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Efficacy of some medicinal plant oils against tobacco caterpillar, *Spodoptera litura* F. on cabbage

Rashmirekha Singh, Kamal Ravi Sharma and NN Singh

Abstract
An experiment was carried out under field conditions at the Vegetable Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during *Rabi* seasons of 2016-17, to evaluate the bio-efficacy of eight essential oils along with one insecticide against, *Spodoptera litura* (F.) and their impact on cabbage yield. Among the different treatments *Pogostemon cablin* oil was most effective against Tobacco caterpillar which was followed by *Curcuma longa* oil, *Ocimum basilicum* var. surabhi oil, *Cymbopogon citrates* oil, *O. basilicum* × *O. tenuiflorum* oil, *Cymbopogon martini* oil, *Ocimum basilicum* var. Saumya, Acephate 75 SP and Mentha sp. oil, respectively. The difference in their effectiveness was statistically significant. Whereas, Mentha sp. oil recorded the lowest efficacy compared with rest of treatments it was also significantly superior over control. The effect of *Cymbopogon citrates* i.e. Citronella oil on cabbage yield was found superior over rest of the treatments. This may be due to the effectiveness of *C. citrates* against other important insect pests of cabbage, whereas the performances of *C. martini* oil, *P. cablin* oil and *O. basilicum* var. saumya oil were also very good like the performance of *C. citrates* oil. The economics (Benefit: Cost ratio) of various treatments applied for management of *Spodoptera litura* were also calculated in which maximum B : C ratio was found with *C. martini* oil (31.27:1) followed by *C. citrates* oil (28.86:1) and *P. cablin* oil (27.69:1) and the least B:C ratio was found in *Mentha* sp. oil (17.70:1).

Keywords: cabbage crop, tobacco caterpillar, essential oils, efficacy, yield

Introduction
Among the various vegetables produced in our country, the cool season cruciferous vegetables, particularly cabbage is one of the most important vegetables in terms of nutritional and economic significance. It is an important source of Vitamin A, B and C, Sodium, Phosphorus, Calcium, Potassium, Sulphur, carbohydrates and fiber. It has occupied around 3.99 lakh hectares with production of 90.37 lakh tonnes and an average productivity of 22.64 MT/ha in India during 2017-18 [1]. However the yield of cabbage is comparatively low in India than the world average. One of the major problems against attaining higher yield in this crop is the damage caused by insect pests that attack at various stages of crop growth. Among these pests, Tobacco caterpillar, *Spodoptera litura* (F.) (Lepidoptera: Noctuidae), is a serious polyphagous pest of several cultivated crops causing economic loss and has attained global importance. Farmers mostly rely on insecticides for the management of insect pests [2, 3]. Due to improperuse of chemical insecticides this insect-pest has developed resistance to these synthetic chemicals [4, 5]. In recent years the problem of resistance to chemical has worsened, resulting in 20-30% crop loss due to pests in India and causing widespread hardship especially amongst the poor farmers. There In addition to the development of resistance in pests, indiscriminate and injudicious use of synthetic pesticides has contaminated almost each and every component of the biosphere, causing resurgence of pests and reduction in number of natural enemies and beneficial insects in agroecosystems [6]. Because of these hazards caused due to the pesticides, there is a growing awareness among the people for the safe use of synthetic pesticides. Biopesticides or green pesticides obtained from plants or pathogenic microorganisms, offer an ecologically sound and effective solution to pest problems as they are specific to target pest and safe to the humans and their environment. Accordingly, the use of botanical pesticides offer potential benefits to agriculture and public health programmes are considerable. Therefore, the research was conducted to determine the impact of medicinal plant oils against Tobacco caterpillar as well as the Yield of cabbage was assessed.

Materials and Methods

The experiment was carried out under field conditions at the Vegetable Research Farm of Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during *Rabi* season of 2016-2017. The field experiment was laid out in simple Randomized Block Design (RBD) with ten treatments, which includes eight plant essential oils, one insecticide as a check and one untreated control, each replicated four times. The plot size was kept 3 × 4.5 m^2 with row to row spacing 60cm and plant to plant spacing 45 cm, respectively. Transplanting of seedlings of variety "Golden Acre" was done in the 3rd week of November. Five plants were selected from each plot and tagged and the total larval population was counted at specific day interval starting with the incidence of Tobacco caterpillar population to monitor the Economic Threshold Level and to decide the time of application of medicinal plant oils.

To study the bio-efficacy of various plant essential oils against Tobacco caterpillar, eight medicinal plants like Basil oil (*Ocimum basilicum* var. *saumya*, *Ocimum basilicum* var. *surabhi*, *O. basilicum* × *O. tenuiflorum*, *Cymbopogon citrates* oil, *Cymbopogon martini* oil, *Pogostemon cablin* oil, *Curcuma longa* oil, *Mentha* sp. oil and one insecticide, Acephate 75% SP (as a check) were selected and sprayed by using a hand sprayer. Post-treatment counts of Tobacco caterpillar were taken on 1st, 3rd, 5th, 7th and 10th days of application of treatments. The per cent reduction in population under different treatments was analyzed on the basis of number of larvae before spraying and after spraying at different days of observational periods. The significance of difference between treatments was judged by Critical Difference (CD) at 5% level of significance. The per cent field efficacy of various treatments was also calculated against *S. litura* larvae by using the formula as given below:

$$\text{Per cent reduction of larvae} = \left[\frac{Tb - Ta}{Tb}\right] \times 100$$

Where, Tb = Number of larvae on untreated plot before spraying.

Ta = Number of larvae on treated plot after treatment

The yield of marketable cabbage head in kilograms was recorded from each plot. In total there were 3 pickings of heads from each plot at weekly interval and the cumulative yield was obtained by adding weights of heads from different harvests. The cumulative yield thus obtained from each plot was converted into yield in quintal/ ha. The yield data obtained from each plot in each replication received a certain essential oil treatment and from untreated check was statistically analyzed to test the significance of mean yield variation in different treatments. The per cent increase in yield over control in various treatments was calculated by using the following formula.

$$\text{Increase in yield (\%)} = \frac{\text{Yield in treatment} - \text{Yield in control}}{\text{Yield in control}} \times 100$$

The benefit cost ratio (B:C) of each treatment was also calculated from the value of additional yield received over control as well as the cost incurred over the treatment. The cost of treatment included the material cost of the particular treatment and also labor cost for its application.

Results and Discussion

Prior to imposition of treatments, the population Tobacco Caterpillar Larvae (TCL) varied from 3.21 to 4.45 larvae per five plants and did not vary significantly among the treatments (Table 1). However, on the 1st day after imposing the treatments, *P. cablin*, recorded the lowest number TCL (1.99 larvae per 5 plants) followed by *C. longa* (2.23 larvae per 5 plants) which is statistically at par with *O. basilicum* var. Surabhi (2.45 larvae per 5 plants). Higher number of insect counts were observed in Acephate 75 SP (3.88 larvae per 5 plants) and untreated control (3.99 larvae per 5 plants). All the treatments proved statistically superior over control in reducing the *S. litura* population. On 3rd days of spraying, the minimum larval population was recorded in the plots treated with *P. cablin* oil (0.51 larvae per 5 plants) and proved to be most effective treatment followed by *O. basilicum* var. Surabhi (0.86 larvae per 5 plants) which is statistically at par with *C. longa* (0.98 larvae per 5 plants) and significantly differ with rest of the treatments. Whereas, the highest larval population was recorded plot treated with Mentha oil (2.32 larvae per 5 plants) and untreated control (4.78 larvae per 5 plants). The efficacy of different treatments after five days of spraying was found that the plots treated with *P. cablin* oil (0.58 larvae per 5 plants) proved most effective treatment followed by *C. longa* oil (0.80 larvae per 5 plants), which was statistically at par with *O. basilicum* var. surbhi (0.88 larvae per 5 plants) and superior from rest of the treatments. However, the highest larval population was recorded plot treated with Mentha oil (2.30 larvae per 5 plants) and untreated control (4.98 larvae per 5 plants). The *S. litura* population was recorded after seven days of spraying and it found that *P. cablin* treated plots again proved most effective treatment to reducing the *S. litura* population (1.11 larvae per 5 plants). The second most effective treatment was found to be *C. longa* treated plots (0.85 larvae per 5 plants) which were statistically at par with *O. basilicum* var. Surbhi (1.30 larvae per 5 plants) differ significantly with rest of the treatments and the highest *S. litura* population was recorded in Acephate (2.36 larvae per 5 plants), Mentha oil (2.55 larvae per 5 plants) and untreated control (5.41 larvae per 5 plants). On 10th days after treatment again *P. cablin* treated plot found most effective treatment to reducing the *S. litura* population (1.81 larvae per 5 plants) followed by *O. tenuiflorum* (2.32 larvae per 5 plants), where the least effective treatment was Acephate (2.99 larvae per 5 plants), Mentha oil (3.18 larvae per 5 plants) and untreated control (6.13 larvae per 5 plants). Overall efficacy of different treatments were found in order of *P. cablin* > *C. longa* > *basilicum* var. Surbhi > *C. citrates* > *O. basilicum* × *O. tenuiflorum* > *C. martini* > *O. basilicum* var. Saumya oil > Acephate and Mentha oil. The results of present investigation revealed that the *P. cablin* and *C. longa* are most effective essential oil to reducing the insect population. The present finding is in accordance with Gokulakrishnan *et al.*, 2013 [7] reported that Patchouli, *Pogostemon cablin* (Solanaceae) is an essential oil which showed insecticidal activity against important vector mosquitoes viz., *Aedes aegypti*, *Anopheles stephensi* and *Culex quinquefasciatus* (Diptera: Culicidae). This is also the first report on the mosquito repellent and pupicidal activities of the reported *P. cablin* chemical compositions. Further, Tavere *et al.*, 2016 [8] reported that the essential oil of *Curcuma longa* was having insecticidal action against the important agricultural pest *Trichoplusia ni*. Turmeric powder and its derivatives caused 10–20% mortality in third instar

Trichoplusia ni at a very low dose (10µg/larva). Tripathy *et al.*, 2002 [9] observed that the essential oil of turmeric, *Curcuma longa* L. exhibiting contact and fumigant action on *Rhyzopertha dominica*, *Sitophilus oryzae* and *Tribolium castaneum*, reduced oviposition and egg hatching upto 80%. The effectiveness of basil oils was also studied by Keita *et al.*, 2000 [10], where a 50% lethal concentration at 48 h was found to be 65 ml/g for *Ocimum basilicum*. This oil exhibited a significant effect both on the egg hatch rate and on the emergence of adults. Similarly, Chang *et al.*, 2009 [11], observed insecticidal activity on three tephritid fruit fly species (*Ceratitis capitata, Bactrocera dorsalis and Bactrocera cucurbitae*) which showed mortality up to 90%. Further, Choi *et al.*, 2003 [12] and Park *et al.*, 2008 [13] tested the effect of Citronella oil against *Trialeurodes vaporariorum* adults and larvae of *Lycoriella ingenua* and found 100 per cent mortality @ 2.3 ×10-3 µl/ml air and 90 per cent mortality @ 30 × 10-3 mg/l air, respectively. Deletere *et al.*, 2015 [14] found the effect of citronella on *Bemisia tabaci* exhibiting repellent, toxic and irritant effect on the insect.

The impact of different essential oils on cabbage yield was also studied under present investigation (Table 2) and maximum yield of cabbage heads was obtained in the plots treated with *P. cablin* oil (233.89 q/ha^{-1}) followed by *C. longa* (230.93 q/ha^{-1}), *C. martini* oil (229.07 q/ha^{-1}), while, lowest yield was recorded in plot treated with Acephate (225.19 q/ha^{-1}) Mentha oil (217.22 q/ha^{-1}) and untreated control (187.22 q/ha^{-1}). Ithas been found that *P. cablin* is very much effective against insect pests cabbage (Rashmirekha *et al.*, 2018) [15]. Benefit/cost ratio (B:C ratio) of various treatments applied for management of *S. litura* were also calculated and presented in Table 3. The highest B:C ratio was found in the treatment of *C. martini* 0.05% (31.27:1) followed by *C. citrates* oil 0.05% (28.86:1), *P. cablin* 0.05% (27.69:1), *O. basilicum* var. saumya 0.1% (25.78:1), *O. basilicum* × *O. tenuiflorum* 0.1% (25.54:1), *O. basilicum*v ar. surabhi 0.1% (25.42:1) and Acephate (25.03:1). Though, the maximum yield was obtained from plots treated with *C. citrates* oil, the highest B:C ratio was obtained from the plots treated with *C. martini* oil. This may be due to the cost of essential oils.

Table 1: Effect of different treatments on the population of *S. litura.*

Treatments	Dose in per cent or g/ha	Avg. no. of *S. litura* larvae/5 plants one day before spray	Avg. no. of *S. litura* larvae per 5 plants at different days after essential oil spray					
			1 DAS	3 DAS	5 DAS	7 DAS	10 DAS	Overall Mean
Ocimum basilicum var. Saumya	0.10%	4.52* (2.21)**	3.70 (2.04)	1.92 (1.55)	1.77 (1.50)	1.92 (1.55)	2.88 (1.83)	2.43 (1.69)
Curcuma longa	0.1%	3.21 (1.92)	2.23 (1.65)	0.98 (1.21)	0.80 (1.14)	1.11 (1.26)	2.70 (1.78)	1.56 (1.43)
Cymbopogon martinii	0.05%	4.45 (2.21)	3.59 (2.02)	1.55 (1.39)	1.39 (1.37)	1.72 (1.48)	2.79 (1.84)	2.20 (1.64)
Pogostemon cablin	0.05%	3.99 (2.11)	1.99 (1.47)	0.51 (1.00)	0.58 (1.03)	0.85 (1.16)	1.81 (1.51)	1.14 (1.28)
Cymbopogon citrates	0.05%	3.88 (2.09)	3.26 (1.93)	1.29 (1.33)	1.22 (1.31)	1.61 (1.45)	2.55 (1.74)	1.98 (1.57)
O. basilicum var. Surbhi	0.1%	3.34 (1.95)	2.45 (1.71)	0.86 (1.16)	0.88 (1.17)	1.30 (1.34)	2.41 (1.70)	1.58 (1.44)
O. basilicum × *O. tenuiflorum*	0.1%	3.98 (2.11)	3.11 (1.90)	1.63 (1.45)	1.52 (1.42)	1.81 (1.51)	2.32 (1.67)	2.07 (1.60)
Mentha	0.1%	4.22 (2.17)	3.41 (1.97)	2.32 (1.67)	2.30 (1.67)	2.55 (1.74)	3.18 (1.91)	2.75 (1.80)
Acephate 75 SP	500 g/ha	4.30 (2.12)	3.88 (2.09)	2.06 (1.59)	1.86 (1.53)	2.36 (1.69)	2.99 (1.86)	2.63 (1.76)
Control	-	3.83 (2.08)	3.99 (2.11)	4.78 (2.29)	4.98 (2.34)	5.41 (2.43)	6.13 (2.57)	5.05 (2.35)
SE(m)	-	-	0.04	0.05	0.03	0.04	0.05	-
C.D. at 5%	-	NS	0.12	0.14	0.10	0.11	0.15	-

*Mean of four replications, **Figures in the parenthesis are Square root transformed values, square root of (x+0.5), DAS Days after spray

Table 2: Impact of various treatments on cabbage yield during *Rabi* season 2016-17

S. No.	Treatments	Dose %/a.i./ha	Average Yield Kg/ plot	Yield in Kg/ha	Yield in Qt/ha	% increase in yield over control
1	*Ocimum basilicum* var. Saumya	0.1%	30.85	22851.85	228.52	22.06
2	*Curcuma longa*	0.1%	31.18	23092.59	230.93	23.34
3	*Cymbopogon martinii*	0.05%	30.93	22907.41	229.07	22.35
4	*Pogostemon calbin*	0.05%	31.58	23388.89	233.89	24.93
5	*Cymbopogon citrates*	0.05%	30.50	22592.59	225.93	20.67
6	*Ocimum basilicum* var. Surabhi	0.1%	30.78	22796.30	227.96	21.76
7	*O. basilicum* × *O. tenuiflorum*	0.1%	30.80	22814.81	228.15	21.86
8	*Mentha*	0.1%	29.33	21722.22	217.22	16.02
9	Acephate 75 SP	500gm	30.40	22518.52	225.19	20.28
10	Control	-	25.28	18722.22	187.22	-

CD at 5%- 3.37

Table 3: Benefit : Cost analysis of different essential oil treatment on cabbage

S. No.	Treatment	Dose in per cent or g/ha	Yield in Qt/ha	Total increase in yield over control (q/ha)	Per cent increase in yield over control	Return from increased yield (Rs)*	Totalcost/ expenditure (Rs)**	Net profit (Rs ha^{-1})	B:C Ratio
1	*Ocimum basilicum* var. Saumya	0.10%	228.52	41.30	22.06	49560	1850	47710	25.78:1
2	*Curcuma longa*	0.1%	225.93	38.71	20.67	46452	1950	44502	22.82:1
3	*Cymbopogon martinii*	0.05%	230.93	43.71	23.34	52452	1625	50827	31.27:1
4	*Pogostemon cablin*	0.05%	229.07	41.85	22.35	50220	1750	48470	27.69:1
5	*Cymbopogon citrates*	0.05%	233.89	46.67	24.93	56004	1875	54129	28.86:1
6	*Ocimum basilicum* var. surbhi	0.1%	227.96	40.74	21.76	48888	1850	47038	25.42:1
7	*O. basilicum* × *O. tenuiflorum*	0.1%	228.15	40.93	21.86	49116	1850	47266	25.54:1
8	*Mentha*	0.1%	217.22	30.00	16.02	36000	1925	34075	17.70:1
9	Acephate 75 SP	500 g/ha	225.19	38.71	20.67	46452	1950	44502	22.82:1
10	Control	-	187.22	-	-	-	-	-	-

Note: Price of cabbage Rs 12/kg, * Cost of cabbage during current season Rs. 1200/- q^{-1}, ** It includes cost of insecticides and labour charge **(**Labour charges = Rs 250/man day, for the spray of 1 ha area, total man days required = 5 man days)

Conclusion

These essential oils used in the treatments are repellent in their mode of action. All treatments showed high efficacy in reducing the population as compared to untreated control. Among the different treatments, *P. cablin* oil was found most effective against the caterpillar followed by *C. longa* oil Whereas, Mentha oil recorded the lowest efficacy compared with rest of treatments but it was also significantly superior over control. The yield data revealed that the effect of different essential oils was quiet good when compared with untreated control. The effect of *C. citrates* i.e. Citronella oil on cabbage yield was found superior over rest of the treatments whereas, the performances of *C. martinii* oil, *P. cablin* oil and *O. basilicum* var. *saumya* oil were also very effective. The yield from rest of the treatments was also found superior over control. It has also been found that a maximum return in terms of rupees was obtained from plots treated with *C. citrates*, whereas the maximum B:C ratio was observed in case of *C. martinii*. Application of *P. cablin* and *C. longa* oil was found as most potent and effective which can be applied against *S. litura*. These plant based insecticides are not only efficacious in reducing the pest density but also do not possess any harmful impact on human health and environment which is a good alternative to the detrimental synthetic chemicals.

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