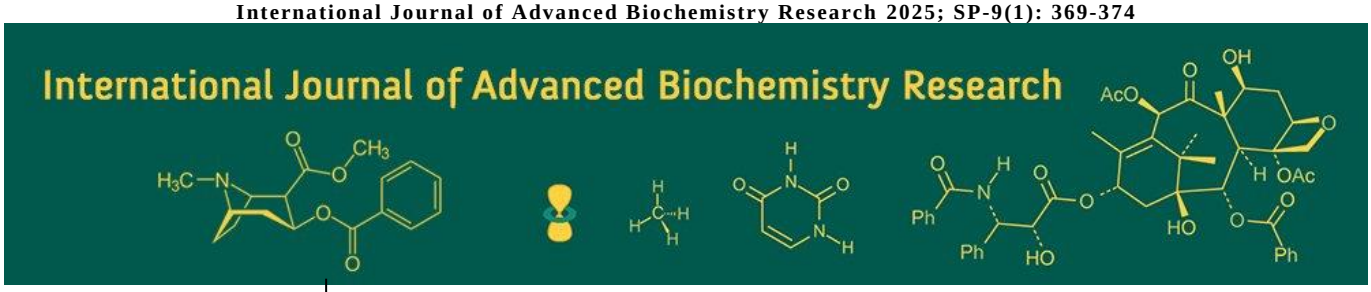

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Bio-efficacy of insecticidal spray schedule for sucking pest of chilli

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Abstract
Experiment was conducted in randomised block design during *Kharif* 2023 at Experimental Farm, Department of Agricultural Entomology, College of Agriculture, Latur, Maharashtra to study the bio-efficacy of the different molecule combined in six spray schedule along with one untreated control. The study brought out the significant difference among the effect of different insecticides spray schedule against major pests of chilli and indicated that all the insecticides were found to be significantly superior in recording minimum number of thrips, aphid, whitefly, mite and percent infestation of fruit borer over untreated control. Among different insecticides spray schedule, schedule of insecticides *i.e.* fipronil 0.5 SC + tolfenpyrad 15 EC + cyantraniliprole 10.50 OD was found most effective at all four spray to reduce the population of whitefly, aphid, mite and it was at par with schedule of lambda-cyhalothrin 5 SC + diafenthiuron 50 WP + emamectin benzoate 0.5 SG followed by spinosad 45 SC + broflanilide 300 G/L SC + flubendamide 20 WG in pooled data and The maximum population of lady beetle was recorded in the spray schedules with imidacloprid 70 SC + spinetoram 11.7 SC + spinosad 45 SC and acephate 75 SP + flonicamide 50 WG + novaluron 10 EC whereas, lowest population of lady beetle was evidenced in spinosad 45 SC + broflanilide 300 G/L SC + Flubendamide 20 WG.

Keywords: Chilli, bio-efficacy, spray schedule, sucking pests, natural enemy

Introduction
Portuguese introduced chilli to India. India which is considered “the home of spices” produces chillies practically every season because of the suitable climate conditions, soil properties, irrigation facilities and intensive practices followed by farmers and now produces 40 percent of total chilli production in the world and is the world leader in green chilli production with an area of 418 lakh , annual production of 45.05 million tonnes and an average productivity of 11 mt ha^{-1} in the years 2021–2022, followed by China and Pakistan (Anonymous 2022) [1]. In Maharashtra, it is cultivated over an area of 99.50 ha with production of 45.60 tonnes and productivity 0.46 tonnes (Anonymous, 2022) [1].

According to The Hindu 2020-2021 report, total chilli exports in 2020-21 were 6,01,500 tonnes valued at ₹8,430 crore, up 21 percent in quantity and 26 percent in value. Last year, it was 2, 64,500 tonnes worth ₹3,605 crore. Majorly chilli producing states in India are Andhra Pradesh, Karnataka, West Bengal, Madhya Pradesh, Maharashtra and Tamil Nadu.

Among the many constraints to low productivity the insect being the prime production constraints can cause the yield loss ranging from 50-90 percent (Nelson and Natrajan, 1994) [13]. Insect pest infestation causes the significant damage to the crop and its holds the major share for low quality and productivity of chilli. The crop is attacked by 55 species of insect pests (Jadhav *et al*., 2004) [6]. The major pests attacking chilli crop are thrips (*Scirtothrips dorsalis* Hood), whiteflies (*Bemisia tabaci* Gennadius), aphids (*Aphis gossypii* Glover), jassids (*Amrasca bigutulla bigutulla*) Ishida, tobacco leaf eating caterpillar (*Spodoptera litura* Fabricius), fruit borer (*Helicoverpa armigera* Hubner) and mites (*Polyphagotarsonemus latus* Banks) (Sorensen, 2005) [15]. These pests attack chilli crop from the time of transplanting till the final harvest of the crop.

These chemicals need to be used wisely in the management of key pest like chilli thrips with a due consideration of cost economics and environmental damage by new group of insecticides reported in the recent past. Insecticides application can substantially reduce yield losses caused by pests.

Pest resistance to pesticides is an increasing problem because pesticides are an integral part of high-yielding crop production in agriculture. Therefore present study is aimed to find most effective spray schedule to manage the sucking pest of the chilli.

Materials and Methods

The field experiments was conducted at Research Farm, and laboratory of Division of Agriculture Entomology, College of Agriculture, Latur (MS), India during *Kharif* 2022 in Randomized Block Design with seven treatments.

Table 1: The details of the insecticides in spray schedules

Treatments	Spray 1	Spray 2	Spray 3
T_1	Fipronil 0.5 SC	Tolfenpyrad 15 EC	Cyantraniliprole 10.50 OD
T_2	Imidacloprid 70 SC	Spinetoram 11.7 SC	Spinosad 45 SC
T_3	Dimethoate 30 SC	Chlorantraniliprole 18.50 SC	Profenophos 50 EC
T_4	Spinosad 45 SC	Broflanilide 300 G/L SC	Flubendamide 20 WG
T_5	Lambda-cyhalothrin 5 SC	Diafenthiuron 50 WP	Emamectin benzoate 0.5 SG
T_6	Acephate 75 SP	Flonicamide 50 WG	Novaluron 10 EC
T_7	Control	Control	Control

The observations on sucking pests was recorded regularly in the treated as well as in control plot throughout the period of investigation in all experiments just before first spraying (Pre) and 1, 3, 5, 7 and 14 days after spraying (DAS).

Observations were recorded to assess sucking pest population from five leaves, one from top and two each from middle and bottom of randomly selected five plants from each net plot for mites, whitefly and aphids whereas from five terminal leaves for thrips (Pathipati *et al.* 2012) [14]. Different schedules and treatments were also assessed for their safety to the naturally occurring bio-agents. Observations were recorded on the population of *Chrysopa* and ladybird beetle. Population of these predators was recorded on randomly selected ten plants from each net plot on weekly interval during both the years. These observations were analysed.

Results

The results obtained in the present investigations on bio-efficacy of insecticides against major pests of chilli based upon pooled data from Table no. 2 (pooled over periods and spray schedule) indicated minimum population of whitefly, in plots sprayed with fipronil 0.5 SC + tolfenpyrad 15 EC + cyantraniliprole 10.50 OD (1.63 whitefly per leaf) population of whitefly, followed by lambda-cyhalothrin 5 SC + diafenthiuron 50 WP + emamectin benzoate 0.5 SG (1.64 whitefly per leaf). Next best spray schedule were acephate 75 SP + flonicamide 50 WG + novaluron 10 EC (1.66 whitefly per leaf) and imidacloprid 70 SC + spinetoram 11.7 SC + spinosad 45 SC (1.85 whitefly per leaf). These insecticides found most effective against whitefly as they exhibited significantly less number of the pest over rest of the spray schedules and spinosad 45 SC + broflanilide 300 G/L SC + Flubendamide 20 WG (2.02 whitefly per leaf) and dimethoate 30 SC + chlorantraniliprole 18.50 SC + profenophos 50 EC (2.55 whitefly per leaf) were recorded significantly less whitefly population than unsprayed plots (5.44 whitefly per leaf).

Over all pooled data from Table no. 3 (pooled over periods and spray schedule) indicated minimum population of aphids, in plots sprayed with lambda-cyhalothrin 5 SC + diafenthiuron 50 WP + emamectin benzoate 0.5 SG (1.44 aphids per leaf) followed by fipronil 0.5 SC + tolfenpyrad 15 EC + cyantraniliprole 10.50 OD (1.65 aphids per leaf) and acephate 75 SP + flonicamide 50 WG + novaluron 10 EC (1.70 aphids per leaf) .Next best insecticides spray schedules in order of effectiveness was spinosad 45 SC + broflanilide 300 G/L SC + Flubendamide 20 WG (1.76 aphids per leaf) .These insecticides spray schedule was optimally effective against aphids as they exhibited significantly less number of the pest over rest of the spray schedule. The spray schedule with dimethoate 30 SC + chlorantraniliprole 18.50 SC + profenophos 50 EC (1.81 aphids per leaf) and imidacloprid 70 SC + spinetoram 11.7 SC + spinosad 45 SC (1.98 aphids per leaf) were next effective spray schedules and recorded significantly less aphids population than unsprayed plots (5.71 aphids per leaf).

On the basis of overall impact of insecticides spray schedule applications after first, second and third spray, fipronil 0.5 SC + tolfenpyrad 15 EC + cyantraniliprole 10.50 OD (1.38 mites/leaf) and lambda-cyhalothrin 5 SC + diafenthiuron 50 WP + emamectin benzoate 0.5 SG (1.57 mites/leaf) was most significantly effective treatment in reducing mite population. The application of dimethoate 30 SC + chlorantraniliprole 18.50 SC + profenophos 50 EC (1.80 mites/leaf) was found effective in reduction of pest population. Acephate 75 SP + flonicamide 50 WG + novaluron 10 EC (2.04 mites/leaf) and imidacloprid 70 SC + spinetoram 11.7 SC + spinosad 45 SC (2.20 mites/leaf) were the next treatments which were proved little effective in mites management. Spinosad 45 SC + broflanilide 300 G/L SC + Flubendamide 20 WG (2.24 mites/leaf) which was least effective in mites management. (Table 4)

The pooled data (Table 5) of first, second and third spray suggested that the highest population of lady bird beetle was noticed in control plots (4.23 beetles per plant) followed by the plots treated with imidacloprid 70 SC + spinetoram 11.7 SC + spinosad 45 SC (2.54 beetles per plant), acephate 75 SP + flonicamide 50 WG + novaluron 10 EC (2.37 beetles per plant), fipronil 0.5 SC + tolfenpyrad 15 EC + cyantraniliprole 10.50 OD (2.36 beetles per plant), spinosad 45 SC + broflanilide 300 G/L SC + Flubendamide 20 WG (2.35 beetles per plant), dimethoate 30 SC + chlorantraniliprole 18.50 SC + profenophos 50 EC (2.29 beetles per plant) and lambda-cyhalothrin 5 SC + diafenthiuron 50 WP + emamectin benzoate 0.5 SG (2.09 beetles per plant) recorded lowest population of lady bird beetle but all spray schedules were found to be statistically at par with each other.

More or less similar findings where observed earlier researchers like by Nagaraju and Kumar (2022) revealed that among the different treatments Fipronil 5 percent SC (94.06%) proved to be the most effective treatment followed by spinosad 45 percent SC (93.16%), imidacloprid 17.8 percent SL (92.27%), profenophos 50 percent EC (84.37%).

Manideep and sake (2023) evaluate that spinosad 45 SC @ 0.2 ml/lt. stood first in the order of efficacy with 80.20 percent reduction in thrips population. The order of efficacy of chemical insecticides against black thrips in chrysanthemum are spinetoram 11.7SC (76.245%) > cyantraniliprole 10OD (73.92%) > fipronil. Manjunatha *et al.* (2018) [10] examined spinosad application resulted in maximum reduction of 91 percent followed byacephate (72%), dimethoate (69%), imidacloprid (61%), fipronil (61%), diafenthiuron (60%), clothianidin (55%) and thiamethoxam (55%) application. Further, spinosad treatment continued to record significant decline in thrips population up to 10 days. Chavan *et al. (*2017) investigated nine insecticidal treatments against thrips, aphids, whiteflys, cutworms and fruit borers. Among all the treatments, Fipronil 200 percent SC 250 mL/ha, was found to be the best treatment a.i/ha were found most effective against different pest compelex of chilli. Mahendra and Singh. (2022) [7] results indicated that the imidacloprid 17.8 SL (0.22 ml/lit.) and Acetamiprid 20 SP (0.20 ml/lit.) were found to be more effective for the control of whitefly on tomato.

The present findings are more or less also parallel to Mandal (2012) [8] who found that cyantraniliprole 10% OD @ 90 and 105 g a.i./ha was highly effective in controlling the aphid, A. gossypii and white fly, B. tabaci of tomato. Nderitu *et al,* (2007) [12] showed that Tracer 48 SC and Regent 5 SC sprayed plots had the lowest thrips numbers across all varieties. Karthik *et al.* (2017) [5] determined that cyantraniliprole 10% OD at 90 g a.i./ha was significantly effective when sprayed twice at 15 days interval in 152 minimizing the sucking pests population and increased cotton yield. Govindappa *et al.* (2013) [4] reported that among the test chemicals, cyantraniliprole 10 OD at 60 and 75 g a.i./ha had knockdown effect and caused 100 percent mortality of thrips at 48 hrs after treatments and also recorded least virus transmission (10 and 5%) respectively.

Table 2: Evaluation of insecticidal spray schedule against whitefly infesting chilli (Pool data)

Tr. No	Treatments	Mean no of whitefly/leaf						
		BS	Ist Spray	IInd Spray	IIIrd Spray	IVth Spray	Vth Spray	Pool
T_1	Fipronil 0.5 SC + tolfenpyrad 15 EC + cyantraniliprole 10.50 OD	3.50 (1.98)*	1.80 (1.52)	1.64 (1.46)	1.46 (1.36)	1.87 (1.55)	1.38 (1.37)	1.63 (1.42)
T_2	Imidacloprid 70 SC + spinetoram 11.7 SC + spinosad 45 SC	3.40 (1.97)	1.68 (1.48)	2.66 (1.77)	1.78 (1.51)	1.38 (1.37)	1.75 (1.50)	1.85 (1.53)
T_3	Dimethoate 30 SC + chlorantraniliprole 18.50 SC + profenophos 50 EC	3.50 (2.00)	2.80 (1.80)	3.55 (2.01)	1.51 (1.42)	1.97 (1.56)	2.94 (1.85)	2.55 (1.74)
T_4	Spinosad 45 SC + broflanilide 300 G/L SC + Flubendamide 20 WG	3.40 (1.97)	2.96 (1.86)	2.20 (1.68)	1.85 (1.53)	1.54 (1.58)	1.59 (1.49)	2.02 (1.58)
T_5	Lambda-cyhalothrin 5 SC + diafenthiuron 50 WP + emamectin benzoate 0.5 SG	3.63 (2.02	2.14 (1.69)	1.58 (1.45)	1.70 (1.48)	1.46 (1.40)	1.34 (1.36)	1.64 (1.46)
T_6	Acephate 75 SP + flonicamide 50 WG + novaluron 10 EC	3.43 (1.98)	1.77 (1.51)	1.65 (1.47)	1.90 (1.55)	1.41 (1.38)	1.40 (1.38)	1.66 (1.48)
T_7	Untreated control	3.65 (2.70)	4.60 (2.25)	5.22 (2.39)	5.42 (2.43)	5.78 (2.50)	6.18 (2.58)	5.44 (2.43)
	SE±	NS	0.07	0.06	0.05	0.06	0.05	0.04
	CD 5%		0.21	0.20	0.15	0.16	0.12	0.11
	CV%		7.26	7.108	6.558	7.325	6.496	6.43

*Figures in parentheses are square root transformed values ($\sqrt{x} + 0.5$)
N.S.: Non-significant

Table 3: Evaluation of insecticidal spray schedule against aphid infesting chilli (Pool data)

Tr. No	Treatments	Mean no of thrips /leaf				
		BS	Ist Spray	IInd Spray	III Spray	Pool Mean
T_1	Fipronil 0.5 SC + tolfenpyrad 15 EC + cyantraniliprole 10.50 OD	3.50 (1.98)*	1.89 (1.50)	2.48 (1.72)	0.60 (1.04)	1.65 (1.46)
T_2	Imidacloprid 70 SC + spinetoram 11.7 SC + spinosad 45 SC	3.40 (1.97)	1.93 (1.60)	2.56 (1.74)	1.47 (1.40)	1.98 (1.57)
T_3	Dimethoate 30 SC + chlorantraniliprole 18.50 SC + profenophos 50 EC	3.50 (2.00)	1.99 (1.62)	2.66 (1.77)	0.80 (1.14)	1.81 (1.53)
T_4	Spinosad 45 SC + broflanilide 300 G/L SC + Flubendamide 20 WG	3.40 (1.97)	2.06 (1.64)	1.65 (1.47)	1.59 (1.44)	1.76 (1.50)
T_5	Lambda-cyhalothrin 5 SC + diafenthiuron 50 WP + emamectin benzoate 0.5 SG	3.63 (2.02	2.02 (1.59)	1.62 (1.46)	0.68 (1.08)	1.44 (1.38)
T_6	Acephate 75 SP + flonicamide 50 WG + novaluron 10 EC	3.43 (1.98)	1.94 (1.56)	1.59 (1.45)	1.65 (1.46)	1.70 (1.48)
T_7	Untreated control	3.65 (2.70)	5.77 (2.50)	6.22 (2.59)	5.15 (2.37)	5.71 (2.49)
	SE±	NS	0.03	0.05	0.11	0.03
	CD 5%		0.1	0.15	0.34	0.11
	CV%		6.947	7.101	8.76	6.76

*Figures in parentheses are square root transformed values ($\sqrt{x} + 0.5$)
N.S.: Non-significant

Table 4: Evaluation of insecticides spray schedule against mite infesting chilli (Pool data)

Tr. No	Treatments	Mean no of mite/leaf				
		BS	Ist Spray	IInd Spray	IIIrd Spray	Pooled Mean
T_1	Fipronil 0.5 SC + tolfenpyrad 15 EC + cyantraniliprole 10.50 OD	1.97 (1.56)	1.18 (1.29)	2.01 (1.58)	0.95 (1.20)	1.38 (1.37)
T_2	Imidacloprid 70 SC + spinetoram 11.7 SC + spinosad 45 SC	2.47 (1.53)*	2.16 (1.63)	2.22 (1.65)	2.24 (1.65)	2.20 (1.64)
T_3	Dimethoate 30 SC + chlorantraniliprole 18.50 SC + profenophos 50 EC	2.87 (1.83)	2.06 (1.60)	1.83 (1.54)	1.52 (1.38)	1.80 (1.51)
T_4	Spinosad 45 SC + broflanilide 300 G/L SC + Flubendamide 20 WG	2.60 (1.58)	2.40 (1.70)	2.23 (1.66)	2.10 (1.61)	2.24 (1.67)
T_5	Lambda-cyhalothrin 5 SC + diafenthiuron 50 WP + emamectin benzoate 0.5 SG	1.83 (1.52)	1.54 (1.43)	1.46 (1.41)	1.72 (1.50)	1.57 (1.45)
T_6	Acephate 75 SP + flonicamide 50 WG + novaluron 10 EC	2.93 (1.56)	2.31 (1.67)	1.55 (1.43)	2.28 (1.67)	2.04 (1.59)
T_7	Untreated control	3.97 (2.11)	4.70 (2.28)	5.07 (2.35)	5.20 (2.38)	4.99 (2.34)
	SE±	NS	0.09	0.04	0.03	0.05
	CD 5%		0.28	0.12	0.11	0.15
	CV%		7.02	7.27	6.93	6.32

*Figures in parentheses are square root transformed values ($\sqrt{x} + 0.5$)
N.S.: Non-significant

Table 5: Biosafety of insecticidal spray schedule to ladybird beetles on chilli (pooled data)

Tr. No	Treatments	Mean no. of LBB/plant				
		1 DBS	Ist Spray	IInd Spray	IIIrd Spray	Pooled mean
T_1	Fipronil 0.5 SC + tolfenpyrad 15 EC + cyantraniliprole 10.50 OD	3.10 (1.90)*	2.68 (1.78)	2.45 (1.72)	1.97 (1.57)	2.36 (1.71)
T_2	Imidacloprid 70 SC + spinetoram 11.7 SC + spinosad 45 SC	3.17 (1.91)	2.38 (1.70)	3.18 (1.92)	2.08 (1.61)	2.54 (1.74)
T_3	Dimethoate 30 SC + chlorantraniliprole 18.50 SC + profenophos 50 EC	3.00 (1.86)	2.57 (1.75)	3.25 (1.94)	1.07 (1.25)	2.29 (1.67)
T_4	Spinosad 45 SC + broflanilide 300 G/L SC + Flubendamide 20 WG	3.10 (1.89)	3.15 (1.91)	2.37 (1.69)	1.53 (1.43)	2.35 (1.68)
T_5	Lambda-cyhalothrin 5 SC + diafenthiuron 50 WP + emamectin benzoate 0.5 SG	3.03 (1.87)	2.60 (1.76)	2.47 (1.72)	1.20 (1.30)	2.09 (1.60)
T_6	Acephate 75 SP + flonicamide 50 WG + novaluron 10 EC	3.17 (1.91)	2.85 (1.83)	2.55 (1.75)	1.73 (1.49)	2.37 (1.69)
T_7	Untreated control	3.20 (1.92)	3.97 (2.11)	4.63 (2.27)	4.30 (1.94)	4.23 (2.17)
	SE±	NS	0.1	0.13	0.13	0.06
	CD 5%		0.32	0.36	0.40	0.18
	CV%		7.38	8.95	8.73	8.73

*Figures in parentheses are square root transformed values ($\sqrt{x} + 0.5$)
N.S.: Non-significant

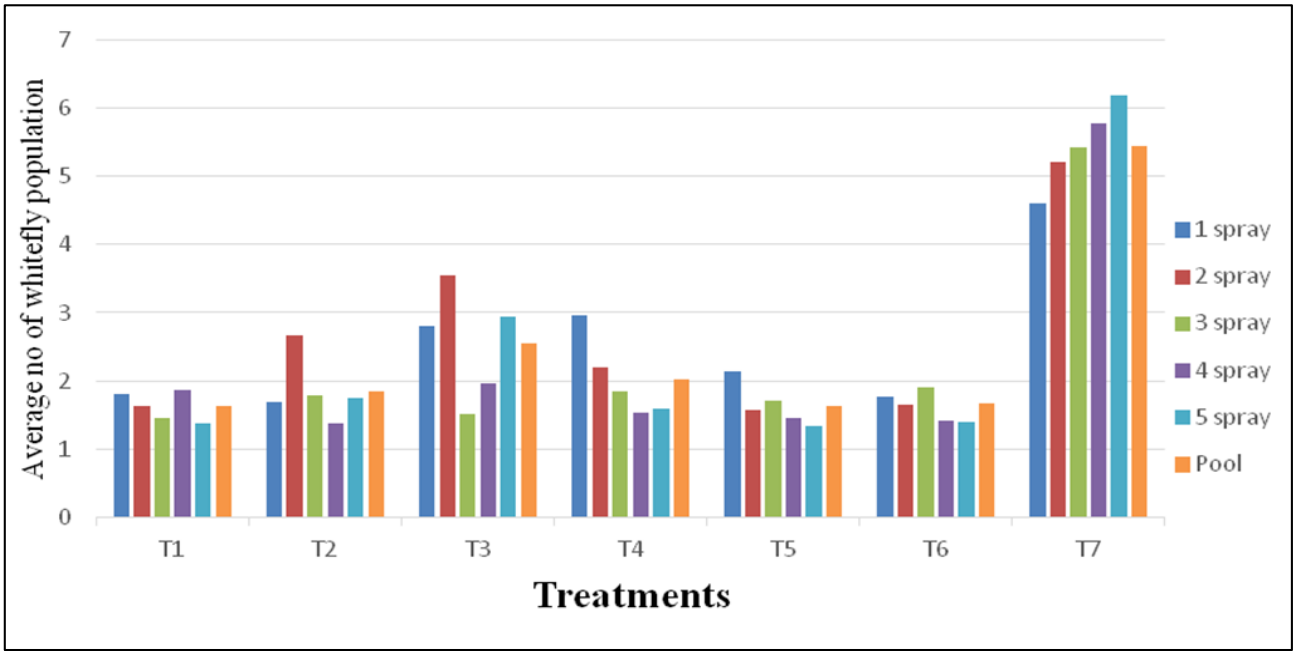

Fig 1: Evaluation of insecticidal spray schedule against whitefly infesting chilli

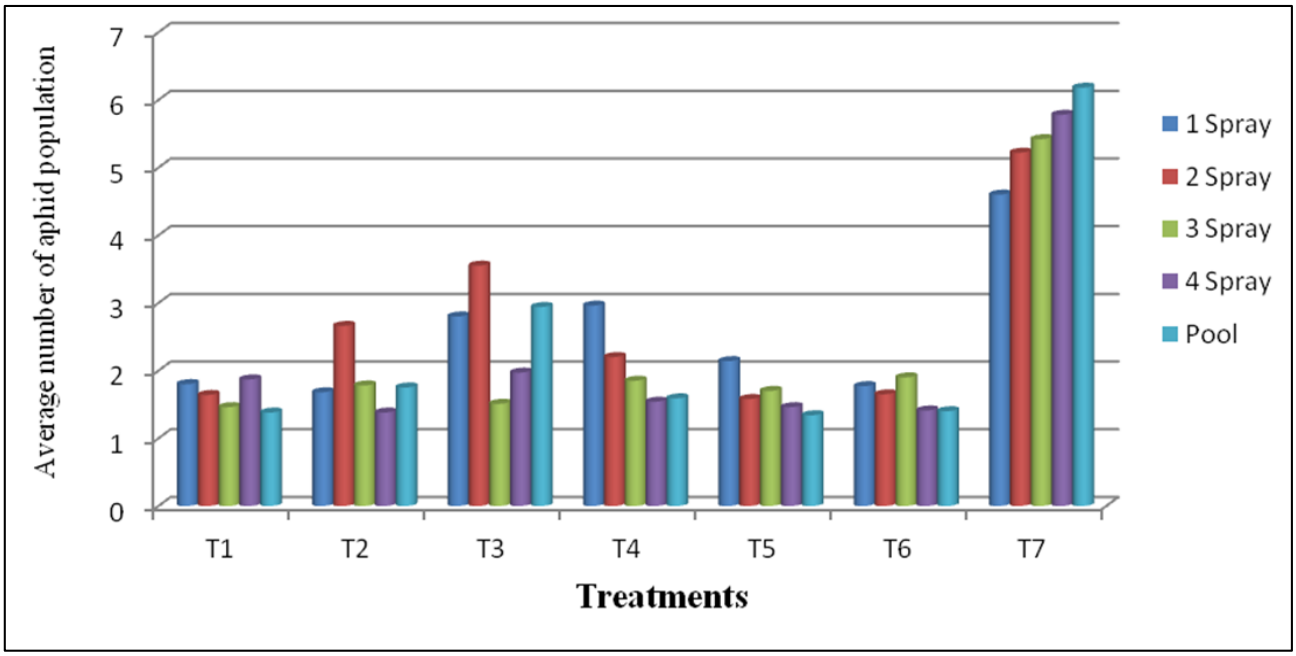

Fig 2: Evaluation of Insecticides spray schedule against aphid infesting in chilli

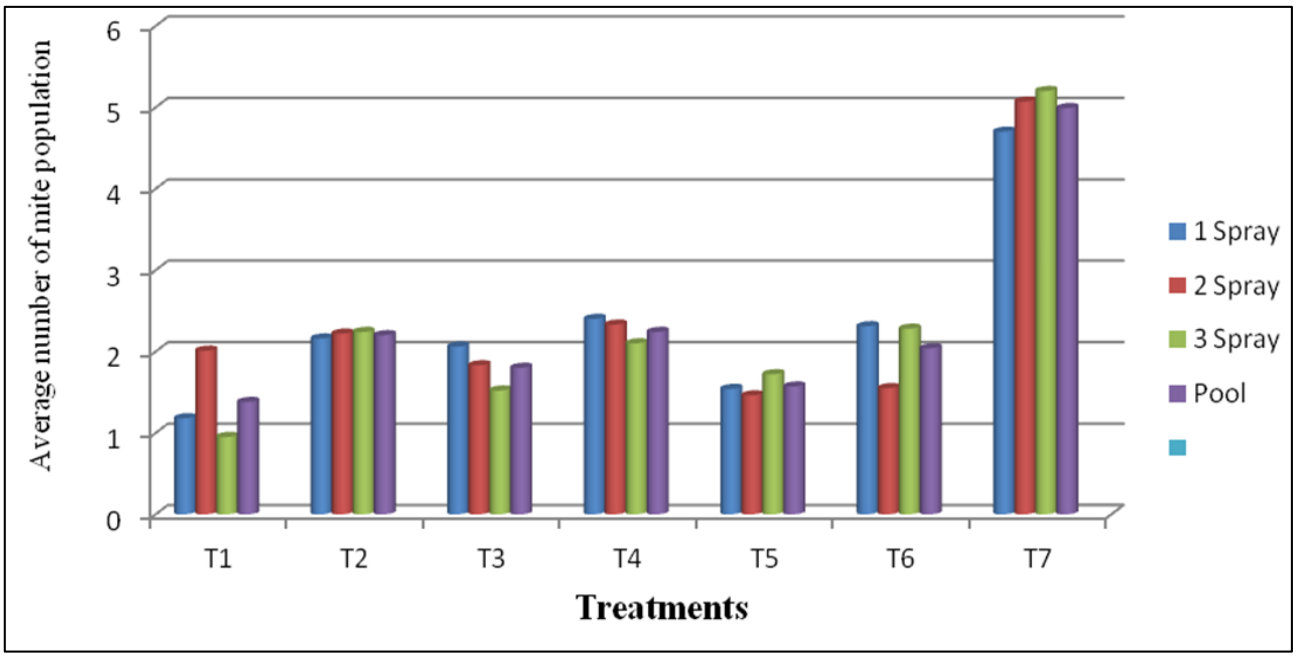

Fig 3: Evaluation of insecticidal spray schedule against mite infesting chilli

Conclusion

The present study indicated the significance of all the insecticides spray schedule as they were found to be significantly superior in recording minimum number of aphid, whitefly, mite over untreated control. The results indicated that among different treatment schedule of insecticides consisting spraying of fipronil 0.5 SC + tolfenpyrad 15 EC + cyantraniliprole 10.50 OD was found most effective sprays schedules was at par with lambda-cyhalothrin 5 SC + diafenthiuron 50 WP + emamectin benzoate 0.5 SG and followed by spinosad 45 SC + broflanilide 300 G/L SC + flubendamide 20 WG.

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