Field efficacy of plant extracts on larval populations of *Plutella xylostella* L. and *Helicoverpa armigera* Hub. and their impact on cabbage infestation

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ABSTRACT

The field efficacy of four plant extracts such as *Vitex negundo* L. (Verbenaceae), *Clerodendrum inerme* (L.) Gaertn. (Verbenaceae), *Lantana camara* L. (Verbenaceae) and *Eupatorium odoratum* L. (Asteraceae) were evaluated against the diamondback moth, *Plutella xylostella* L. and the cotton bollworm, *Helicoverpa armigera* Hub. larvae on cultivated cabbage. Treatments with 1% *V. negundo* and *C. inerme* extracts significantly reduced *P. xylostella* larval density, and the percentage of infested plants, proving to be more effective than a standard insecticide Challenger 10EC (cypermethrin). Treatment with *L. camara* extract (1%) reduced the percentage of *H. armigera* infested plants and the intensity of cabbage damage. However, the plant extracts did not effectively reduce *H. armigera* larval density, and cabbage damage. Phytotoxic effects on cabbage plants were not observed in any extract treatment. Two plant extracts, *V. negundo* and *C. inerme* at 1% significantly reduced the *P. xylostella* larval density and proved more effective than Challenger. The intensity of cabbage damaged caused by *P. xylostella* was significantly lower in *L. camara* and *C. inerme* than control and Challenger.

Key words: Plant extracts, field efficacy, *Plutella xylostella, Helicoverpa armigera,*

INTRODUCTION

Cabbage is an important vegetable crop grown for the edible value. It is highly valuable to insect pests especially the diamondback moth, *Plutella xylostella* L. and cotton bollworm, *Helicoverpa armigera* Hub. have being causing both quantitative and qualitative losses in many cabbage producing areas in North Karnataka and South Maharashtra, resulting in decreased income for growers (Reena *et al.,* 2006). The application of synthetic insecticides is the main means of controlling these insect pests, particularly *P. xylostella.* However, the failure of these applications has been reported in many cabbage production areas. The development of insect resistance, particularly in *P. xylostella* .larvae, may be the main reason for the failure to control these insect populations. In Karnataka and Maharashtra, *P. xylostella* has become resistant to most major classes of insecticides (Reena *et al.,* 2006). The same pattern in the development of *P. xylostella* resistance was also reported in other states (Kranthi *et al.,* 2002). Cruciferous family crops are important for the human diet and the economic stability of the farmer and thus we should develop a rational and sustainable management strategy for these insect pests. For the past four decades, considerable efforts have been made towards the screening of plants in order to determine their biological activity against insect pests. Results revealed that many plant extracts possess biological activity against various insect species (Grainage and Ahmed, 1988; Sahayaraj, 1998; Murugesan and Thilagavathy, 2008; Dubey *et al.,* 2008). Furthermore, laboratory and field experiments were conducted to evaluate plant biological activity against cabbage pests (Singh and Singh 1985; Morallo-Rejesus, 1985; David *et al.,* 1988; Schumutterer, 1990; Anwar *et al.,* 1992; Meiying *et al.,* 1993; Anonymous, 1994; Ganeshan *et al.,* 1995; Scott *et al.,* 2003; Samarasinghe *et al.,* 2007). Numerous plant extracts and their compounds can potentially be incorporated into an alternative and novel strategy to control a range of insect pests, including *P. xylostella* (Foon and Tong, 1993) and *H. armigera* (Sahayaraj. and Paulraj, 2001; Opender *et al.,* 2002; Balasubramanian *et al.,* 2008). Plant chemicals are ecologically sound, economically practical, socially acceptable and environmentally sustainable. Selective in their activity, suggesting that their application would be environmentally acceptable and compati-ble with integrated pest management (IPM) programs as well as being effective in countering insect resistance. This study was conducted to evaluate the efficacy of four plant extracts like *Vitex negundo* L. (Verbenaceae),

Clerodendrum inerme L. Gaertn. L. (Verbenaceae), *Lantana camara* (Verbenaceae), and *Eupatorium odoratum* L. (Asteraceae) against *P. xylostella* and *H. armigera* in field conditions. The percentage of infested plants, pest levels were considered in this study.

MATERIALS AND METHODS

Healthy leaves of *V. negundo, C. inerme, L. camara*, and *E. odoratum* were collected from in and around the Kolhapur city, Maharashtra. All leaves were washed three times in tap water and dried under shade for a week and were pulverized (60-80 mash) by using domestic grinder. Powder from each plant species was extracted by soaking in ethanol for 72 h (1: 2.5; w/v), filtered by filter paper (Filtroll) and ethanol was then evaporated using a rotary evaporator (JSGW) under reduced pressure to give a crude extract. 3,852 g of *V. negundo,* 3,680 g of *L. camara*, 3,800 g of *E. odoratum*, and 3,852g of *C. inerme* yielded 156.0, 165.0, 112.0, and 194.0 g of crude extract respectively and extract colour was dark green. All crude extracts were stored at 4ºC in a refrigerator until use.

An appropriate amount of each extract was diluted with ethanol and water containing emulsifier Triton X -100 (polyethylene glycol 4-tetroctylpenolethre) (SD fine) 0.05% was then added to produce the desired extract concentration. Two extract concentrations such as 1% and 0.5%, of each plant extract were applied and water containing 0.75% ethanol and 0.05% emulsifier served as a control. In order to compare the efficacy of extracts to conventional insecticides, Challenger 10EC (cypermethrin) (M/s Searle Agrochemicals India Limited) was used as a standard insecticide and applied at the recommended rate (2 ml/liter). All treatments were applied at morning between 7 AM and 8 AM using a lever-operated knapsack sprayer (ASPY Hi tech) at the rate of 2litre/plot. The first application was performed 9 weeks after transplanting and continued at one week intervals till 11 week. The first observation was done one day before the first application, and the next observation one week after application. In total three applications of plant extract and four observations were made.

Field tests were conducted in 810 m^2 area of cabbage (Variety: Manas; Ankur Seeds private Limited) in the farmer's field at Borgoan, Belgaum district, Karnataka from September to October, 2008. Cabbage seedlings were transplanted to plots (5.25 x 5.25 m). Each plot consisted of 7 rows of plants with 0.75 m spacing between rows and 0.75 m between plants, so that each plot contained 49 plants. Fertilizer of nitrogen, phosphorus and potassium (4kg N:5kg P:8kg K/plot) was applied twice, once after transplanting and after cabbage had formed a head and weeds were removed mechanically when necessary.

The plots were arranged in a randomized block design (RBD) with three replications. Ten plants from each plot were randomly selected for sampling. The number of larvae per plant (larval density), and the intensity of cabbage damage were observed. The larvae of *P. xylostella* and *H. armigera* were observed with no distinction of instar. All data were subjected to one-way ANOVA using the SPSS (version 10) procedure and differences among the treatment means were compared with Fisher's protected least significant difference (LSD) test at 5% probability level. The percentage intensity (I) of cabbage plant damage was calculated by the following formula:

Table 1. *P. xylostella* and *H. armigera* larvae infested cabbage (in %) treated with different plant extracts

Treatments	Weeks after transplantation							
	9		10		11		12	
	P. xylostella	*H. armigera*	*P. xylostella*	*H. armigera*	*P. xylostella*	*H. armigera*	*P. xylostella*	*H. armigera*
C. inerme (1.0%)	16.7±5.7^{a}	0.0±0.0^{a}	0.0±0.0^{a}	53.3±11.5^{a}	63.3±5.7^{a}	3.3±5.7^{a}	16.7±5.7^{a}	10.0±10.0^{a}
C. inerme (0.5%)	26.7±5.7^{a}	0.0±0.0^{a}	6.7±5.7^{ab}	50.0±10.0^{a}	60.0±10.0^{a}	0.0±0.0^{a}	56.7±11.05^{a}	20.0±17.3^{a}
L. camara (1.0%)	23.3±15.3^{a}	0.0±0.0^{a}	10.0±10.0^{ab}	30.0±10.0^{a}	70.0±10.0^{a}	6.7±5.7^{a}	16.7±5.7^{a}	13.3±5.7^{a}
L. camara (0.5%)	20.0±10.0^{a}	0.0±0.0^{a}	6.7±5.7^{ab}	46.7±5.8^{a}	60.0±10.0^{a}	16.7±5.7^{a}	43.3±15.2^{ab}	23.3±5.7^{a}
V. negundo (1.0%)	30.0±17.3^{a}	3.3±5.7^{a}	16.7±5.7^{ab}	60.0±10.0^{a}	46.7±5.7^{a}	20.0±10.0^{a}	16.7±5.7^{a}	30.0±0.0^{a}
V. negundo (0.5%)	20.0±10.0^{a}	0.0±0.0^{a}	3.3±5.7^{ab}	30.0±10.0^{a}	70.0±10.0^{a}	10.0±10.0^{a}	66.7±5.7^{b}	13.3±5.7^{a}
E. odoratum (1.0%)	16.7±5.7^{a}	0.0±0.0^{a}	3.3±5.7^{ab}	46.7±5.8^{a}	60.0±10.0^{a}	10.0±10.0^{a}	60.0±0.0^{ab}	20.0±10.0^{a}
E. odoratum (0.5%)	13.3±5.7 ^{a}	0.0±0.0^{a}	3.3±5.7^{ab}	53.3±11.5^{a}	56.7±5.7^{a}	10.0±10.0^{a}	53.3±5.7^{ab}	16.7±11.5^{a}
Challenger	23.3±15.7^{a}	0.0±0.0^{a}	3.3±5.7^{ab}	60.0±10.0^{a}	63.3±11.5^{a}	3.3±5.7^{a}	66.7±5.7^{b}	6.7±5.7^{a}
Control	3.3±11.5^{a}	0.0±0.0^{a}	6.7±5.7^{ab}	60.0±10.0^{a}	70.0±10.0^{a}	36.7±5.7^{a}	70.0±10.0^{b}	30.0±0.0^{a}

-indicates no animal recorded ; Column followed by the same letter are not significantly different (LSD, p=0.05)

Table 2. Intensity of damage (in %) caused by *P. xylostella* and *H. armigera* larvae on cabbage treated with plant extracts

Treatments	Weeks after transplantation							
	9		10		11		12	
	P. xylostella	*H. armigera*	*P. xylostella*	*H. armigera*	*P. xylostella*	*H. armigera*	*P. xylostella*	*H. armigera*
C. inerme (1.0%)	2.8±1.9^{a}	-	10.0±4.4^{a}	-	13.9±6.6^{a}	1.7±2.8^{a}	5.0±0.0^{a}	11.6±2.8^{a}
C. inerme (0.5%)	4.4±0.9^{a}	-	10.5±6.3^{a}	1.6±1.6^{a}	11.1±1.9^{a}	-	6.7±0.6^{ab}	10.0±0.8^{a}
L. camara (1.0%)	3.9±0.7^{a}	-	5.6±3.4^{a}	3.3±2.8^{a}	17.8±4.1^{a}	5.6±9.6^{ab}	5.0±1.1^{a}	4.2±2.5 ^{a}
L. camara (0.5%)	2.8±1.9^{a}	-	7.8±3.4^{a}	1.1±0.9^{a}	16.1±2.5^{a}	12.2±9.1^{b}	7.2±2.5^{ab}	10.6±3.4^{a}
V. negundo (1.0%)	7.2±0.9^{a}	-	11.7±4.4^{a}	4.7±4.7^{a}	12.8±5.8^{a}	12.2±5.3^{b}	6.6±0.5^{ab}	17.2±8.5^{a}
V. negundo (0.5%)	3.3±1.6^{a}	-	6.6±2.8^{a}	0.6±0.9^{a}	14.4±3.4^{a}	5.0±0.0^{ab}	22.2±2.5^{b}	7.8±2.5^{a}
E. odoratum (1.0%)	2.8±0.6^{a}	-	7.8±0.9^{a}	1.7±2.8^{a}	17.2±5.3^{a}	6.1±0.5^{ab}	14.9±6.5^{ab}	10.5±2.5^{a}
E. odoratum (0.5%)	2.8±0.8^{a}	-	10.6±6.6^{a}	1.7±2.8^{a}	12.8±5.8^{a}	8.9±1.9^{ab}	14.9±5.9^{ab}	14.4±5.0^{a}
Challenger	4.4±1.9^{a}	-	10.0±1.0^{a}	1.1±1.9^{a}	17.8±4.3^{a}	0.6±0.9^{a}	22.2±6.5^{b}	1.1±1.0^{a}
Control	6.1±2.0^{a}	-	6.1±0.9^{a}	2.7±4.7^{a}	13.3±3.3^{a}	7.2±1.9^{a}	19.0±6.4^{b}	6.6±0.5^{a}

-indicates no animal recorded ; Column followed by the same letter are not significantly different (LSD, p=0.05)

I = {Ó(n×v) / (N×V)} × 100

where, n=number of plants at a certain category of damage, *v*=category of damage, N=total number of selected plants (10), and V=the highest value of damage category (6). The *v* values of damage were categorized as follows: 0, no plant damage; 1, 0 ≤ 5%; 2, 5 ≤ 20%; 3, 20 ≤ 40%; 4, 40 ≤ 60%, 5, 60 ≤ 80%; and 6, > 80%.

RESULTS

The first observation was completed 9 weeks after transplantation (one day before the first application). Mean numbers of *P. xylostella* and *H. armigera* larvae showed no significant difference among the treatments (for *P. xylostella* F=1.2700; *p*=0.3519 and for *H. armigera* F=0.7100; p=0.6932). This tendency continued until the day before the second application at 10 weeks after transplantation. After the third application, treatments with 1% of *V. negundo* and *C. inerme* resulted in 1.0% and 0.7% larvae/plant respectively of *P. xylostella* and Challenger 10EC revealed 8.7 larvae / plant and non treatment demonstrated 3.7 larvae / plant (Fig.1). Mean of 0.7 larvae / plant was recorded for in *E. odoratum* (0.5%) treatment. Challenger was highly effective against *H. armigera* (0.3% larva / plant) (Fig.1) than tested plant extracts. Among the plant extract treatments, *E. odoratum* (1%) treatment had more impact on *H. armigera* followed by *L. camara, V. negundo* and *C. inerme.*

Treatments with *V. negundo, L. camara* and *C. inerme* showed a significantly lower percentage of *P. xylostella* infestation than challenger (Table 1). Challenger treatment resulted low percentage of *H. armigera* infested plants compared to plant extract treatments. Among plant extract treatments, *C. inerme* (1%), *L. camara* (1%) and *V. negundo (*0.5%) tended to result in lower percentages of infested plants. The intensity of cabbage damage caused by *P. xylostella* was significantly lower in *L. camara* (1%) and *C. inerme* (1%) than control and challenger treatments (Table 2). Treatment with *L. camara* (1%) tended to result in a lower percentage of intensity of cabbage damage caused by *H. armigera* than control and other plant extract treatments, but it was higher than challenger treatment after the third application.

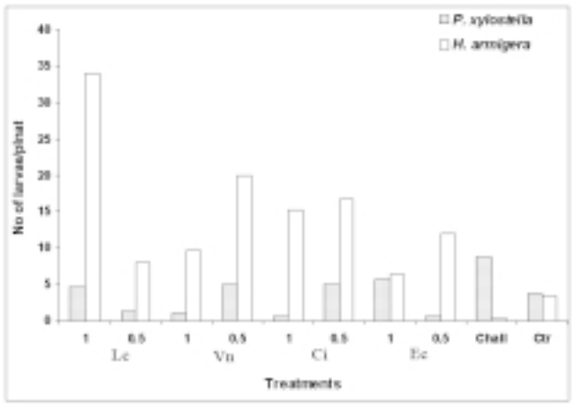

Figure 1. Mean numbers of *P. xylostella* and *H. armigera* larvae on a cabbage treated with extracts (Lc - *L. camara,* Vn - *V. negundo,* Ci - *C. inerme* and Eo - *E. odoratum*), challenger and control after 12 weeks

DISCUSSION

The extracts of *V. negundo, C. inerme, L. camara,* and *E. odoratum* caused high mortality against *A. janata, P. xylostella* and *S. litura* larvae in the laboratory assay (Kulkarni, 2002; Yankanchi, 2003). In addition, active compounds from *C. inerme have* been isolated and elucidated as a diterpene Clerodedron A and B (Kato and Munakata, 1972; Kato *et al.,* 1973). Thin layer chromatography studies revealed that alkaloids, saponin and flavonoids were present in the leaf of *V. negundo* (Sahare *et al.,* 2008).

V. negundo and C. inerme extracts at 1%, significantly reduced *P. xylostella* larval density and proved more effective than challenger. The failure to control larvae with challenger is likely to be due to the development of resistance by *P. xylostella* to this insecticide. According to Reena *et al.* (2006), cabbage growers in Belgaum district use insecticides such as challenger as the main means to control *P. xylostella* both before and after cabbage transplantation. Repeated and continuous chemical spraying has resulted in the development of resistance by *P. xylostella* to insecticides (Morallo-Rejesus, 1985). A high efficacy of *V. negundo and C. inerme* was shown in laboratory (Kulkarni, 2002; Yankanchi, 2003) and field experiments in the present study. Thus, the use of *V. negundo and C. inerme* might be effective in overcoming the resistance of *P. xylostella* against synthetic insecticides. Unfortunately, *E. odoratum* and *L. camara* did not efficiently reduce the *P. xylostella* population in the field. This might be due to the rapid degradation of the active compound under field conditions (Singh and Singh, 1985).

No treatment showed significant differences in reducing *H. armigera* larval population. Larval population of *H. armigera* tended to be higher in plant extract treatments than with challenger. The development of resistance by *H. armigera* to insecticides has been reported by Armes *et al.,* (1996) though indicating that this insecticide remains effective against *H. armigera* (Meena *et al.,* 2006; Tamobli and Lolage, 2008; Ashok *et al.,* 2008). Previous studies show that plant extracts were also effective against this pest (Sahayaraj and Paulraj, 2001; Sahayaraj and Tirkey, 2006; Balasubramanian *et al*., 2008).

The effectiveness of *V. negundo and C. inerme* extracts were also shown by the decreased the number of *P. xylostella* larvae/plants. Furthermore, *C. inerme* and *L. camara* efficiently reduced the per-centage of cabbage damage caused by *P. xylostella*. Quality of cabbage production is an important factor in setting a price at market. A low percentage of infested plants and intensity of cabbage damage improved the yield of cabbage both quantitatively and qualitatively. Treatment with challenger resulted in lower percentages of *H. armigera* infested plants and of the intensity of cabbage damage. Treatments with 1% *L. camara, V. negundo and C. inerme* were slightly effective on *H. armigera* infested plants, and 1% *L. camara* effectively reduced the percentage intensity of cabbage damage.

In general, although *V. negundo and C. inerme* were effective only against *P. xylostella,* these plant extracts can be applicable to cabbage pest management through reducing the use of synthetic insecticides spray in an integrated pest management (IPM) programme. *Plutella xylostella* occurs just after cabbage transplantation, earlier than *H. armigera*. At this stage, it is recommended to the cabbage growers to apply *V. negundo* and *C. inerme* extract to avoid *P. xylostella* population. Moreover, conventional insecticides can be applied if growers find a large population of *H. armigera*. This control programme reduces the intensity of conventional insecticide use and shows the normal efficacy of *V. negundo and C. inerme* extracts in maintaining quality and quantity of cabbage production.

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