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Research Paper

Management of varroa mite, *Varroa destructor* by essential oil and formic acid in *Apis mellifera* Linn. colonies

Vimla Goswami[*1], M .S. Khan [2]

Department of Entomology, College of Agriculture, G.B. Pant University of Agriculture and Technology, Pantnagar-263145 (Uttarakhand)

*Corresponding Author

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ABSTRACT

Varroa destructor is a dangerous pest directly for beekeeping and indirectly for crops that require insect pollination. The present investigation has been carried out to study the efficacy and persistence of some essential oils and formic acid against varroa mite in colonies of *Apis mellifera* L. at Pantnagar, Uttarakhand. The number of dead/ fallen mites on the thick white paper sheet at bottom of the hives was used to determine the mite mortality. The results revealed among seven treatments applied for varroa mite control, Garlic oil (T_2) treatment gave significantly superior results in reducing the varroa mite population up to three weeks with an overall mean value of 75.03 per cent followed by formic acid giving 72.94 per cent mite mortality. The overall miticidal efficacy during the 3 weeks observation indicated that high persistence was observed in the garlic oil treatment with 29.69 fallen mites /hive after one week of treatment, 26.23 fallen mites/hive after two weeks of treatment and 18.33 fallen mites/hive after three weeks of treatment with mite mortality ranging from 76.00 to 76.73 per cent. The hives treated with tulsi oil, turmeric oil, ajwain oil, cinnamon oil, clove oil and formic acid also showed good persistence with mite mortality ranging from 56.85 to 75.03 per cent up to 3 weeks of the treatments.

Keywords: *Apis mellifera;* Varroa mite; Essential oils; Formic acid.

INTRODUCTION

The mites (Acari) that parasitize honey bees have become a global problem. They are threatening the survival of managed and feral honey bees, the beekeeping industry and, due to the role of bees in pollination, the future of many agricultural crops. Varroa destructor (Anderson and Trueman, 2000) formerly named Varroa jacobsoni Oudemans is potentially the main parasite of *Apis mellifera* L. and it can cause the collapse of untreated colonies in a few years. This mite which feeds on haemolymph of brood and adult bees causes colony disorder, weakness, decrease in brood and deformation of bees. It also reduces colony ability to pollinate plants (De Jong, et al., 1984). The parasite destroys the mechanical protective barriers of the integument and impairs the immune system of the bees (Glinski, 1991). The varroa mite has been a threat to world

beekeeping industry and now a potential threat to Indian apiculture (Gatoria, et al., 2004).

Several chemical substances were used successfully to control mites, and a wide array of chemicals were highly effective, killing more than 99% of the mites present in infested colonies (Ferrer-Dufol, et al., 1991). In recent years, resistance to acaricides has become a major problem in the control of varroa. Increased tolerance to the most widely used synthetic active ingredients has been observed. Varroa destructor strains have been reported to be resistant to fluvalinate and flumethrin (Baxte,r et al., 1998), coumaphos (Spreafico, et al., 2001) and to amitraz (Elzen, et al., 2000a). Also, the use of acaricides should be minimized in beekeeping because of the residues and their breakdown products in honey and wax (Wallner, 1999). There is current concern about contamination of bee products with synthetic used against the varroa (Howis, and Nowakowski, 2009).

The problems associated with the use of acaricides proved considerable incentive to develop new treatment strategies and screening for potential acaricides that minimize these problems. Natural products having components with various modes of action might provide effective solution to the problem of varroaosis (Imdorf, et al., 1999). These natural products such as essential oils and their components or organic acids, especially formic acid, oxalic acid and citric acid were used for controlling varroa mites (Mutinelli, et al., 1997).

Keeping in view of the serious threat of varroa mite in beekeeping and several constraints for its control, the present investigation was carried out to develop safe and effective management option for the mite population. The present work aimed to determine the effective control of varroa mite by using some essential oils and compared with widely used acaricide, formic acid in the hive of *A. mellifera* colonies.

MATERIALS AND METHODS

The field experiments were conducted during 2012 at Apiary, Department of Entomology College of Agriculture, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Utttarakhand.

For conducting this experiment, in total six oils (tulsi oil, garlic oil, turmeric oil, ajwain oil, cinnamon oil and clove oil) along with formic acid were used for testing their efficacy against varroa mite. The experiment was conducted with 8 treatments (including formic acid and untreated control) replicated three times. Before treatment all the cracks and crevices in the hive were plugged with mud. A thick white paper sheet was placed on the bottom board beneath the frames. In each treatment, two stirps of blotting paper (5x2 inches each) were soaked in equal quantity (5 ml) for 24 hours placed at bottom of hive near to brood.

Each treatment was repeated after seven days of interval and observations were taken daily from one day after treatment to twenty one day (At weekly) by counting the fallen/ dead mite on white sheet and sheet was changed daily. The number of fallen/dead mites on the white paper sheet at the bottom of the hives was used to determine mite mortality.

The data collected from experiments were statistically analysed. The randomized block design was used to find out the efficacy of different essential oils against the mite, *V. destructor*.

% mite mortality in bee colonies was calculated by using formula (Pawar, 2008):

$$\text{Percent mite mortality} = \frac{\text{Mite mortality in treatment}}{\text{Mite mortality in treatment + Mite mortality in control}} \times 100$$

RESULTS

The efficacy and persistence of essential oils and formic acid were evaluated against varroa mite and number of fallen mites/hive/week and per cent mite mortality is summarized in Table 1 and 2.

First week observations revealed that highest no. of dead/fallen mites per colony (29.69:76.73 %) mortality was recorded in treatment T_2 (garlic oil) followed by treatment T_7 (formic acid) with from 28.22 dead/fallen mites giving 75.82% mite mortality. Both these treatments gave significantly higher mite mortality as compared to other treatments. The number of fallen mites recorded after one weeks in treatments T_3 (turmeric oil), T_6 (clove oil), T_1 (tulsi oil), T_5 (cinnamon oil) and T_4 (ajwain oil) treated colonies were 24.00, 22.98, 22.21, 21.65 and 18.32 fallen mites/hive/week with 72.72, 71.85, 71.16, 70.63 and 55.51 per cent mite mortality, respectively.

The observations after second week indicated that number of fallen mites recorded in treatment T_2 (garlic oil) and T_7 (formic acid) were 26.69 and 25.21 dead / fallen mites / hive / week with 76.00 and 75.59 percent mite mortality which were significantly higher than in T_3 (turmeric oil), T_6 (clove oil), T_1 (tulsi oil), T_5 (cinnamon oil) and T_4 (ajwain oil) treated colonies with 20.44, 19.00, 18.00, 17.11and 12.90 fallen mites/hive/week giving 71.87, 70.37, 69.23, 68.14 and 61.72 percent mite mortality, respectively. Similar pattern was observed in third week after treatments but with deceased number of fallen mites and percent mortality.

The results showed that among seven treatments applied for varroa mite control, Garlic oil (T_2) and Formic acid (T_7) treatments were significantly better. Garlic oil (T_2) treatment gave highest mite mortality (76.73%) after one week which decreased to 76.00% after two weeks and then to 72.36% after three weeks giving an overall mortality of 75.03%. Similarly formic acid treatment recorded 75.82 percent mortality after one week which decreased to 75.59 percent after two weeks and further to 67.43% after three weeks with an overall mean mortality of 72.94%.

DISCUSSION

The overall results showed that among seven treatments applied for *Varroa* mite control, Garlic oil (T_2) treatment gave significantly superior results in reducing the *Varroa* mite population up to three weeks with an overall mean value of 75.03% mite mortality after first application and 77.85% mite mortality after second application. Chen et al., 1995; Rademacher, 1995; Calderone, 1999; Calderone and Spivak, 1995 ; Le and Pham, 2002; Yucel, 2005 were also reported that formic acid when applied singly or in combination with each other was effective in controlling *Varroa* mite. Percent mite mortality in Filter/Blotting paper strip in which garlic oil (T_2) was significantly higher (P<0.005) than turmeric oil (T_3), clove oil (T_6), cinnamon (T_5), tulsi oil (T_1) and ajwain (T_4) treatments. Similar to present results, Allam et al. (2003), also observed acaricidal activity of clove oil and formic acid against *V.* mite.

CONCLUSION

Garlic oil is effective in causing varroa mite mortality to a level of 76.00 up to two weeks and the application should be repeated thereafter for achieving effective control. The effectiveness of garlic oil suggests it as an alternative to formic acid, a chemical treatment widely being used in *A. mellifera* colonies against varroa mite.Depending upon the varroa mite infestation level either of the essential oils may be repeated after

three weeks. Further the effectiveness of these compounds seems to be greatly dependent on temperature, time of year, colony strength and brood area.

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Table-1: Effect of different essential oils and formic acid against *V. destructor* based on mite fall in *A. mellifera* colonies.

Treatment	Oils	Dose/hive	Average number of dead/fallen mite/ hive			
			Pre treatment Count	1st week after treatment	2nd week after treatment	3rd week after treatment
T_1	Tulsi oil	5ml	17.44 (2.39)*	22.21 (2.70)	18.00 (2.53)	12.33 (2.12)
T_2	Garlic oil	5ml	15.00 (2.19)	29.69 (3.22)	26.23 (3.02)	18.33 (2.55)
T_3	Turmeric oil	5ml	14.67 (2.26)	24.00 (2.86)	20.44 (2.57)	14.66 (2.32)
T_4	Ajwain oil	5ml	15.62 (2.29)	18.32 (2.55)	12.90 (2.17)	8.00 (1.76)
T_5	Cinnamon oil	5ml	15.22 (2.19)	21.65 (2.64)	17.11 (2.48)	9.00 (1.87)
T_6	Clove oil	5ml	13.65 (2.07)	22.98 (2.78)	19.00 (2.59)	13.34 (2.21)
T_7	Formic acid	5ml	14.44 (2.17)	28.22 (3.14)	25.21 (2.95)	14.24 (2.28)
T_8	control	--	15.80 (2.29)	9.00 (1.87)	8.00 (1.76)	7.20 (1.68)
SEM±			**2.66 (0.56)**	**1.78 (0.36)**	**1.35 (0.27)**	**0.65 (0.14)**
CD at 5%			**8.07ns (1.70)**	**5.47 (1.09)**	**4.12 (0.84)**	**1.97 (0.45)**

- ns = non significant
- *Data given in parentheses are square root transformed values.

Table- 2: Efficacy of essential oils and formic acid against varroa mite, *V. destructor* based on percent mortality in *A. mellifera* colonies.

Treatment	Oils	Per cent mite mortality			
		1st week after treatment	2nd week after treatment	3rd week after treatment	Mean
T_1	Tulsi oil	71.16 (25.12)*	69.23 (27..40)	63.78 (24.09)	68.56
T_2	Garlic oil	76.73 (28.07)	76.00 (27.53)	72.36 (26.57)	75.03
T_3	Turmeric oil	72.72 (26.23)	71.87 (25.67)	67.06 (26.28)	70.55
T_4	Ajwain oil	55.51 (23.74)	61.72 (23.68)	53.33 (22.43)	56.85
T_5	Cinnamon oil	70.63 (27.47)	68.14 (26.79)	56.25 (24.04)	65.00
T_6	Clove oil	71.85 (26.46)	70.37 (25.89)	65.58 (25.67)	69.26
T_7	Formic acid	75.82 (27.72)	75.59 (27.74)	67.43 (26.41)	72.94
T_8	Control	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00
SEM±		**2.73 (1.93)**	**2.77 (1.10)**	**1.52 (1.13)**	**1.43**
CD at 5%		**20.82 (18.85)**	**14.00 (13.36)**	**18.57 (16.45)**	**15.09**

- *Data given in parentheses are angular transformed values.

