Persian J. Acarol., 2021, Vol. 10, No. 1, pp. 85–94.
https://doi.org/10.22073/pja.v10i1.61968
Journal homepage: http://www.biotaxa.org/pja

Article

Management of mites with homemade neem fruit aqueous extract in capsicum under protected cultivation

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ABSTRACT
Capsicum is a highly nutritious and commercial vegetable crop grown in open field and protected conditions throughout the world. But two-spotted spider mite, *Tetranychus urticae* Koch and yellow mite, *Polyphagotarsonemus latus* (Banks) cause major problems in its cultivation under protected conditions resulting in significant losses. The objective of this study was to evaluate the efficacy of different biorationals especially neem fruit aqueous extract against *T. urticae* and *P. latus* under poly-nethouse and open field conditions in different vegetable growing areas of the state from 2017–2019. Results revealed that the homemade neem fruit aqueous extract (NFAE) was moderately effective causing 41–62% reduction in the mite population. In the NFAE treated plots the yield varied from 234.76 to 242.79 q/acre as compared to 247.99 q/acre in Malathion 50 EC® 4ml/L with significant differences as compared to control (224.69 q/acre). These botanicals can be integrated for effective mite management programs under protected conditions.

KEY WORDS: Biorationals; protected conditions; *Polyphagotarsonemus latus*; *Tetranychus urticae*; vegetable crop.

PAPER INFO.: Received: 23 May 2020, Accepted: 3 August 2020, Published: 15 January 2021

INTRODUCTION

Protected cultivation of high value vegetable crops has shown tremendous potential during the last decade. In terms of area of fruit and vegetable crops under protected cultivation, India ranks at seventh position worldwide (Nair and Barche 2014). Capsicum (*Capsicum annuum* var. *frutescens*) is nutritious and highly remunerative vegetable crop grown throughout the world in field as well as protected cultivation. During the last decade, its cultivation has greatly increased under protected conditions so as to make it available all around the year. In protected cultivation, crops are grown under controlled conditions like water, temperature, fertilizers, humidity, light, etc. However, the protected environment also provides congenial micro-climate for the multiplication of sucking insects and mites which cause economic damage to crops.

How to cite: Bhullar, M.B., Kaur, P., Kumar, S., Sharma, R.K., Kumar, R., Kumari, S., Singh, V., Kaur, A., Kaur, J., Sharma, U. & Kaur, J. (2021) Management of mites with homemade neem fruit aqueous extract in capsicum under protected cultivation. *Persian Journal of Acarology*, 10(1): 85–94.

About 35 species of insect and mite pests have been reported to infest capsicum under field conditions which include thrips, aphids, whiteflies, fruit borers and mites (Sorensen 2005). However, In India, under poly-net and nethouses, yellow mite, *Polyphagotarsonemus latus* (Banks) (Acari: Tarsonemidae) and two-spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae) cause major problems and hamper crop productivity (Gupta 2012; Anonymous 2018). Both the species, *T. urticae* and *P. latus* attack capsicum in open field conditions also. Characteristic damage symptoms of *P. latus* include twisting and downward curling of leaf margin, and bronzing of terminal leaves and shoots. In case of severe attack, leaves turn pale golden yellow with purplish color on underside of leaves followed by abscission. The plants develop rosette appearance and later die. On the other hand, *T. urticae* causes yellowish-white specklings and in severe cases webbing occurs which decreases photosynthesis (Jeppson *et al*. 1975; Dhooria 2016). Under Punjab conditions, the mites have been reported to cause 11.54 % avoidable losses on capsicum under protected cultivation (Anonymous 2020)

Consumer's demand for healthy and 'green' produce is ever-increasing but farmers generally rely on chemicals for pest control, and the indiscriminate use of these chemicals leads to adverse effects like residues in the fruits, pest resurgence and destruction of natural enemies which suggest the need to develop alternative management strategies (Hoy 2011). In order to mitigate these problems, interest on alternate methods of pest management in recent years has shown a great potential for management of mites under protected cultivation (Rathee *et al*. 2018).

In recent years, plant extracts and botanical pesticides have showed great importance in agricultural fields due to their cheap and low expenses, with little residual effects, environmentally friendly, and highly toxic against major sucking pests (Tang *et al*. 2002). Azadirachtin is a triterpenoid and one of the main bioactive compounds which is obtained from Neem, *Azadirachta indica* A. Juss. This compound can be found in various parts of the Neem tree (seeds, callus, fruits and leaves) but the concentrations are quite variable with values ranging from 0.25 μg g^{-1} in callus to 48,000 μg g^{-1} in seeds. Azadirachtin is abundantly present in mature seeds of Neem but is only detected at trace amounts in plant leaves. The potential to use Azadirachtin as an insecticide has already been duly tested and proven (Dougoud *et al*. 2019; Fernandes *et al*. 2019). As no systematic work on the management of mites using botanicals and their extracts, has been carried out on capsicum under protected and open field cultivation in Punjab, so keeping this in view the present studies were planned to develop an effective management strategy against *P. latus* and *T. urticae* using biorational approaches.

MATERIALS AND METHODS

The research trials i.e. one trial each at Entomological Research Farm, PAU, Ludhiana and at KVK, Nurmahal, District Jalandhar were conducted in 2017 and 2018 to evaluate the efficacy of homemade neem fruit extract for management of mites on capsicum under protected conditions.

Under nethouse conditions at Ludhiana in 2017

For evaluation of neem fruit aqueous extract against *T. urticae* on capsicum crop under nethouse cultivation, capsicum hybrid *Indra* was raised under nethouse and 30 days old seedlings were transplanted on November 19, 2016 following recommended agronomic practices. The experiment was laid out in randomized block design (RBD) with each of the concentration of biorational as one treatment and three replications were kept for all the treatments. Application of biorationals was done on May 26, 2017 at the appearance of 20–25 percent mite infestation on plants. The maximum temperature and minimum temperature varied from 39 ºC to 42.0 ºC and 25.6 ºC to 29.4 ºC, respectively while morning and evening relative humidity varied from 44 to 48% and 26 to 28%, respectively during the trials. Observations were recorded from randomly selected three leaves each from top, middle and bottom canopies. These leaves were collected and brought to the laboratory. The number of mites were recorded per leaf under stereozoom binocular microscope at

pretreatment, 3, 7, 10 and 14 days after each spray.

Under polyhouse conditions at Nurmahal in 2018

For evaluation of neem fruit aqueous extract against *P. latus* on capsicum crop under polyhouse cultivation, capsicum hybrid *Indra* was raised under polyhouse and 30 days old seedlings were transplanted on October 12, 2017 following recommended agronomic practices. The experiment was laid out in randomized block design (RBD) with each of the concentration of biorational as one treatment and three replications were kept for all the treatments. Application of biorationals was done on January 8, 2018 at the appearance of 20–25 percent mite infestation on plants. The temperature and relative humidity in the polycarbonate glass house were maintained at 27–30 ℃ and 60–65% relative humidity.

Multi-locational trials in 2019

In 2019, multi-locational research trials were conducted at eleven locations in different agro-climatic zones of the Punjab State, with nine in protected conditions (2 trials each at Nurmahal, Ballowal Saunkhri, Kapurthala and 1 trial each at Ferozepur, Moga, Bathinda) and two in open field conditions (Abohar and Mansa). In the poly-nethouses, incidence of yellow mite, *P. latus* was observed. Abohar and Mansa fall in the south-west areas of Punjab with comparatively dry climate. At both these locations, incidence of *T. urticae* was observed naturally in May, 2019. Since incidence of both the mite species is seen in protected conditions and open conditions, so the trials were carried out on both the species at various locations. The trials were conducted in a randomized block design with three replications

Preparation of botanical homemade neem fruit aqueous extract (NFAE)

Fresh neem fruits were collected and dried under shade and powdered by using electric grinder and passed through a 20 mesh sieve and kept in a polythene bag. Thereafter, 40, 50, 60 g of the powder was soaked, respectively in one litre of water each and shaken for 2 h in a mechanical shaker and kept overnight. The extract was separated using fine muslin cloth and then filtered. The filtrate was collected to get desired concentrations of 4, 5 and 6 percent, i.e. 4, 5 and 6 kg per 100 litres of water, respectively and used as such without dilution. The spray was initiated with homemade neem fruit extract at 4, 5 and 6 percent along with standard Malathion 50 EC® 400 ml/acre/100 litres of water and an untreated control which was left unsprayed at the appearance of 20–25 percent mite infestation on plants. Three replications each were kept for these trials. The treatments were given using a knapsack sprayer. Observations were recorded from randomly selected three leaves each from top, middle and bottom canopies of five plants. These leaves were collected and brought to the laboratory. The number of active stages of mites were recorded per leaf under stereozoom binocular microscope (Carl Zeiss Discovery V 8) at pretreatment, 3, 7, 10 and 14 days after each spray in 2017, 2018 and 2019.

Statistical analysis

The data was subjected to square root transformation and analysed using Randomized block design (RBD) in Analysis of variance (ANOVA) at 5 percent level of significance in the CPCS1 program.

RESULTS

Protected conditions

The effect of NFAE was observed on active stages of mites.

2017, Ludhiana

In 2017 at Ludhiana, the number of active stages of mites per leaf before spray ranged from

9.44 to 12.67 mites/leaf. In case of active stages, 3 days after spray (DAS) all treatments were found at par, however 7 DAS neem fruit extract at 60 g/L gave significantly more reduction in population of mites as compared to Malathion® 4 ml/L. After 10 and 14 DAS, all treatments were found significantly at par in reducing mite population (Table 1).

Table 1. Efficacy of homemade neem fruit aqueous extract against active stages of mites at Ludhiana in 2017.

Treatment	Concentration (g or ml/L)	number of mites/leaf (DAS)				
		Pre-spray	3	7	10	14
Neem fruit aqueous extract	40 g	11.66 (3.55)	3.08 (1.98)	3.53 (2.09)	4.19 (2.26)	6.65 (2.76)
	50 g	12.67 (3.70)	2.55 (1.84)	1.77 (1.66)	1.97 (1.71)	5.28 (2.50)
	60 g	9.44 (3.22)	2.32 (1.80)	3.20 (1.95)	2.59 (1.83)	5.31 (2.50)
Malathion	4 ml	11.22 (3.48)	2.68 (1.91)	2.33 (1.82)	2.50 (1.87)	7.33 (2.88)
Untreated control	-	9.56 (3.24)	6.81 (2.78)	7.70 (2.93)	7.70 (2.92)	10.35 (3.36)
CD (p = 0.05)	-	(0.29)	(0.45)	(0.76)	(0.57)	(0.31)

Figures in parentheses are square root transformed values.

2018, Nurmahal

In 2018, at Nurmahal, the data on mean mite incidence one day before spray indicated non-significant differences among all the treatments. In case of active stages, 3 DAS all treatments were found at par, however 7 DAS neem fruit extract at 60 g/L gave significantly more reduction in population of mites as compared to Malathion® 4 ml/L. After 10 and 14 DAS, all treatments were found significantly at par in reducing mite population (Table 2).

Table 2. Efficacy of homemade neem fruit aqueous extract against active stages of mites on capsicum at KVK, Nurmahal in 2018.

Treatment	Concentration (g or ml/L)	number of mites/leaf (DAS)				
		Pre-spray	3	7	10	14
Neem fruit aqueous extract	40 g	13.59	1.33 (1.49)	3.00 (1.95)	2.89 (1.93)	3.00 (1.96)
	50 g	13.42	1.11 (1.40)	1.11 (1.42)	4.00 (2.04)	2.89 (1.89)
	60 g	13.68	0.44 (1.19)	0.33 (1.15)	0.44 (1.19)	1.44 (1.54)
Malathion	4 ml	13.63	0.56 (1.24)	2.22 (1.78)	0.89 (1.34)	3.11 (1.98)
Untreated control	-	13.75	11.00 (3.46)	13.89 (3.85)	13.77 (3.84)	15.00 (3.99)
CD (p = 0.05)	-	NS	(0.48)	(0.58)	(1.03)	(0.88)

Figures in parentheses are square root transformed values.

2019, Multilocational trials

1. Protected conditions

The data of multilocational trials revealed that the population of yellow mites (*P. latus*) did not differ significantly in all the treatments before spray. The population of mites was 8.69, 9.40, 11.03, 13.61 mites/leaf in NFAE at 40 g/L; 7.91, 8.22, 9.97, 12.54 in NFAE at 50 g/L and 8.26, 7.94, 7.43, and 10.89 mites/leaf in NFAE at 60 g/L after 3, 7, 10 and 14 days of application of NFAE, respectively. After 7 DAS, all doses of NFAE were found significantly at par with each other, however Malathion® 4 ml/L gave more significant reduction as compared to NFAE at 40 g/L and at par with NFAE at 50 g/L and 60 g/L. After 10 and 14 DAS, Malathion® 4 ml/L gave more reduction of mites as compared to neem treatments (Tables 3a and 3b). However, all the treatments were better than untreated control.

Table 3. Efficacy of homemade neem fruit aqueous extract against mites on capsicum under protected conditions in multi-locational trials.

Treatment	conce-ntration (g or ml/L)	Population of mites/leaf in different districts									
		Nurmahal		Ballowal Saunkhri		Bathinda	Moga	Ferozepur	Kapurthala		Pooled mean
		Expt. 1	Expt. 2	Expt. 3	Expt. 4	Expt. 5	Expt. 6	Expt. 7	Expt. 8	Expt. 9	
		Before spray									
Neem fruit aqueous extract	40g	14.11	11.96	17.06	17.73	23.21	13.00	13.55 (3.81)	13.07 (3.75)	15.57	14.96
	50g	14.15	12.07	16.81	17.15	22.00	13.26	13.00 (3.74)	13.19 (3.77)	16.62	14.67
	60g	14.04	12.08	16.34	16.59	23.02	13.37	13.00 (3.74)	13.22 (3.77)	15.53	14.91
Malathion 50 EC	4ml	14.00	11.96	17.21	17.41	21.43	13.07	13.11 (3.76)	12.78 (3.71)	16.15	14.99
Control	-	14.89	12.44	16.95	17.49	23.00	13.78	13.03 (3.75)	14.19 (3.90)	16.01	15.15
CD (p = 0.05)		NS	NS	NS	NS	NS	NS	(0.78)	(0.70)	NS	NS
		3 Days after spray									
Neem fruit aqueous extract	40g	8.45 (3.07)	6.74 (2.78)	8.80 (3.13)	9.45 (3.23)	10.57 (3.40)	9.15 (3.18)	7.85 (2.98)	7.74 (2.96)	9.46 (3.23)	8.69 (3.11)
	50g	8.22 (3.04)	6.33 (2.71)	8.13 (3.02)	7.87 (2.98)	8.62 (4.00)	8.44 (3.07)	7.67 (2.94)	7.52 (2.92)	9.18 (3.19)	7.91 (2.98)
	60g	7.82 (2.97)	5.82 (2.61)	6.64 (2.76)	6.83 (2.79)	6.57 (2.74)	7.74 (2.96)	15.26 (4.03)	6.89 (2.81)	8.30 (3.04)	8.26 (3.01)
Malathion 50 EC	4 ml	7.30 (2.88)	5.48 (2.55)	8.23 (3.04)	8.31 (3.05)	7.00 (2.82)	7.44 (2.90)	6.60 (2.76)	5.26 (2.50)	7.10 (2.84)	7.69 (2.92)
Control	-	15.74 (4.09)	12.85 (3.72)	17.27 (4.27)	17.67 (4.32)	24.56 (5.06)	14.26 (3.91)	7.37 (2.89)	15.22 (4.03)	16.82 (4.22)	15.17 (3.98)
CD (p = 0.05)		(0.11)	(0.13)	(0.23)	(0.30)	(0.35)	(0.18)	(0.12)	(0.89)	(0.20)	(0.37)
		7 Days after spray									
Neem fruit aqueous extract	40g	9.44 (3.23)	7.63 (2.94)	8.65 (3.10)	8.65 (3.10)	12.00 (3.60)	8.48 (3.08)	9.12 (3.18)	8.37 (3.06)	8.31 (3.04)	9.40 (3.22)
	50g	9.19 (3.19)	6.93 (2.81)	7.14 (2.85)	6.98 (2.82)	9.67 (3.26)	7.78 (2.96)	9.08 (3.17)	8.26 (3.04)	8.14 (3.02)	8.22 (3.03)
	60g	8.52 (3.09)	6.26 (2.69)	6.24 (2.69)	6.09 (2.66)	6.89 (2.81)	7.11 (2.85)	8.22 (3.04)	7.93 (2.99)	7.75 (2.95)	7.94 (2.96)
Malathion 50 EC	4ml	5.82 (2.61)	4.33 (2.31)	6.33 (2.71)	6.00 (2.64)	7.03 (2.83)	6.30 (2.70)	5.52 (2.55)	3.89 (2.21)	5.78 (2.60)	6.73 (2.73)
Control	-	16.67 (4.20)	13.37 (3.79)	18.49 (4.41)	18.80 (4.45)	26.06 (5.20)	14.74 (3.97)	16.34 (4.16)	16.92 (4.23)	17.76 (4.33)	17.23 (4.25)
CD (p = 0.05)		(0.17)	(0.12)	(0.27)	(0.25)	(0.30)	(0.19)	(0.14)	(0.10)	(0.14)	(0.30)
		10 Days after spray									
Neem fruit aqueous extract	40	11.48 (3.53)	9.44 (3.23)	9.82 (3.29)	9.48 (3.23)	13.25 (3.77)	11.07 (3.47)	11.30 (3.51)	10.22 (3.35)	8.78 (3.12)	11.03 (3.46)
	50	10.44 (3.38)	8.52 (3.09)	8.28 (3.04)	8.24 (3.04)	14.00 (3.87)	10.59 (3.40)	10.18 (3.34)	9.33 (3.21)	8.49 (3.08)	9.97 (3.30)
	60	9.78 (3.28)	7.74 (2.96)	7.06 (2.84)	7.13 (2.85)	9.03 (3.16)	9.37 (3.22)	9.56 (3.25)	8.56 (3.09)	7.70 (2.95)	9.29 (3.18)
Malathion 50 EC	4 ml	6.93 (2.82)	4.82 (2.41)	6.66 (2.76)	6.71 (3.23)	8.00 (3.00)	6.56 (2.75)	6.63 (2.76)	4.81 (2.41)	5.18 (2.48)	7.43 (2.86)
Control	-	16.74 (4.21)	13.37 (3.79)	19.12 (4.48)	18.83 (4.45)	28.43 (5.42)	15.30 (4.04)	16.49 (4.18)	16.44 (4.18)	17.99 (4.35)	17.83 (4.31)
CD (p = 0.05)		(0.13)	(0.96)	(0.32)	(0.28)	(0.27)	(0.13)	(0.10)	(0.11)	(0.88)	(0.28)

Mean of 9 experiments. Figures in the parentheses indicate square root transformation.

Table 3. Continued.

Treatment	conce-ntration (g or ml/L)	Population of mites/leaf in different districts									Pooled mean
		Nurmahal		Ballowal Saunkhri		Bathinda	Moga	Ferozepur	Kapurthala		
		Expt. 1	Expt. 2	Expt. 3	Expt. 4	Expt. 5	Expt. 6	Expt. 7	Expt. 8	Expt. 9	
		14 Days after spray									
Neem fruit aqueous extract	40g	12.89 (3.73)	12.44 (3.67)	10.51 (3.39)	10.17 (3.34)	26.45 (5.24)	12.26 (3.64)	12.59 (3.69)	11.59 (3.55)	9.84 (3.29)	13.61 (3.78)
	50g	11.78 (3.57)	11.70 (3.56)	9.90 (3.30)	9.92 (3.30)	25.00 (6.00)	10.70 (3.42)	11.44 (3.53)	11.04 (3.47)	8.96 (3.15)	12.54 (3.64)
	60g	10.52 (3.39)	10.37 (3.37)	8.61 (4.00)	7.83 (2.97)	14.00 (3.87)	10.44 (3.38)	10.30 (3.36)	10.15 (3.34)	8.16 (3.02)	10.89 (3.43)
Malathion 50 EC	4 ml	7.93 (2.99)	6.85 (2.80)	8.15 (3.02)	7.89 (2.98)	15.47 (4.06)	7.30 (2.87)	7.74 (2.96)	6.52 (2.74)	6.46 (2.73)	9.34 (3.17)
Control	-	16.67 (4.20)	14.30 (3.91)	19.35 (4.51)	19.06 (4.48)	35.76 (6.06)	16.41 (4.17)	16.44 (4.18)	16.22 (4.15)	18.52 (4.41)	18.93 (4.42)
CD (p = 0.05)		(0.12)	(0.14)	(0.21)	(0.19)	(0.21)	(0.26)	(0.16)	(0.88)	(0.11)	(0.28)

Mean of 9 experiments. Figures in the parentheses indicate square root transformation.

2. Open conditions

Trials conducted at Mansa and Abohar revealed similar trend with NFAE at 60 g/L showing higher efficacy against two-spotted spider mites (*T. urticae*) as compared to untreated (Tables 4, 5).

Table 4. Efficacy of homemade neem fruit aqueous extract against mites on capsicum under open conditions at Abohar.

Treatment	Concentration (g or ml/L)	number of mites/leaf (DAS)				
		Pre-spray	3	7	10	14
Neem fruit aqueous extract	40g	14.00 (3.86)	13.60 (3.82)	15.40 (4.04)	15.80 (4.09)	16.20 (4.11)
	50g	11.30 (3.45)	9.50 (3.23)	12.30 (3.64)	13.20 (3.75)	13.60 (3.81)
	60g	10.40 (3.37)	8.40 (3.03)	9.00 (3.15)	10.20 (3.34)	11.40 (3.52)
Malathion	4 ml	20.80 (4.65)	10.60 (3.40)	6.40 (2.72)	7.40 (2.89)	10.27 (3.35)
Untreated control	-	10.60 (3.40)	11.60 (3.54)	13.70 (3.83)	15.80 (4.09)	16.20 (4.14)
CD (p = 0.05)	-	(0.50)	NS	(0.54)	(0.56)	NS

Table 5. Efficacy of homemade neem fruit aqueous extract against mites on capsicum under open conditions at Mansa.

Treatment	Concentration (g or ml/L)	number of mites /leaf				
		Pre-spray	3 DAS	7 DAS	10 DAS	14 DAS
Neem fruit aqueous extract	40g	12.88	6.63 (2.76)	8.00 (2.99)	9.22 (3.19)	10.37 (3.37)
	50 g	11.37	6.81 (2.79)	7.22 (2.86)	9.26 (3.19)	10.18 (3.34)
	60g	12.44	6.40 (2.72)	6.85 (2.80)	8.26 (3.03)	8.77 (3.12)
Malathion	4 ml	12.74	6.25 (2.69)	4.70 (2.38)	6.07 (2.63)	7.22 (2.86)
Untreated control	-	13.29	14.11 (3.88)	13.59 (3.81)	12.51 (3.67)	13.03 (3.74)
CD (p = 0.05)	-		(0.08)	(0.21)	(0.32)	(0.24)

Yield

In 2017 at Ludhiana capsicum yield per treatment and average height of plant per treatment was recorded after spray. In plots treated with neem fruit extract, comparatively more mean yield (3.60 to 4.0 kg/10 plants) and mean height (32 to 52 cm) was recorded and minimum in control plots (31 cm) (Table 6). In 2018, at Nurmahal, the plants were visually assessed for the mite damage symptoms in different treatments by following the damage score card and number of fruits per plant, percent damage and damage score was calculated in case of all the treatments. In case of plants treated with neem fruit extract, comparatively a greater number of fruits (1.65/plant) were observed at the concentration of 60 g/L. The total yield could not be recorded in Nurmahal in 2018 due to less fruiting in all the treatments. In 2019, the pooled analysis of yield revealed that the yield was 234.76, 236.80 and 242.79 q/acre in NFAE at 40, 50 and 60 g/L, respectively as compared to 247.99 q/acre in Malathion with significant differences as compared to control (224.69 q/acre) (Table 7).

Table 6. Effect of homemade neem fruit aqueous extract on yield of capsicum at Ludhiana in 2017.

Treatment	dose	Yield per treatment (kg/10 plants)	Average plant height (cm)
Neem fruit extract	40 g/L	3.60	40
	50 g/L	3.65	52
	60 g/L	4.00	52
Malathion®	4 ml/L	4.20	53
Control	-	3.00	31
CD (p = 0.05)	-	0.41	0.11

Table 7. Efficacy of homemade neem fruit aqueous extract on yield of capsicum under protected conditions in multi-locational trials.

Treatment	Concen-tration (g or ml/L)	Yield (q/acre)									Pooled mean
		Nurmahal		Ballowal Saunkhri		Bathinda	Moga	Feroz epur	Kapurthala		
		Expt. 1	Expt. 2	Expt. 3	Expt. 4	Expt. 5	Expt. 6	Expt. 7	Expt. 8	Expt. 9	
Neem fruit aqueous extract	40g	240.31 (15.53)	242.79 (15.61)	196.87 (14.07)	210.97 (14.56)	379.00 (19.49)	241.65 (15.58)	208.41 (14.47)	176.24 (13.31)	216.62 (14.75)	234.76 (15.26)
	50g	241.91 (15.59)	244.61 (15.67)	200.96 (14.21)	214.77 (14.69)	378.70 (19.49)	242.55 (15.61)	210.55 (14.54)	176.80 (13.33)	220.37 (14.87)	236.80 (15.33)
	60g	242.37 (15.60)	244.97 (15.68)	205.97 (14.39)	219.78 (14.86)	413.90 (20.37)	243.90 (15.65)	212.03 (14.60)	177.28 (13.35)	224.91 (15.03)	242.79 (15.50)
Control	-	234.51 (15.35)	237.19 (15.43)	188.57 (13.77)	202.48 (14.26)	350.50 (18.75)	233.50 (15.32)	198.73 (14.13)	170.52 (13.09)	206.24 (14.39)	224.69 (14.94)
Malathion 50 EC	4 ml	252.86 (15.93)	255.50 (16.02)	207.41 (14.44)	220.26 (14.87)	400.60 (20.04)	253.80 (15.96)	222.83 (14.96)	187.45 (13.72)	231.19 (15.23)	247.99 (15.68)
CD (p = 0.05)		(0.12)	(0.12)	(0.18)	(0.11)	(0.39)	(0.99)	(0.95)	(0.40)	(0.13)	(0.15)

Mean of 9 experiments. Figures in the parentheses indicate square root transformation.

DISCUSSION

In similarity to the present work, Senthurpandian *et al*. (2009) and Roobakkumar *et al*. (2010) observed that increase in concentration of Neem kernel aqueous extract increased mortality percentage against red spider mite, *Oligonychus coffeae* (Nietner) and the highest concentration i.e. NKAE at 50 g/L caused maximum mortality (72%) as compared to lowest concentration of NKAE 1.25 (50% mortality) after 72 hours. Singh *et al*. (2017) reported that neem oil at 4% caused 58 percent reduction in mite population three days after spray but mortality decreased to 46 percent

after seven days of spray, similar trend has been found in our study also. Neem, *Melia azedarach* is constituted of different compounds which are mainly categorized under limonoids, triterpinoids and steroids (El-Wakeil 2013). The main active ingredient azadirachtin is a chemically complex compound synthesized as a secondary metabolite having wide array of acaricidal activity such as anti-feedancce, fecundity deterrence, oviposition deterrence, growth inhibition, detrimental to physiological processes (Bezzar-Bandjazia *et al*. 2017). Azadirachtin exhibiting high levels of acaricidal activity derives support from the findings of Sharma *et al*. (2014). Also, from the above observations, it became clear that homemade aqueous extract of neem fruit requires a higher concentration for pest management as compared to the commercial formulation. Neem-based products (azadirachtin) which are commercially available in the market have varied pest control properties, disturbing insect growth stages, fertility, and anti-feeding activity, in addition to their direct toxicity and oviposition restrain changes. Azadirachtin had a moderate efficacy (69 and 56%) against *Aphis gossypii* and *T. urticae*, respectively, on hydroponic cucumber, which is probably due to its mode of action and which is different from synthetic compounds (Saleem *et al*. 2019). The neem extract was also extremely effective in controlling jassid, whitefly, aphid, and mites on brinjal (Ali *et al*. 2017). All these studies strengthen our studies wherein neem fruit aqueous extract at 50 g/L has shown moderate efficacy in controlling the mite population on capsicum grown under protected cultivation.

CONCLUSION

The homemade neem fruit aqueous extract at 50 g/L showed moderate effectiveness in reducing the mite population, both *P. latus* and *T. urticae* on capsicum raised under poly-nethouse conditions. It is an eco-friendly, safe method of managing mites on capsicum and holds promise for the control of mites especially when their population is low in the season. This also enhances the choice of the farmers in selecting the non-chemical approaches in mite management in capsicum.

ACKNOWLEDGMENTS

The authors are grateful to the Professor and Head, Department of Entomology, Punjab Agricultural University, Ludhiana and Indian Council for Agricultural Research, New Delhi for the financial support under the All India Network Project on Agricultural Acarology. The first author is also grateful for the infrastructural assistance under the Department of Science and Technology - Promotion of University Research and Scientific Excellence (DST-PURSE, Phase 2) and Fund for Improvement of S&T infrastructure in universities & higher educational institutions (DST-FIST) projects.

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مدیریت کنه‌ها با عصارهٔ آبی خانگی میوهٔ درخت چریش در کشت محافظت شده فلفل

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چکیده

فلفل گیاهی بسیار مغذی و تجاری است که در زمین‌های باز و شرایط محافظت شده در سراسر جهان رشد می‌کند. اما کنهٔ تارتن دو لکه‌ای، *Tetranychus urticae* Koch و کنهٔ زرد، *Polyphagotarsonemus latus* (Banks) مشکلات بزرگی در کشت آن در شرایط محافظت شده ایجاد و در نتیجه خسارات مهمی به بار می‌آورند. هدف از این بررسی ارزیابی اثرات مختلف گیاهان بیورشنال به ویژه عصارهٔ آبی میوهٔ چریش علیه *T. urticae* و *P. latus* در شرایط گلخانه‌ای و گیاهان باز در مناطق مختلف رشد گیاهان ایالت پنجاب از سال ۲۰۱۷-۲۰۱۹ بود. نتایج نشان داد که عصارهٔ آبی میوهٔ چریش خانگی به نسبت موثر بوده و باعث کاهش ۴۱-۶۲ درصدی در جمعیت کنه‌ها شده است. در کرت‌های تیمار شده با عصارهٔ آبی میوهٔ چریش خانگی عملکرد از ۲۳۴/۷۶ تا ۲۴۲/۷۹ q/acre در مقایسه با ۲۴۷/۹۹ q/acre در دوز ۴ میلی‌لیتر بر لیتر امولسیون ۵۰ مالاتیون با اختلاف معنی‌داری نسبت به شاهد (۲۲۴/۶۰ q/acre) متفاوت بود. این مواد گیاهی را می‌توان برای برنامه‌های موثر مدیریت کنه‌ها تحت شرایط محافظت شده تلفیق کرد.

واژگان کلیدی: بیورشنال؛ شرایط محافظت شده؛ *Polyphagotarsonemus latus*؛ *Tetranychus urticae*؛ صیفی‌جات.

اطلاعات مقاله: تاریخ دریافت: ۱۳۹۹/۳/۳، تاریخ پذیرش: ۱۳۹۹/۵/۱۳، تاریخ چاپ: ۱۳۹۹/۱۰/۲۶