Effect of Neem Based Insecticides on Cabbage Aphid (*Brevicoryne brassicae*) and its Predator in the Central Rift Valley of Ethiopia

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Abstract

The effect of two different rates of aqueous neem (*Azadirachta indica*) seed extracts (25g and 50g/l) and a commercial formulation of neem (Nimbecidine) on cabbage aphid (*Brevicoryne brassicae*) and predacious hover fly (Diptera: Syrphidae) was assessed at Melkassa Agricultural Research Centre and on farmer's field at Wonji from October 2005 to January 2006. λ-cyhalothrin (Karate®) and water were included as standard and untreated control, respectively. At both locations, the highest rate of neem seed extract (50g/l) and λ-cyhalothrin resulted in lower aphid infestation. The yield losses recorded in the control viz. the best treatment was 66 % and 62 % at Melkassa and Wonji respectively. This is interpreated into 47 and 44 t/ha losses at Melkassa and Wonji, respectively. The population of hover fly counted in aqueous neem seed extract- treated plots was significantly lower than the control but higher than on λ-cyhalothrin treated plots showing that neem seed extract is compatible with the biocontrol agents.

Introduction

In the development and promotion of Integrated Pest Management (IPM), interest in using botanicals has gained attention in recent years. This is because of their benefit in reducing environmental pollution, minimum effect on non target organism, and averting insecticide- induced resistance among others (Weathersbee and Mckenzie 2005). One such plant is neem tree, *Azadirachta indica*, which produces a biodegradable insecticidal liminoid called Azadirachtin (Isman 1999). Research on botanical control of insect pests in Ethiopia has so far concentrated on storage pest management (Abraham 2008). Information on their potential against field pests is scanty. Development of biocontrol based IPM entails replacement of non selective synthetic insecticides by selective and IPM compatible products.

A number of insect species including cabbage aphid, *Brevicoryne brassicae* L. (Hemiptera: Aphididae), diamondback moth (DBM), *Plutella xylostella* L. (Lepidoptera: Plutellidae), mustard aphid, *Lipaphis erysimi* Kaltenbach (Hemiptera: Aphididae), flee beetles, *Phylloterta* spp. and cabbage leaf miner, *Chromatomyia horticola* Goureau (Diptera: Agromyzidae) inflict damage on brassica crops in Ethiopia (Tsedeke and Gashawbeza 1994). Of these the DBM and the mealy cabbage aphid are by far the most important in affecting cabbage production in Ethiopia. Unlike DBM (Gashawbeza 2006, Gashawbeza and Ogol 2006), published information on various aspects including economic importance and ecology are not available on mealy cabbage aphid in Ethiopia.

Although no experimental yield loss assessment has been carried out in Ethiopia, Gashawbeza (2006) reported the importance of cabbage aphid in brassica production. It has been learned that in some season the pest can cause total crop failure (Gashawbeza 2003). Based on this information, it can be regarded as the most important in those seasons. In other parts of the world yield loss as high as 100% has been reported (Ellis and Farrell 1995, Brown *et al.* 1999).

Program on biological control of insect pests such as DBM in brassica production entails a search for safe and IPM compatible options for pests occurring concurrently which otherwise may nullify the control effort targeting DBM. In Kenya, for example, the potential of granulovirus of *Plutella xylostella* (*Plxy* GV) to reduce damage to cabbage by the DBM was hampered because of heavy infestation caused by cabbage aphids (Oruku and Ndun'gu 2001). In Dominican Republic the performance of *Bt* products in controlling DBM and minimizing yield loss in brassica fields was nullified due to its failure to control aphid infestation (Schmutterer 1990a).

There are a number of cabbage aphid natural enemies which could contribute a lot in the management of this pest if conducive environment is created. Syrphid flies are one of the most important predators of aphids which are highely sensitive to synthetic insecticides (Schmutterer 1990b). Larvae of syrphid flies prey on aphids, scale insects and thrips and they may quickly suppress aphid infestations because one fly consumes hundreds of aphids during its larval development period (Curran 1920).

Products that are effective for multiple key pests and safe to naturla enemies is useful in implementing and promoting IPM. This study was therefore conducted to assess the effect of neem based products on cabbage aphid and its major predator (hover flies).

Materials and Methods

The experiment was conducted at Melkassa Agricultural Research Center (8° 24' N; 39° 21' E, 1550 m asl.) and on farmer's field at Wonji (8° 27' N, 39° 13' E, 1550 m asl.) from October 2005 to January 2006.

Crop establishment

Seeds of the cabbage (*Brassica oleracea* var. *capitata*) variety, Copenhagen Market, were seeded on 5m^2 raised seedbed on September 5, 2005. and transplanted. Seedlings were transplanted to the field on October 21 and 22, 2005 at Melkassa and Wonji, respectively when they reached three to four true leaves. Each plot had 10 rows of 6m length with a row spacing of 60 cm and plant spacing of 40 cm. Spacing between plots and blocks were 1 m and 1.5 m, respectively.

At both locations, fields were irrigated twice per week for the first 3 - 4 weeks after transplanting and weekly thereafter. Fields at Melkassa were fertilized with diammonium phosphate (DAP) and Urea at the rates of 200 and 100 kg /ha, respectively. The DAP was applied just before transplanting wheras urea was applied splitted into two. The first half was applied one week after transplanting and the remaining half at the beginning of head formation. At Wonji both types of fertilizers were applied at the rate of 200 kg /ha and urea was applied in the same fashion as described for Melkassa. Other field management practices like weeding, cultivation and maintenance of ridges were carried out as needed.

The treatments

The treatements were two rates (25 and 50g/l) of aqueous neem seed extracts, a commercial neem seed extract, Neem oil (Nibecidine®), a synthetic inseecticide (λ-cyhalothrin) and a control (water). Nimbecidine was obtained from domestic chemical company called "Markos international" and λ-cyhalothrin was purchased from the local pesticide traders. Ripe neem seeds were collected from Dire Dawa, Eastern Ethiopia and dried under shade and strored in sack for abut 6 months before use.

One day before treatment application neem seeds were crushed into fine powder using wooden made mortar and pestle, and sieved using wire-mesh. The extract was made by mixing the powder with water in plastic container at the proportion of 25 g powder (referred as Neem 25) and 50 g powder (referred as Neem 50) per liter of water. After mixing, the solution was stirred carefully until all powder aggregates were separated. The solution obtained was left overnight. The following morning the extract was filtered into the sprayer using plastic mesh.

Application of lower rate of aqueous neem extracte (25g/l) correspond to 15kg/ha amd the higher rate (50g/ha) to 30kg/ha. λ-cyhalothrin was applied at the rate of 320ml/ha and watre, as a control, was applied at the rate of 600 liters per ha . Application of the treatments started two weeks after transplanting and continued at weekly interval until about ten days before harvest. Spray was made using manually operated Knapsack sprayer of 15 liters capacity using flat fan nozzle.

Data collection and analysis

A day before treatment application, 10 randomly selected plants from the central six rows were examined for *Brevicoryne brassicae* colony, hover fly larvae and pupae, and diamondback moth larvae and pupae. Colonies of aphids were recorded based on the scale of 0 to 3 (0= no colony, 1= 1-3 colonies, 2= 4-10 colonies, 3= more than 10 colonies) (Brown *et al.* 2004, Gashawbeza 2006). DBM and hover fly larvae and pupae were recorded by examining individual plant.

Data were analyzed using the SAS statistical package (SAS 1999). ANOVA was carried out to examine the effect of treatments with respect to the following: aphid infeststion, predator number and DBM number. Correlation analysis was made to establish the relationship between yield and infestation level. Before analysis data on hover fly were log transformed. Mean separation was done using Student-Newman-Keuls Test (SNK).

Results

Effect on aphid infestation

Mean weekly cabbage aphid, Brevicoryne *brassicae* colonies count per plant varied between 0 and 5.5 at Wonji (Figure 1a) and between 0 and 5.3 at Melkassa (Figure 1b). In the first five weeks sampling period, infestation was low and differences between treatments were not significant at both locations. But from the sixth week onward λ-cyhalothrin, Neem 50 and Neem 25 resulted in significantly lower number of aphid colonies than the rest of the treatments. The number of colonies recorded on plots treated with these three products did not exceed 3.5 per plant at both locations.

Data on mean aphid infestation levels (pooled for the entire season) is presented in Figure 2. At both locations, significantly higher aphid infestation was observed from Nimbecidine treated and the control plots. Lower infestation level was obtained from Neem 50 and λ-cyhalothrin treated plots without significant difference between them at boht locations.

Effect on diamondback moth

The number of DBM recorded per plant ranged from 0.12 on Neem 25 treated plot to 0.28 on the control plot at Melkassa and from 0.08 on Neem 50 treated plot to 0.14 on λ-cyhalothrin treated plot at Wonji (Table 1). This level of infestation was too low to create variability.

Table 1. Mean diamondback moth number (larvae and pupae) per plant on head cabbage treated with different insecticides at Melkassa and Wonji, 2005-2006

Treatment	Melkassa	Wonji
Neem 25	0.12 ±0.07a	0.10±0.03a
Neem 50	0.21±0.10a	0.08±0.04a
Λ-cyhalothrin	0.17±0.04a	0.14±0.09a
Nimbecidine	0.22±0.08a	0.13±0.10a
Control (water)	0.28±0.09a	0.10±0.04a

Means in a column followed by the same letter are not significantly different from each other at 5% significance level (SNK)

Effect on yield

Low yield at both locations was recorded from the Nimbecidine and untreated check plots (Table 2). Higher yield was recorded from Neem 50 and λ-cyhalothrin treatments with no significant difference between them at both locations. Of the two cabbage insect pests observed in this experiment it was the aphid's infestation responsible for the observed yield difference among the different treatments; relationship between aphid infestation and yield level was strongly negative and highely significant both at Melkassa ($r= -0.60$, $P= 0.0172$) and Wonji ($r= -0.90$, $P< 0.0001$). While the relation between yield and DBM infestation level was not significant both at Melkassa ($r= -0.09$, $P= 0.7322$) and Wonji ($r= 0.05$, $P= 0.8467$). The yield loss level observed by comparing the control with the best treatmente was 66 percent at Melkassa and 62 percent at Wonji (Table 2). This corresponds to 47 and 44 t/ha at Melkassa and Wonji, respectively.

Effect on predator (hover fly)

At both locations, significantly higher number of hover flies was recorded from Nimbecidine and untreated plots (Figure 3). λ-cyhalothrin treated plots had significantly lower number of hover flies than the rest of the treatments. The effect of aqueous extracts of neem was intermediate between λ-cyhalothrin and, Nimbecidine and untreated check.

Table 2. Marketable yield (tons per ha) of head cabbage sprayed with different insecticides at Melkassa and Wonji, 2005-2006

Treatments	Melkassa		Wonji	
	Yield	Percentage yield gain	Yield	*Percentage yield gain
Neem 25	50.92±11.64a	54.03	67.68±2.06a	60.79
Neem 50	63.14±15.92a	62.92	65.46±6.58a	59.46
λ-cyhalothrin	70.78±18.26a	66.93	71.37±4.61a	62.81
Nimbecidine	29.31±9.78b	5.90	34.78±5.44b	23.69
Control (water)	23.41±9.09b	-	26.54±4.42b	-

Means in a column followed by the same letter are not significantly different from each other at 5% significance level (SNK)
*percentage yield advantage over the control

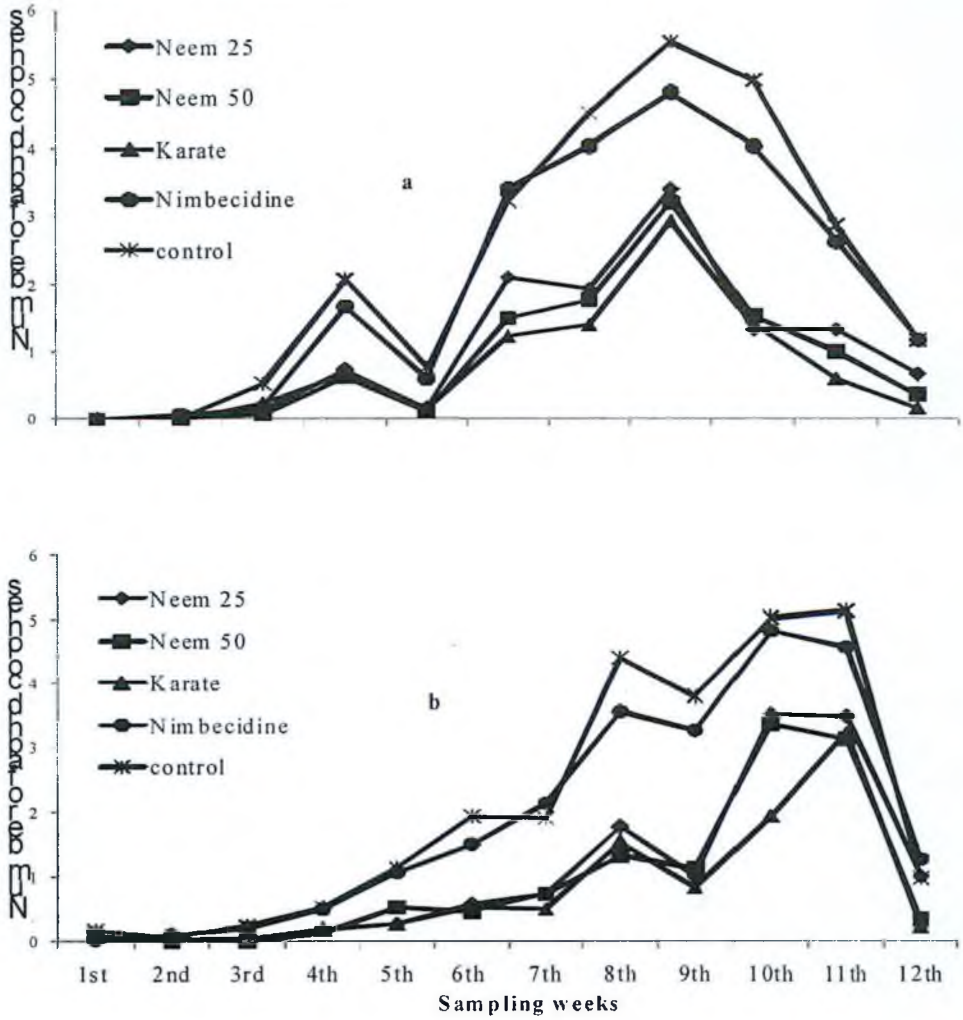

Figure 1. The effect of insecticides on aphids colony at different weeks of crop growth at Wonji (a) and Melkassa (b), 2005-2006

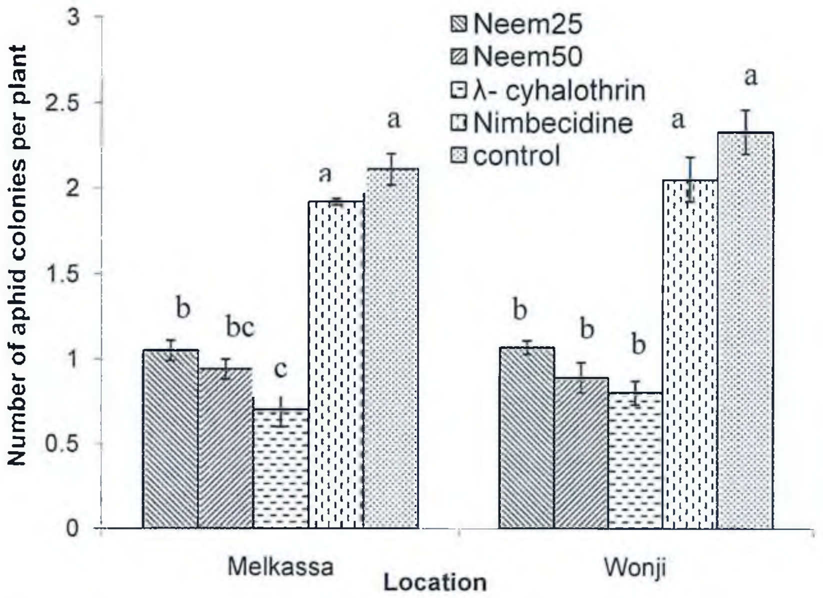

Figure 2. Level of aphid infestation of head cabbage sprayed with different insecticides at Melkassa and Wonji, 2005-2006

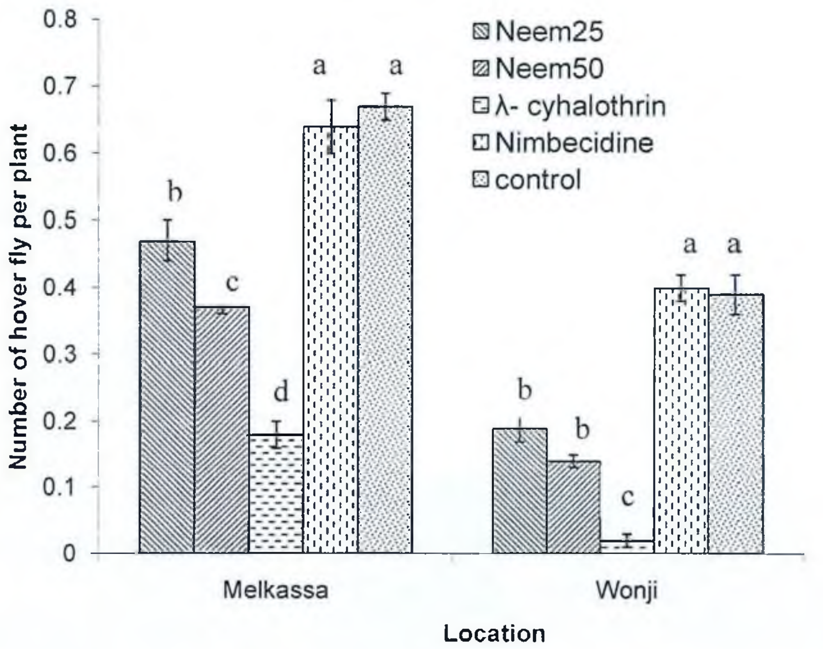

Figure 3. Number of hover fly (larvae and pupae) per plant on cabbages sprayed with different insecticides at Melkassa and Wonji, 2005-2006

Discussion

The level of yield loss observed in this study clearly indicates the economic importance of *B. brassicae* in brassica production in Ethiopia. In this study the DBM number never exceeded 0.1 and 0.3 per plant at Wonji and Melkassa, respectively, and differences between treatments was not significant at both locations. The correlation analysis corroborates this. Although both pests occur concurrently on cabbage, the observed difference in yield among treatments was due to differences in aphid infestation. Relationship between yield and aphid infestation was strong and significant but weak and non significant between DBM number and yield. It has been reported that DBM has developed resistance against λ-cyhalothrin (Lidet *et al.* 2009). This could partly be responsible for the observed lack of effectivness of λ-cyhalothrin against DBM. However the effectivness of aqueous neem extracts in controling DBM was reported on seasons of high DBM infestation (Lidet *et al.* 2009) The high level of aphid infestation and low level of DBM infestation observed in this study reflect their relative importance in this particular season of production.

The two rates of aqueous neem seed extracts were equaly effective in controling cabbage aphids and their effect was comparabile with λ-cyhalothrin wihich is synthetic inseticide. The effectiveness of these rates in the control of cabbage aphid was also reported by Okoth *et al.* (2002). It would be more economical to use 25 g/l for plant treatment since the 25 and 50 g/l neem-treated plants did not differ significantly in the observed level of aphid infestation. Results of field and laboratory studies showed that different aphid species treated with different commercial neem formulations as well as water extracts experienced interruption of growth, development, feeding and fecundity, and direct toxicity (Nisbet *et al.* 1993, 1994, Stark and Rangus 1994, Stark & Wennergren 1995, Edelson *et al.* 2002, Terezinha *et al.* 2004, Karagounis *et al.* 2006, Ahmed *et al.* 2007, Nabil and Saleh 2007). Perhaps azadirachtin, the main active principle in neem seed kernel affects the development of insects by influencing on the hormonal system, especially on ecdysteroids (Schmutterer 1990b).

Though it is difficult to give a complete explanation on the observed high aphid infestation on Nimbecidine treated plots than the aqueous extracts, availability of more diversified active ingredients in the aqueous neem extract than in the commercial products may partly be responsible. Similar observations have been made by Charleston *et al.* (2006). They observed a high level of DBM population on plots treated with a commercial preparation of neem called Neemix 4.5 ® which was even higher than the untreated plot.

The population of hover fly counted in the aqueous neem seed extract-treated plots were significantly less than that of the control and greater than the λ-cyhalothrin treated plot. On the other hand population of hover flies in the Nimbecidine treated plot was comparable with the untreated plot. This finding agrees with reports of Shafie (2001) who reported significantly higher number of hover flies in neem treated plots than plots treated with the synthetic insecticide, Sumicidine, and untreated plot respectively. The observed lower number of syrphid flies in neem treated plots than the untreated plot shows the relative toxicity of neem seed preparation to the predator as reported by Schmutterer (1997) and this could be due to the neem picked up by the predator from the bodies of its prey. Although neem products are safe to a large number of predators and parasitoids associated with various species of aphids, syrphid flies appeared to be relatively susceptible particularly at the larval stage (Schmutterer 1997). On the other hand the higher number in neem treated plot than the synthetic insecticide shows that they are less sensitive to neem than the synthetic insecticides. This is because of the relatively weak contact effect in insects and the special mode of action of neem-based pesticides that neem products must be ingested to be effective (Schmutterer1990b).

The syrphid flies are the least among the beneficial insects studies with respect to the side-effect of the neem products and scant literature is found on this topic (Shafie 2001). Moreover the available reports are controversial. Schauer (1985) and Schmutterer (1990b) reported the toxic nature of the enriched neem seed kernel extract to the third-instar larvae of the hover fly, *Episyrphus balteatus*. On the other hand a number of field and greenhouse studies showed that botanical extracts derived from *A. indica* did not have negative effect on the different growth stages of various predators including hover fly (Saxena 1987, Isman *et al.* 1991, Siliva and Martinez 2004, Charleston *et al.* 2006).

In the development of integrated pest management where more than one insect species affect production, the main challenge is the availability of products that are effective against the major insect species without posing a negative effect on their natural enemies. The findings in this study clearly showed that neem based products can form integral component in the IPM of main crucifer insect pests because of their efficacy to control major insect pests such as diamondback moth (Lidet *et al.* 2009) and cabbage aphids with no or minimal effect on their natural enemies such as the cabbage aphid's predator.

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