).

Parasitoid population

Parasitoids were recorded on untreated plots at pod setting and maturity stages. None were found on treated plots and in other growth stages of the crop. The density of the parasitoids was increasing as the crop growth stage increased on untreated plots. This is because as the number of aphids increase, the chances of infestation by parasitic wasps also increase. In contrast, on treated plots no parasitoids were recorded, thus there was no need to carry out statistical analysis. This shows that application of dimethoate had significant effect on parasitoids by controlling their host, *i.e*., aphids. Joseph *et al.* (2010) also found that application of insecticide (pymetrozine) reduced the number of parasitoids (*Aphidius ervi)*.

Grain yield loss

According to the overall ANOVA, yield significantly varied among the three treatments ($F=184.4$, $P<0.0001$, $R^2=0.98$). Dimethoate treated plots gave significantly more yield than untreated plots. But there was no difference between half dose and full dose application of dimethoate (Table 7).

On the basis of yield potential from fully controlled plots, yield loss was calculated to be 82.4% on untreated plots and 8.5% on half dose treated plots (Table 7). Similar results were reported on *Aphis craccivora* which caused 83.4% and 96.1% on faba bean cv. Masar 1 and Giza 429, respectively (EI-Defrwi and EI-Harty, 2007).

Yield was negatively correlated with plant density, ladybird beetle and parasitoid but positively correlated with plant height. Aphids and their natural enemies had positive correlation. Plant density and height were negatively correlated (Table 8). The reason that the negative relation between yield and ladybird beetle and parasitoid was as the number of aphids increase, the number of ladybird beetles also

Table 7. Effect of insecticide application on the yield of grass pea in South Achefer, West Gojam, Ethiopia (2010/11)

Treatment	Yield (q/ha)	Yield loss (%)
Untreated	5.6b	82.4
Half dose treatment(0.6 l/ha)	29.2a	8.5
Full dose (1.2 l/ha)	31.9a	0.0

Means followed by the same letter are not significantly different from each other according to Tukey's HSD Test (P<0.05); means were computed from 12 plots; q stands for quintal or 100 kilo grams.

Table 8. Correlation of plant height, density of the plants, aphids, ladybird beetles and parasitoids in South Achefer, West Gojam, Ethiopia (2010/2011).

	Height	Plant density	Aphid density	Ladybird beetle density	Parasitoid density	Yield
Height	1.0					
Plant density	-0.5	1.0				
Aphid	-1.0	0.58	1.0			
Ladybird	-1.0	0.71	0.99	1.0		
Parasitoid	-0.99	0.59	1.0	0.99	1.0	
Yield	1.0	-0.49	-0.99	-0.96	-0.99	1.0

increase then yield decreases and vice versa. Melaku Wale (2004) , on the other hand found positive relationship between yield and ladybird beetle and parasitoids because the density of natural enemies was relatively higher, which eventually forced aphid numbers down and thus increased yields. Aphid and plant density had positive relationship which shows that high plant density carries high aphid population. Similar results were reported in previous studies done by Melaku Wale *et al*. (2003).

CONCLUSIONS

Aphids have significance effect on grass pea. When we compare the treated plots with untreated one, the untreated plots carried more aphids and their natural enemies (ladybird beetle and parasitoids). Number of aphids and parasitoids increased as the growth stage of the crop increased on untreated plots. Ladybird beetles decreased after pod setting. Plant height was negatively correlated with aphids, ladybird beetles, parasitoids and plant density. Yield was positively correlated with height but negatively with aphids, plant density, ladybird beetle and parasitoids. Dimethoate treated plots give more yield than untreated plots. Half and full dose treatments did not significantly vary in yield.

Based on these field and survey experiment results on pea aphids, *Acyrthosiphon pisum* (Homoptera: Aphididae) infestation level and damage on grass pea, *Lathyrus sativus* in South Achefer, West Gojam, Ethiopia, the following recommendations are given. Using insecticide significantly reduced pea aphids so that if biological control agents fail to stop them insecticides may be used. Applying half dose is more economical than full dose. Applying at pod setting stage is effective if farmers spray once, before flowering and before maturity if twice. Further research is required to determine the density of aphids and their natural enemies including their damage on grass pea at more representative sites. Economic threshold may be determined at hotspot locations.

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