Journal of Crop and Weed, 18(2): 253-258 (2022)
ISSN- O : 2349 9400 ; P : 0974 6315
http://cwssbckv.org
www.cropandweed.com

Efficacy of some promising neonicotinoids against *Scirtothrips dorsalis* Hood infesting chilli, their impact on the important natural enemies and economic benefits in West Bengal

[*]P. RAI AND [1]P. K. SARKAR

College of Agriculture (extended campus of B.C.K.V.), Susunia, Bankura, West Bengal, 722 132
[1]Department of Agricultural Entomology, B.C.K.V, Mohanpur, Nadia

Received : 29.04.2022 ; Revised : 06.07.2022 ; Accepted : 18.07.2022

DOI: https://doi.org/10.22271/09746315.2022.v18.i2.1597

ABSTRACT

Six neonicotinoid chemicals were evaluated for their bioefficacy against Scirtothrips dorsalis Hood infesting chilli in West Bengal. It was evident that all the treatments of neonicotinoids except dinotefuran 20 SG, performed significantly better than the standard check, acephate 75 SP. Acetamiprid 20 SP *emerged to be the most effective treatment recording highest reduction in thrips population* (90.31%) *and per cent increase in yield* (63.48%). *The remaining neonicotinoid chemicals provided satisfactory reduction in the thrips population ranging between 75.53 to 85.97% as compared to 77.68% in acephate 75 SP. Acephate 75 SP recorded a mere 14.54 percent increase in yield as compared to 30.83 to 56.55 percent in the remaining neonicotinoids evaluated. Acetamiprid 20 SP was observed to be the safest treatment against important natural enemies in the chilli ecosystem closely followed by thiamethoxam 25 WG and imidaloprid 17.8 SL while acephate 75 SP was the most toxic treatment. Acetamiprid 20 SP registered the highest yield (18.98 tons ha^{-1}) and CBR (1:89.97) followed by thiamethoxam 25 WG and imidaloprid 17.8 SL whereas the lowest yield (8.11 tons ha^{-1}) and CBR (1: 1.32) was registered in acephate 75 SP.*

***Keywords*:** Chilli, neonicotinoid, coccinellid beetles, spiders, *Scirtothrips dorsalis* Hood, CBR

Scirtothrips dorsalis is a polyphagous native pest of the Indian subcontinent which reportedly infests more than 100 crops belonging to 40 distinct plant families (Mound and Palmer, 1981). During early 1900s, the first report of crop infestation by *Scirtothrips dorsalis* in India came from the tea plantations of Toklai, Assam (Dev, 1964). However, the pest was found infesting a variety of crops including chilli, cotton, brinjal, groundnut, *etc* in Coimbatore, Tamil Nadu in the southern part of India by 1916 (Ramakrishna Ayyar, 1932; Ramakrishna Ayyar and Subbiah, 1935). Presently, it has attained the status of key pest of chilli cultivation in India considering the sharp decline in chilli yield associated with leaf curl virus disease vectored by them (Mondal and Mondal, 2012). *Scirtothrips dorsalis*, together with *Polyphagotarsonemus latus* is reported to cause heavy economic loss to chilli farmers in three different agro-climatic zones in southern West Bengal (Sarkar *et al.*, 2008; Rai and Sarkar, 2021).

The era of neonicotinoid insecticide started with the discovery of imidacloprid in 1991 which was followed by thiamethoxam and clothianidin (Maienfisch *et al.*, 2001a; Meredith *et al.,* 2002; Tomizawa and Casida, 2011). These chemicals have a novel mode of action, lower application rates, safety to non-target organisms and are very effective against insect pests with suctorial mouthparts. They are systemic poison which are absorbed by the roots or leaves and are translocated within the plant, ultimately manifesting its toxicity to insects that feed on these plants (Simon-Delso *et al.*, 2015). Therefore, they exhibit safer toxicity profile against ambient natural enemies in the agro-ecosystem. However, few neonicotinoids have been reported to have adverse effect on the biology of important pollinator, especially Honey bees which visits the flowers for foraging of nectar and pollen. The neonicotinoid insecticides are nerve poisons which act as nicotinic Acetyl Choline Receptor (nAChRs) agonists in insects. However, the inhibitory effect of neonicotinoids on nAChRs of mammal is much lower as compared to insects and is therefore relatively safe to humans (Houchat *et al.*, 2020).

MATERIALS AND METHODS

The experiment was conducted at A/B block farm, BCKV, Kalyani, West Bengal during *rabi* seasons of 2014 and 2015 using Randomized Block Design with eight treatments which were replicated thrice. Thirty (30) days old healthy chilli seedlings ('Bullet' variety) were transplanted in 20 m^2 plot size maintaining a spacing of 75 x 45 cm. The standard set of agronomic practices for cultivation of chilli were strictly followed in the field for raising a healthy crop. A total of 48 plants were maintained in each plot, out of which 5 plants were selected randomly and tagged for recording the pest population. The first round of treatment were imposed when the population of *Scirtothrips dorsalis* crossed the

Email: pranayraibckv@gmail.com

Economic Threshold Level (ETL) in the field. Two rounds of treatment were imposed at an interval of fifteen days using 500 litres of spray fluid per hectare employing a battery operated automatic Knapsack sprayer (Aspee) with a tank capacity of 16 litres. The observations on pest population were taken a day before treatment followed by 3, 7 and 10 days after treatment application whereas that for the natural enemies were done at 14 days after treatment. The active nymphs and adults of thrips were counted in situ from three apical leaves of five plants in each plot using 10 X hand lens. The percent reduction in pest population was calculated as per formula given by Henderson and Tilton (1955) as:

$$\text{Percent reduction} = 1-\left\{\frac{(Ta*Cb}{Tb*Ca}\right\}*100$$

The necessary statistical transformations of the raw data were done prior to analysis of variance. The following set of treatments were imposed in the experimental field –

Treatment number	Treatment	Trade name	Dosage (g a.i. ha^{-1})
T_1	Acetamiprid 20 SP	Pride	20
T_2	Clothianidin 50 WDG	Dantop	20
T_3	Dinotefuran 20 SG	Token	60
T_4	Thiamethoxam 25 WG	Actara	50
T_5	Thiachloprid 21.7 SC	Alanto	60
T_6	Imidacloprid 17.8 SL	Confidor	20
T_7	Acephate 75 SP	Starthene	750
T_8	Untreated control	-	-

For calculating the incremental cost benefit ratio, the marketable yield of chilli obtained in each treatment was converted into tons hectare^{-1}. The total return obtained in each treatment was calculated by multiplying the total yield by the existing market price of chilli. The total cost for each treatment includes the cost of respective insecticide procurement plus the operational charges incurred for two round of treatment application. The net benefit was calculated by subtracting the total cost from total return whereas the benefit over control for each treatment was calculated by subtracting the net benefit in untreated control form net benefit of the respective treatment. Finally, the incremental cost: benefit ratio (CBR) for each treatment was calculated by dividing the benefit over control by the total cost incurred in each treatment.

RESULTS AND DISCUSSION

a) Relative efficacy of different neonicotinoids against chilli thrips

Table 1 represents the relative efficacy of different neonicotinoids against *Scirtothrips dorsalis* Hood. The results suggest that all the treatments of neonicotinoid except dinotefuran 20 SG, performed significantly better than the standard check, acephate 75 SP. The pre-treatment count of thrips during the first season varied between 3.45 and 4.27 per leaf. The highest per cent reduction in thrips population was recorded in acetamiprid (93.54%) followed by thiamethoxam (90.06%), imidacloprid (88.09%) and Clothianidin (82.35%). Plots treated with thiacloprid recorded 79.67 per cent reduction in thrips population and was at par with acephate (79.08%) while dinotefuran was observed to be the most inferior treatment against *Scirtothrips dorsalis* Hood with 76.01 per cent reduction in population.

During the second season, similar trend in bio-efficacy was observed where acetamiprid proved to be the best treatment recording 87.08 per cent reduction in thrips population followed by imidacloprid (83.85%) and thiamethoxam (81.33%). Here also, the lowest per cent reduction in thrips population was recorded in dinotefuran (75.05%) followed by acephate (76.29%) and thiacloprid (77.63%).

The findings of this research was in conformity with the findings of Agale *et al.* (2010); Varghese and Mathew (2013) who reported that acetamiprid and thiamethoxam were the most effective molecule in managing the population of chilli thrips and subsequently increasing the yield. Further, Bambhaniya *et al.* (2018) and Jadhao *et al.* (2019) reported that dinotefuran exhibited lower efficacy against *Scirtothrips dorsalis* in comparison to imidacloprid, thiacloprid, acetamiprid and thiamethoxam. However, contrasting results were reported by Nayak *et al.* (2014); Manyam and Byadgi (2013); Prabhu *et al.* (2014); Kaur and Singh (2013) who concluded that imidacloprid performed much better than acetamiprid and thiamethoxam recording the lowest thrips population while Sreenivas *et al.* (2015) reported the superiority of dinotefuran over imidacloprid and thiamethoxam in managing thrips population.

b) Efficacy of different neonicotinoids against important natural enemies

The impact of different treatments of neonicotinoid on the important natural enemies found in the agro-ecosystem has been depicted in table 2. The lowest reduction in the number of predatory coccinellid beetles was recorded in acetamiprid (3.57%) and thiamethoxam (3.91), both of which were found statistically at par. The remaining treatments of neonicotinoids recorded 6.86 to 17.40 per cent reduction in coccinellid population. In the case of predatory spiders, thiamethoxam can be adjudged the safest treatment considering the lowest reduction in their population (8.83%), closely followed by acetamiprid (9.50%). All the other neonicotinoids collectively caused 12.41 to 25.49 per cent population reduction of spiders in the field.

Similar conclusions were also given by Sabry *et al.* (2014), Zala *et al.* (2015) and Rana *et al.* (2016), who

Table 1: Relative efficacy of some promising neonicotinoids against *Scirtothrips dorsalis* Hood at Kalyani, Nadia, West Bengal

Treatment	Doseg a.i. ha^{-1}	First season PT (no. of thrips/leaf)	First season % reduction (-)/ increase(+) in population of *Scirtothrips dorsalis* Hood at 3DAS*	7DAS*	10DAS*	Mean	Second season PT (no. of thrips/leaf)	Second season % reduction (-)/ increase(+) in population of *Scirtothrips dorsalis* Hood at 3DAS*	7DAS*	10DAS*	Mean	Pooled Mean
acetamiprid 20 SP	20	3.45	96.68 (79.50)	94.01 (75.83)	89.93 (71.49)	93.54	3.62	90.14 (71.69)	88.00 (69.73)	83.12 (65.74)	87.08	90.31
clothianidin 50 WDG	20	4.16	87.95 (69.68)	82.99 (65.64)	76.11 (60.73)	82.35	3.51	82.10 (64.97)	79.05 (62.76)	76.90 (61.27)	79.35	80.85
dinotefuran 20 SG	60	3.55	87.94 (69.67)	75.87 (60.57)	64.24 (53.27)	76.01	3.26	78.59 (62.43)	76.33 (60.88)	70.23 (56.93)	75.05	75.53
thiamethoxam 25 WG	50	4.27	93.13 (74.80)	90.14 (71.69)	86.92 (68.79)	90.06	3.22	83.98 (66.40)	80.95 (64.12)	79.08 (62.78)	81.33	85.70
thiacloprid 21.7 SC	60	3.87	85.98 (68.01)	80.02 (63.44)	73.01 (58.70)	79.67	3.63	80.01 (63.44)	77.48 (61.66)	75.40 (60.26)	77.63	78.65
imidacloprid 17.8 SL	20	4.08	91.87 (73.43)	88.65 (70.31)	83.75 (66.22)	88.09	3.00	86.71 (68.61)	83.12 (65.74)	81.72 (64.68)	83.85	85.97
acephate 75 SP	750	3.80	86.21 (68.20)	80.76 (63.98)	70.28 (56.96)	79.08	3.40	80.22 (63.59)	76.86 (61.24)	71.79 (57.91)	76.29	77.68
Untreated Control	-	4.03	+7.86 (0.00)	+10.96 (0.00)	+14.62 (0.00)	+11.14	3.47	+4.01 (0.00)	+8.19 (0.00)	+9.96 (0.00)	+7.38	+9.26
LSD(0.05)	**NS**	**4.26**	**5.31**	**3.12**	**-**	**NS**	**3.26**	**3.20**	**3.50**	**-**	**-**	
SEm (±)	**-**	**1.44**	**1.76**	**1.04**	**-**	**-**	**1.13**	**1.08**	**1.22**	**-**	**-**	

**** Figures in parenthesis indicate angular transformed values. PT: Pre-treatment count; DAS: Days after spraying***

Table 2: Impact of some promising neonicotinoids against important natural enemies of *Scirtothrips dorsalis* Hood at Kalyani, Nadia, West Bengal

Treatment	Doseg a.i. ha^{-1}	% reduction (-)/ increase(+) in population of *Coccinellids* at 14 DAS of			% reduction (-)/ increase(+) in population of *Spiders* at 14 DAS of			Pooled yield of green chilli (tons ha^{-1})	Percent increase in yield
		First season	Second season	Mean	First season	Second season	Mean		
acetamiprid 20 SP	20	2.57 (9.22)	4.58 (12.35)	3.57	9.07 (17.52)	9.94 (18.37)	9.50	18.98	63.48
clothianidin 50 WDG	20	16.30 (23.81)	18.50 (25.47)	17.40	23.85 (29.23)	27.13 (31.39)	25.49	10.66	34.99
dinotefuran 20 SG	60	13.04 (21.16)	16.45 (23.92)	14.74	17.58 (24.78)	17.87 (25.00)	17.72	10.02	30.83
thiamethoxam 25 WG	50	2.60 (9.27)	5.22 (13.20)	3.91	6.78 (15.09)	10.88 (19.25)	8.83	15.45	55.14
thiacloprid 21.7 SC	60	13.12 (21.23)	16.06 (23.62)	14.57	17.03 (24.37)	16.85 (24.23)	16.94	11.47	39.58
imidacloprid 17.8 SL	20	6.06 (14.25)	7.66 (16.06)	6.86	10.26 (18.68)	14.57 (22.43)	12.41	15.95	56.55
acephate 75 SP	750	36.62 (37.23)	38.74 (38.49)	37.68	44.81 (42.02)	46.31 (42.88)	45.56	8.11	14.54
Untreated Control	-	+58.63 (0.00)	+36.59 (0.00)	+47.61	+26.21 (0.00)	+43.57 (0.00)	+34.89	6.93 -	
LSD(0.05)		**3.36**	**2.13**	**-**	**6.75**	**3.34**	**-**	**2.78**	**-**
SEm(±)		**1.12**	**0.77**	**-**	**2.25**	**1.10**	**-**	**0.92**	**-**

**** Figures in parenthesis indicate angular transformed values ; DAS: Days after spraying***

Table 3: Economic impact of some promising neonicotinoids against *Scirtothrips dorsalis* Hood infesting chilli at Kalyani, Nadia, West Bengal

Treatment	Cost of insecticide (Rs ha^{-1})	Total cost (Rs ha^{-1})	Yield (tons ha^{-1})	Total return (Rs ha^{-1})	Net benefit (Rs ha^{-1})	Benefit over control (Rs ha^{-1})	C:B ratio (CBR)
acetamiprid 20 SP	300	932	18.98	1,32,860.00	1,31,928.00	83,850.00	1: 89.97
clothianidin 50 WDG	1034	1466	10.66	74,620.00	73,154.00	25,076.00	1: 17.11
dinotefuran 20 SG	2500	2932	10.02	70,140.00	67,208.00	19,130.00	1: 6.52
thiamethoxam 25 WG	330	762	15.45	1,08,150.00	1,07,388.00	59,310.00	1: 77.83
thiacloprid 21.7 SC	2970	3402	11.47	80,290.00	76,888.00	28,810.00	1: 8.47
imidacloprid 17.8 SL	450	882	15.95	1,11,650.00	1,10,768.00	62,690.00	1: 71.08
acephate 75 SP	3320	3752	8.11	56,770.00	53,018.00	4,940.00	1: 1.32
Untreated Control	-	432	6.93	48,510.00	48,078.00	-	-

Market price of chilli @ Rs. 7/kg; Labour charges @ Rs. 216/day

reported that neonicotinoids like acetamiprid, thiamethoxam and imidacloprid was relatively safer to predators in the agricultural field such as coccinellid beetles and spiders. However, acephate 75 SP was found to be most toxic treatment contributing to the highest reduction in the population of predatory coccinellid beetles (37.68) as well as beneficial spiders (45.56) among all the treatments.

c) Impact of different neonicotinoids on the yield of chilli

The impact of different treatments of neonicotinoid on the yield of chilli has been depicted in Table 2. It is evident that, the highest yield of marketable chilli fruits were obtained in plots treated with acetamiprid (18.98 tons ha^{-1}) followed by imidacloprid (15.95 tons ha^{-1}) and thiamethoxam (15.45 tons ha^{-1}). The untreated control plots produced lowest yield of chilli fruits (6.93 tons ha^{-1}) which was followed by acephate (8.11 tons ha^{-1}) and dinotefuran (10.02 tons ha^{-1}).

The findings of the experiment is supported by the work of Bambhaniya *et al.* (2018) who reported that the lowest yield of chilli was recorded in dinotefuran treatments whereas highest yield was recorded in plots treated with imidacloprid followed by clothianidin and acetamiprid. However, low yield in plots treated with acephate, a contact and stomach poison may be attributed to its higher toxicity against the natural enemies and pollinators found in agro ecosystem. The experimental finding has a close similarity with the conclusions drawn by Sathua *et al.* (2017) stating that acephate recorded lower yield of chilli fruits despite registering higher efficacy amounting to 80.86% against chilli thrips.

c) Economic impact of different neonicotinoids against *Scirtothrips dorsalis* infesting chilli

Table number 3 represents the economic impact of different treatments against thrips infesting chilli. In terms of economic benefit, acetamiprid 20 SP was observed to be the best treatment which registered the highest CBR (1: 89.97). The following best treatment in line was thiamethoxam 25 WG which recorded higher CBR (1:77.83) as compared to imidacloprid (1:71.08), despite recording lower yield than imidacloprid. The lowest CBR was recorded in acephate 75 SP (1:1.32) followed by dinotefuran 20 SG (1:6.52), thiacloprid 21.7 SC (1:8.47) and clothianidin 50 WDG (1:17.11).

Similar research findings has been reported by Sathua *et al.* (2017) and Bambhaniya *et al.* (2018) who concluded that highest CBR was registered in treatments with imidacloprid and acetamiprid while acephate recorded the lowest CBR.

CONCLUSION

All the neonicotinoid chemicals evaluated were found to be effective in managing the population of *Scirtothrips dorsalis* Hood infesting chilli. The efficacy of different neonicotinoids in the descending order were recorded as acetamiprid 20 SP > imidacloprid 17.8 SL > thiamethoxam 25 WG > clothianidin 50 WDG > thiacloprid 21.7 SC > dinotefuran 20 SG.

REFERENCES

Agale, D. A., Yadav, G. A., Bhosle, B. B. and Bhede, B. V. 2010. Bioefficacy and economics of insecticides against thrips (*Scritothrips dorsalis* Hood) on Bt cotton. *Indian j. entomol.*, **72** (1): 29-32

Bambhaniya, V. S., Khanpara, A. V. and Patel, H. N. 2018. Bio-Efficacy of insecticides against sucking pests; Jassid and Thrips infesting tomato. *J. pharmacogn. phytochem.*, **7** (3): 1471-1479

Dev, H. N. 1964. Preliminary studies on the biology of Assam thrips, *Scirtothrips dorsalis* Hood on tea. *Indian j. entomol.*, **26** (00): 184-194

Henderson, C.F. and Tilton, E. W. 1955. Tests with acaricides against the brow wheat mite. *J. Econ. Entomol.*, **48**:157-161.

Houchat, J. N., Cartereau, A., Mauff, A. L., Taillebois, E. and Thany, S. H. 2020. An Overview on the effect of neonicotinoid insecticides on mammalian cholinergic functions through the activation of neuronal Nicotinic Acetylcholine Receptors. *Int. J. Environ. Res. Public Health*, **17**, 3222; doi:10.3390/ijerph17093222

Jadhao P. B., Kadam D. R., Jadhav R. D. and Kangale, G. K. 2019. Efficacy of insecticides against pomegranate thrips, *Scirtothrips dorsalis* (HOOD). *Indian j. entomol.*, **81** (2): 286-290

Kaur, S. and Singh, S. 2013. Efficacy of some insecticide and botanicals against sucking pest on capsicum under net house. *Agron Sustain Dev*, **1**: 39-44

Maienfisch, P., Angst, M., Brandl, F., Fischer, W., Hofer, D., Kayser, H., Kobel, W., Rindlisbacher, A., Senn, R., Steinemann, A. and Withmer, H. 2001a. Chemistry and biology of thiamethoxam: a second generation neonicotinoid. *Pest Manag. Sci.*, **57**: 906–913

Manyam, P. and Byadgi, A. S. 2013. Status of chilli murda disease in northern Karnataka and its management. *Biosci. Trends*, **6** (6): 784 -788

Meredith, R.H., Heatherington, P.J. and Morris, D.B. 2002. Clothianidin- a new chloronicotinyl seed treatment for use on sugar beet and cereals: field trial experiences from Northern Europe. Proceedings of an international conference held at the Brighton Hilton Metropole Hotel, Brighton, UK, 18-21 November 2002. *British Crop Protection Council Conference: Pests and diseases*, Volumes 1 and 2. pp. 691-696

Mondal, B. and Mondal, P. 2012. Ecofriendly pest management practices for leaf curl complex of chilli (*Capsicum annuum* L.). *J. Biopestic*., **5** :115-118

Mound, L. A. and Palmer, J. M. 1981. Identification, distribution and host plants of the pest species of *Scirtothrips* (*Thysanoptera: Thripidae*). *Bull. Entomol. Res.*, **71**(3): 467-479

Nayak, U.S., Soni, V. K. and Senapati, S. 2014. Comparative efficacy of certain insecticides against thrips (*Scirtothrips dorsalis* H.) and aphids (*Aphis gossypii* G.) on chilli. *J. Plant Prot. Environ.*, **11**(1): 44-48

Prabhu, S.T., Nagaraja, M.V. and Ganapathi, T. 2014. Evaluation of Bio-Efficacy of Imidacloprid 17.8% SL against chilli insect pests. *Biosci. Trends,* **7**: 3331-3334

Rai, P. and Sarkar, P. K. 2021. Survey for the key pests of chilli (*Capsicum annuum* l.) in different agro-climatic zone of West Bengal. *Agri-India TODAY*, **1** (2):14-18

Ramakrishna Ayyar, T. V and Subbiah, M. S. 1935. The leaf curl disease of chilies caused by thrips in the Guntur and Madura tracks. *Madras Agric. J.*, **23**: 403-410.

Ramakrishna Ayyar, T.V. 1932. Bionomics of some thrips injurious to cultivated plants in South India. *Agric. Live-stock India*, **2**: 391-403

Rana, B. S., Ahir, K. C., Sonkamble M. M. and Desai S. D. 2016. Bioefficacy of imidacloprid 350 SC against sucking insect pests in chilli (*Capsicum annum* L.) *j. Appl. Nat. Sci.*, **8** (4): 1815-1820

Sabry, A.H., Hassan, K. A. and Rehman, A. E. 2014. Relative toxicity of some modern insecticides against the pink bollworm, *Pectinophora gossypiella* (saunders) and their residues effects on some natural enemies. *Int. j. Sci. Environ. Technol.*, **3** (2): 481-491.

Sarkar, H., Mahato, S., Somchoudhury, A. K. and Sarkar, P.K.2008.Management of yellow mite, *Polyphagotarsonemus latus* (Banks) (Acari: Tarsonemidae) infesting chilli (*Capsicum annum* L.) in gangetic alluvial plains of West Bengal. *J. Entomol. Res.*, **32** (2): 127-130.

Sathua, S. K., Reddy, M. S., Sulagitti, A. and Singh, R. N. 2017. Bio-efficacy of various insecticides and botanicals against chilli thrips (*S. dorsalis* Hood) and their comparative cost: Benefit analysis in chilli crop. *J. Entomol. Zool. Stud.,* **5** (2): 130-134

Simon-Delso, N., Amaral-Rogers, V., Belzunces, L. P., Bonmatin, J. M., Chagnon, M., Downs, C., Furlan, L., Gibbons, D. W., Giorio, C., Girolami, V., Goulson, D., Kreutzweiser, D. P., Krupke, C. H., Liess, M., Long, E., McField, M., Mineau, P., Mitchell, E. A. D., Morrissey, C. A., Noome, D. A., Pisa, L., Settele, J., Stark, J. D., Tapparo, A., Van Dyck, H., Van Praagh, J., Van der Sluijs, J. P., Whitehorn, P. R. and Wiemers, M. 2015. Systemic insecticides (neonicotinoids and fipronil): trends, uses, mode of action and metabolites. *Environ Sci Pollut Res Int.*, **22**: 5-34

Sreenivas, A.G., Hanchinal, S.G., Nadagoud, S., Bheemanna, M., Naganagoud, A. and Patil, B. N. K. 2015. Management of sucking insect pest complex of Bt cotton by using dinotefuran – a 3rd generation neonicotinoid molecule. *J. Cotton Res. Dev.,* **29** (1): 90-93

Tomizawa, M. and Casida, J.E. 2011. Neonicotinoid insecticides: highlights of a symposium on strategic molecular designs. *J. Agric. Food Chem.*, **59**: 2883-2886

Varghese, T. S. and Mathew, T. B. 2013. Bioefficacy and safety evaluation of newer insecticides and acaricides against chilli thrips and mites. *J. Trop. Agric.*, **51** (1-2): 111-115

Zala, M. B., Nikoshe, A. P. and Bharpoda, T. M. 2015. Relative impact of insecticidal applications on population of natural enemies in okra. *Bioscan*, **10** (3): 955-958