EFFICACY OF COMBI-PRODUCT FIPRONIL 40%+ IMIDACLOPRID 40%WG AGAINST LEAFHOPPER AND THRIPS IN COTTON

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ABSTRACT

The efficacy of lessenta 80 WG (fipronil 40%+ imidacloprid 40%WG) @ 125, 100 and 75 g ai/ ha was evaluated against sucking pests of cotton in comparison with the fipronil 5%SC @ 125 g ai/ ha, imidacloprid 17.8 SL @ 250 g ai/ ha, lambda-cyhalothrin 5%EC @ 600 g ai/ ha and monocrotophos 36%SL @ 437 g ai/ ha at the Agricultural Research Station, Dharwad, Karnataka, India. Fipronil 40%+ imidacloprid 40%WG @ 125 g ai/ ha recorded significantly minimum (8.25 and 3.01) *Thrips tabaci* (Lindeman) (Thysanoptera: Thripidae) and *Amrasca biguttula biguttula* (Ishida) (Hemiptera: Cicadellidae) incidence, respectively followed by lessenta 80 WG @ 100 g ai/ ha (8.68 and 3.42, respectivey) and fipronil 40%+ imidacloprid 40%WG @ 75 g ai/ ha (9.55 and 3.98, respectively). Further, significantly highest seed cotton yield of 13.99 q/ha, 13.58 q/ha and 12.86 q/ha, respectively were harvested from the fipronil 40%+ imidacloprid 40%WG treatments proving them better choice in effective management of both *A. biguttula biguttula* and *T. tabaci* incidence.

Key words: Lessenta, fipronil, imidacloprid, sucking pests, *Thrips tabaci*, *Amrasca biguttula biguttula*, natural enemies, cotton, combi-product, leafhopper, coccinellids, chrysopids.

Cotton (*Gossypium* spp.) has more than 200 genera and about 2300 species. It belongs to family Malvaceae. There are more than 50 species under genus *Gossypium* reported till now, which are native to Africa, Australia, Central and South America and Asia (Fryxell 1992; Wendel and Grover 2015). Only four species are widespread and used for commercial cultivation- two diploid (2n = 26) species, namely *Gossypium arboreum* and *Gossypium herbaceum* belong to old world cotton and two tetraploid (2n = 52) species, namely *Gossypium barbadense* and *Gossypium hirsutum* belong to new world cotton (Lu et al., 1997). India occupy largest cotton acreage (13.373 mha) and production (36.5 m bales, 1 bale=170 kg) in the world (CICR, 2020). Though, India shares largest area under cotton, however Indian cotton productivity is lowest (464 kg lint/ ha) due to variety of reasons, among them damage due to various arthropod pests is one of the major yield limiting factors (Nagrare et al., 2022). The low yields (up to 35–40%) are mainly attributable to insect pests. Presently the cotton crop in India is attacked by 251 arthropod pest species (including insect and mites) belonging to 9 different insect orders and one order from Acarina. Among these species, about 12 species of insects are major pests during last two decades causing overall losses to the tune of 20-60% to cotton crop while remaining species are occasional, sporadic or minor in nature (Nagrare et al., 2022). Sap feeders *viz.,* leafhopper, *Amrasca biguttula biguttula* and thrips, *Thrips tabaci* Linnaeus damage the cotton crop with regular occurrence at different growth stages, reducing the growth and yield (Bheemanna et al., 2015, Nagrare et al., 2022). The damage inflicted by insect pests has been considered important; leafhoppers are undoubtedly more severe among the many destructive sucking pests of cotton. The estimated loss due to sucking pests is up to 21.20% (Dhawan et al., 1988). The nymphs and adults suck the plant sap mainly from the lower surface of leaves and cause phytotoxic symptoms known as hopper burn which results in complete desiccation and has become one of the limiting factors in economic productivity of the crop. The introduction of synthetic pyrethroids, though brought desirable control of bollworms, resulted in resurgence of sucking pests have also been reported in cotton system due to excessive use of synthetic pyrethroids (Ajri et al., 1986; Patel et al., 1986). Imidaclopride, a neonicotinoid known for its efficacy against sucking pests (Giraddi et al., 2017) and fipronil belongs to a new class of insecticides fiproles and was found to be efficient compared to pyrethroid, OP and carbomate insecticides (Patil and Rajanikanth, 2004). Fipronil and imidacloprid are the two ingredients in the combi product, Lessenta 80 WG having different mode of action is evaluated for its bio-efficacy against sucking pests of cotton i.e., leafhoppers, *A. biguttula biguttula* and *T. tabaci*.

MATERIALS AND METHODS

Field study was under taken at the Agricultural Research Station, Dharwad farm, Dharwad (15.4889° N, 74.9813° E) during kharif, 2017-18 and 2019-20 to evaluate bio-efficacy of Lessenta 80 WG (fipronil 40%+ imidacloprid 40%WG**)** against sucking pests of cotton. The experiment was laid out in randomized block design (RBD) with 8 treatments (T_1 - Control; T_2 - (Fipronil 40%+ Imidacloprid 40%WG) @ 75 g ai/ ha; T_3 - (fipronil 40%+ imidacloprid 40%WG) @ 100 g ai/ ha; T_4 - (fipronil 40%+ imidacloprid 40%WG) @ 125 g ai/ ha; T_5 - fipronil 5 %SC @ 125 g ai/ ha; T_6 - Imidacloprid 17.8%SL @ 250 g ai/ ha; T_7 - lamda-cyhalothrin 5%EC @ 600 g ai/ ha and T_8 - monocrotophos 36%SL @ 437 g ai/ ha) replicated thrice. Cotton Hybrid "SP 911" which is susceptible for sucking pest attack was selected for the study. The cotton seeds were dibbled manually in experimental field, with a plot of 5 x 5 sq. m for each treatment and 30 x 10 cm spacing was maintained. All agronomic practices with recommended dose of fertilizers were followed to maintain good plant stand till the harvest of crop and harvesting was done manually. The treatments were imposed as and when sucking pests crossed ETL viz., 2 nymphs of *Amrasca biguttula biguttula*, or 10 nymphs/adults of *T. tabaci* per leaf. At an interval of 15 days, two sprays of insecticides were sprayed.

The incidence of sucking pests viz., *T. tabaci* and *A. biguttula biguttula* were recorded from randomly selected five plants per plot. Observations were recorded one day before spray (DBS) and at 1st, 3rd, 5th, 7th and 10th days after spray (DAS). Later, the mean of all the data of the pest incidence after spray was calculated. Observations of the mean of first sprays of both the seasons were averaged to get the pooled mean of both the seasons. Similarly, it was followed for the second spray and the mean of first and second sprays of both the seasons. Further, seed cotton was harvested from each treatment and finally expressed yield in q/ha. Observations were subjected to RBD ANOVA single factor statistical analysis using OPSTAT software to assess the impact of a combi product on pest incidence. Reduction of pest incidence in the treatments over untreated check was also calculated.

RESULTS AND DISCUSSION

A day before the execution of treatment for both the sprays, incidence of sucking pest was relatively uniform and above the Economic Threshold Level (ETL) in both the seasons during the vegetative stage of the crop (Table 1). Though the data is recorded a day before spray (DBS) and at 1st, 3rd, 5th, 7th and 10th days after spray (DAS) for two sprays during two seasons, only the pooled mean data was used. Pooled mean after the first and second spray of the two seasons (2017-18 and 2019-20), showed that the incidence of *T. tabaci* and *A. biguttula biguttula* reduced considerably and registered 8.25 and 3.01 per three leaves, respectively in the plots sprayed with combi-product, lessenta 80 WG (fipronil 40%+ imidacloprid 40%WG) @ 125 g ai/ ha followed by fipronil 40%+ imidacloprid 40%WG @ 100 g ai/ ha (8.68 and 3.42/ 3 leaves) and fipronil 40%+ imidacloprid 40%WG @ 75g ai/ ha (9.55 and 3.98/ 3 leaves). Among the other treatments, fipronil 5 %SC @ 125 g ai/ ha (11.42 and 6.47/ 3 leaves) recorded minimum *T. tabaci* and *A. biguttula biguttula* incidence, respectively. Per cent reduction of *T. tabaci* and *A. biguttula biguttula* incidence was higher in the combi-product treatment, fipronil 40%+ imidacloprid 40%WG @ 125 g a.i/ ha (74.56% and 70.94%, respectively) followed by fipronil 40%+ imidacloprid 40%WG @ 100 g ai/ ha (73.23% and 66.99%, respectively) and fipronil 40%+ imidacloprid 40%WG @ 75g ai/ ha (70.55% and 61.60%, respectively), whereas, Monocrotophos 36%SL @ 437 g ai/ ha recorded lowest % reduction of *T. tabaci* (60.01%) and imidacloprid 17.8%SL recorded lowest % reduction of *A. biguttula biguttula* (33.11%).

The observations in treatments like fipronil 40%+ imidacloprid 40%WG, fipronil 5%SC, imidacloprid 17.8 SL, lambda cyhalothrin 5%EC and Monocrotophos 36%SL were revealed that there was non-significant difference among the treatments (Table 1), and found to be safer towards natural enemies viz*.,* coccinellids and chrysopids (Table 1). A combi product, fipronil 40 +imidacloprid 40%WG proved to be better choice in effective management of both *A. biguttula biguttula* and *T. tabaci* incidence while safer to the natural enemies as they may not have come in direct contact with the insecticide due its systemic action and the toxicant might have lost its lethal effect after its activity in the host. The pooled data (2017-18 and 2019-20) on seed cotton yield obtained from the different treatments of test chemicals was significantly higher compared to untreated control (10.42 q/ ha) (Table 1). The higher

Table 1. Efficacy of fipronil 40%+ imidacloprid 40%WG against *T. tabaci* and *A. biguttula biguttula* in cotton Pooled mean (kharif 2017-18 -I season) and kharif 2019-20 (II Season)

Treatments	Number of *T. tabaci*/ 3 leaves					Number of *A. biguttula biguttula*/ 3 leaves					Number of predators/ 5 plant		seed cotton yield (q/ ha)
	DBS	I spray*	II spray*	Mean**	ROC (%)	DBS	I spray*	II spray*	Mean**	ROC (%)	Coccinellids	Chrysopids	
T_1 - Control	30.52 (5.61)	31.57 (5.71)	33.43 (5.87)	32.43[e] (5.78)	--	10.07 (3.33)	9.82 (3.30)	10.91 (3.45)	10.37[f] (3.37)	--	3.75 (2.06)	1.86 (1.54)	10.42[c]
T_2 -Fipronil 40%+ imidacloprid 40%WG @ 75 g ai/ ha	32.32 (5.77)	10.27 (3.36)	9.05 (3.17)	9.55[b] (3.25)	70.55	10.12 (3.33)	3.94 (2.22)	4.02 (2.24)	3.98[c] (2.23)	61.60	4.50 (2.24)	2.11 (1.62)	12.86[ab]
T_3 -Fipronil 40%+ imidacloprid 40%WG @ 100 g ai/ ha	35.67 (6.05)	9.23 (3.20)	8.41 (3.07)	8.68[a] (3.11)	73.23	10.08 (3.33)	3.47 (2.11)	3.38 (2.09)	3.42[b] (2.10)	66.99	4.50 (2.24)	2.37 (1.69)	13.58[a]
T_4 - Fipronil 40%+ imidacloprid 40%WG @ 125 g ai/ ha	30.75 (5.63)	8.78 (3.13)	7.96 (2.99)	8.25[a] (3.04)	74.56	10.51 (3.39)	3.04 (2.01)	2.99 (2.00)	3.01[a] (2.00)	70.94	5.00 (2.35)	2.24 (1.66)	13.99[a]
T_5 -Fipronil 5 %SC @ 125 g ai/ ha	30.74 (5.63)	11.83 (3.58)	11.22 (3.50)	11.42[c] (3.52)	64.79	10.16 (3.34)	7.00 (2.83)	5.95 (2.64)	6.47[d] (2.73)	37.60	4.75 (2.29)	2.30 (1.67)	11.62[bc]
T_6 -Imidacloprid 17.8%SL) @ 250 g ai/ ha	31.0 (5.66)	12.58 (3.68)	12.36 (3.65)	12.39[d] (3.66)	61.79	10.06 (3.32)	7.46 (2.91)	6.41 (2.72)	6.94[e] (2.82)	33.11	4.00 (2.12)	2.20 (1.64)	11.48[bc]
T_7 - Lamda-cyhalothrin 5%EC @ 600 g ai/ ha	31.95 (5.74)	13.01 (3.74)	12.84 (3.72)	12.78[d] (3.71)	60.59	10.20 (3.35)	7.16 (2.86)	6.08 (2.66)	6.62[de] (2.76)	36.19	4.00 (2.12)	2.37 (1.69)	11.44[bc]
T_8 -Monocrotophos 36%SL @ 437 g ai/ ha	30.75 (5.63)	13.25 (3.77)	13.12 (3.76)	12.97[d] (3.74)	60.01	10.27 (3.36)	7.20 (2.86)	5.97 (2.64)	6.59[de] (2.75)	36.47	4.75 (2.29)	2.13 (1.62)	11.29[bc]
S. Em ±	0.172	0.062	0.047	0.038		0.057	0.038	0.038	0.026		0.296	0.172	0.56
CD (p=0.05)	NS	0.188	0.143	0.116		NS	0.116	0.116	0.080		NS	NS	1.72
CV (%)	15.20	12.82	12.18	17.62		12.97	12.49	12.58	17.45		11.62	13.52	8.14

No. of sprays: Two, Cotton Hybrid: SP911; Figures in parentheses square root transformed values; ROC: Reduction over untreated check; *Pooled mean of 1st , 3rd, 5th, 7th and 10th days after spray of both the seasons; **Mean of after two sprays of both the seasons; NS: Non-significant; DBS: Mean of day before first spray of both the seasons; Means followed by same alphabet in a column do not differ significantly (0.05) by DMRT dose of fipronil 40%+ imidacloprid 40%WG @ 125 g/ ha registered 13.99 q/ ha was statistically comparable with fipronil 40%+ imidacloprid 40%WG @ 100 g/ha (13.58 q/ ha) and fipronil 40%+ imidacloprid 40%WG @ 75 g/ ha (12.86 q/ ha). Fipronil 5 SC @ 125 g/ ha (11.62 q/ha) and imidacloprid 17.8 SL @ 250 ml/ ha (11.48 q/ ha) were next best options (Table 1).

The present findings are inline with the work of Patil et al. (2009) who recorded that fipronil 5%SC @ 800 g/ ha registered least number of *T. tabaci* and *A. biguttula biguttula* (8.47 and 3.45/ 3 leaves, respectively) and significantly highest seed cotton yield of 27.23 q/ ha (2007) and 27.50 q/ ha (2008) was harvested. Similarly, Sathyan et al. (2016) reported that the fipronil 5 SC was the most effective insecticide (3.15/3 leaves) with 83.06% reduction in *T. Tabaci* incidence compared to the mean of untreated check (18.60/ 3 leaves) and Rohini (2010) reported that fipronil 5 SC at 0.01% effective against *T. tabaci* incidence. Fipronil 5%SC recorded least number of *T. tabaci* 3.51 per three leaves in cotton (Zanwar et al*.,* 2012). Singh et al. (2002) and Sinha et al. (2007) reported that fipronil @ 50 g ai/ha at fortnightly interval was found to be the best treatment against the *A. biguttula biguttula*. Among the different tested insecticides, fipronil 5%SC @ 50 g.a.i/ ha has shown 76.7% reduction of *T. tabaci*, followed by fipronil 80%WG@ 50 g.a.i/ ha, acephate 75%SP @ 750 g.a.i/ ha and imidacloprid 70%WG @ 21g.a.i/ ha has shown 74.5, 71.6 and 69.0% reduction over the control after ten days after treatment. Furthermore, it has recorded highest yield of 13.5 q/ ha when compared to other treatments (Ramalakshmi et al., 2020)

The reports on the bioefficacy of the nicotinoid molecules *viz.*, imidacloprid in spray and seed dressing formulation against sucking pests of cotton and other crops has been well proved (Vastrad, 2003: Patil and Rajanikanth, 2004). Saleem et al. (2001) reported that imidacloprid 17.8 SL effectively controlled sucking pests up to seven days after the spray in cotton. Baraskar and Paradkar (2020) concluded that two sprays of flonicamid 50 WP @ 150 g/ ha, thiamethoxam 25%WG @ 200 g/ ha, difenthiuron 50 WP @ 600 g/ ha and fipronil 5%SC @1000 ml/ ha were found very effective in controlling major sucking pests of Bt-cotton. Asif et al. (2016) reported that imidacloprid and lambda cyhalothrin were the effective chemicals in the management of cotton sucking pests. There was 20.9% reduction of thrips incidence observed in diafenthiuron, acetamiprid and fipronil sequential spray (Ram Prasad and Ashwini, 2021). The binding sites of imidacloprid (belonging to the neonicotinoids group) to nicotinic acetylcholine receptors (nAChRs) and fipronil (belonging to the phenyl-pyrazole group) to γ-aminobutyric acid (GABA) receptors in the nervous systems of vertebrates are different from those in insects. In general, vertebrates have lower numbers of nicotinic receptors with high affinity to neonicotinoids, which is why neonicotinoids generally show a higher toxicity to invertebrates (Borota et al., 2021) than vertebrates (Tomizawa and Casida, 2003). Similarly, the binding of fipronil to insect GABA receptors is tighter than that observed for vertebrate receptors (Cole et al. 1993; Gant et al. 1998; Hainzl et al., 1996; Ratra and Casida 2001; Ratra et al., 2001; Narahashi et al., 2010). Thus, combination of imidacloprid and fipronil make them comparatively safe for agricultural workers. Further the neonicotinoids and fipronil are also relatively persistent, offering the potential for long-term crop protection activity. However, it is the systemic nature of these insecticides that has made them so successful (Simon-Delso et al., 2015).

ACKNOWLEDGEMENTS

Authors thank the Directorate of Research, University of Agricultural Sciences, Dharwad, Karnataka, India for permitting us to conduct this experiment.

AUTHOR CONTRIBUTION STATEMENT

S V Hugar conducted the experiments and analysed the data. S S Udikeri prepared the manuscript. All the authors read and approved the manuscript.

CONFLICT OF INTEREST

No conflict of interest

REFERENCES

Ajri D S, Mali A R, Shelake S S, Patil C S, Subeda A J. 1986. A status paper on problem of whitefly, *Bemisia tabaci* (Gennadius) in cotton and other crops in western Maharastra. Proceedings. Seminar on Status of whitefly on Cotton, College of Agriculutre, Pune., March 14, 1986. p.7

Asif M U, Muhammad R, Akbar W, Tofique M. 2016. Relative efficacy of some insecticides against the sucking insect pest complex of cotton. The Nucleus 53(2):140-146.

Baraskar J, Paradkar V K. 2020. Bio-efficacy of different group of insecticides against the major sucking pests complex of Bt-Cotton crop. Journal of Pharmacognosy and Phytochemistry SP6: 109-113.

Bheemanna M, Krishna J, Hosamani A C, Naveena R. 2015. Bioefficacy of Insecticides against major sucking pests in cotton ecosystem. International Journal on Agricultural Sciences 6(2): 251-257.

Borota A, Crisan L, Bora A, Funar-Timofei S. 2021. *In silico* studies on acetylcholine receptor subunit Alpha-L1 for Proposal of Novel Insecticides against *Aphis craccivora*. Chemistry Proceedings 3(1): 1-8

CICR, 2020. Annual Report 2020. ICAR-Central Institute for Cotton Research, Nagpur India.

Cole L M, Nicholson R A, Casida J E. 1993. Action of phenylpyrazole insecticides at the GABA-gated chloride channel. Pesticide Biochemistry and Physiology 46: 47-54.

Dhawan A K, Sidhu A S, Simwat G S. 1988. Assessment of avoidable loss in cotton (*Gossypium hirsutum* and *G. arboreum*) due to sucking pests and bollworms. Indian Journal of Agricultural Sciences 58: 290-292.

Fryxell P A. 1992. A Revised Taxonomic Interpretation of *Gossypium* L. (Malvaceae). Rheedea 2(2): 108-65.

Giraddi R S, Reddy B T, Kambrekar D N. 2017. Solomon 300 OD (Betacyfluthrin + Imidacloprid): A combi product for the management of insect pests of chilli (*Capsicum annum* L.). International Journal of Agricultural and Biosystems Engineering 11(11): 798-801.

Gant D B, Chalmers A E ,Wolff M A, Hoffman H B, Bushey D F, 1998. Fipronil: action at the GABA receptor. Review Toxicology 2: 147-156.

Hainzl D, Casida J E. 1996. Fipronil insecticide: novel photochemical desulfinylation with retention of neurotoxicity. Proceedings of the National Academy of Sciences of the United States of America 93: 12764-12767.

Lu Z, Chen J, Percy R G, Zeiger E. 1997. Photosynthetic rate, stomatal conductance and leaf area in two cotton species (*Gossypium barbadense* and *Gossypium hirsutum*) and their relation with heat resistance and yield. Australian Journal of Plant Physiology 24(5): 693-700.

Nagrare V S, Fand B B, Kumar R, Naik V C B, Bhure K, Naikwadi B, Gokte-Narkhedkar N, Waghmare V N. 2022. Arthropod pests and their natural enemies associated with cotton in india: a review. Indian Journal of Entomology 84(3): 713-725.

Narahashi T, Zhao X, Ikeda T, Salgado V L, Yeh J Z. 2010. Glutamate-activated chloride channels: unique fipronil targets present in insects but not in mammals. Pesticide Biochemistry and Physiology 97(2): 149-152.

Patil B V, Rajanikanth R. 2004. New class of insecticides, mode of action and their bio-efficacy. International Symposium. Strategies for Sustainable Cotton Production-A Global Vision 3, University of Agricultural Sciences, Dharwad, Karnataka, India, 2004. pp.77-85.

Patel B K, Rote N B, Mehta N P. 1986. Resurgence of sucking pests by the use of synthetic pyrethriods on cotton. Proceedings. National Symposium on Resurgence of Sucking Pests (Ed. S Jayaraj), Tamil Nadu Agricultural University, Coimbatore, India, 1986. pp. 196-201.

Patil S B, Udikeri S S, Matti P V, Guruprasad G S, Hirekurubar R B, Saila H M, Vandal N B. 2009. Bioefficacy of new molecule fipronil 5%SC against sucking pest complex in *Bt* cotton. Karnataka Journal of Agricultural Sciences 22(5): 1029-1031.

Ramalakshmi Dash L, Padhy D, Prasada Rao G M V. 2020. Bio Efficacy of Different Novel Insecticides against Cotton Thrips, *Thrips tabaci* in Transgenic Cotton. International Journal of Current Microbiology and Applied Sciences 9(5): 2319-7706.

Ram Prasad B, Ashwini D. 2021. Bio-efficacy of certain insecticides sequence on cotton sucking pests and pink bollworm. International Journal of Bio-resource and Stress Management 12(6): 766-773.

Ratra G S, Casida J E. 2001. GABA receptor subunit composition relative to insecticide potency and selectivity. Toxicology Letters 122(3): 215-222

Ratra G S, Kamita S G, Casida J E. 2001. Role of human GABA Areceptor β3 subunit in insecticide toxicity. Toxicology and Applied Pharmacology 172(3): 233-240.

Rohini A. 2010. Screening of germplasm and evaluation of insecticides for the management of major sucking pests on cotton (*Gossypium hirsutum* L.).M.Sc Thesis. Acharya N.G Ranga Agricultural University, Hyderabad.

Saleem M A, Khalid M, Riaz H. 2001. Comparative efficacy of some insecticides against some sucking insect pests of CIM-443, cotton. Pakistan Entomology 23(1/2): 91-92.

Sathyan T, Murugesan N, Elanchezhyan K, Raj J A S, Ravi G. 2016. Efficacy of synthetic insecticides against sucking insect pests in cotton, *Gossypium hirsutum*. International Journal of Entomology Research 1(1): 16-21.

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, Dyck V H, Praagh V J, Van der Sluijs J P, Whitehorn P R, Wiemers M. 2015. Systemic insecticides (neonicotinoids and fipronil): trends, uses, mode of action and metabolites. Environmental Science and Pollution Research 22: 5-34.

Singh J, Simwat G S, Brar K S, Sohi A S. 2002. Efficacy of acetamiprid (N125) against cotton jassid on American cotton. Insect Environment 8:100-101.

Sinha S R, Singh R, Sharma R K. 2007. Management of insect pests of okra through insecticides and intercropping. Annals of Plant Protection Sciences 15(2): 321-324.

Tomizawa M, Casida J E. 2003. Selective toxicity of neonicotinoids attributable to specificity of insect and mammalian nicotinic receptors. Annual Review of Entomology 48: 339-364.

Vastrad A S. 2003. Neonicotinoids current success and future outlook. Pestology 27: 60-63.

Wendel J F, Grover C E. 2015. Taxonomy and evolution of the cotton genus, *Gossypium* pp. 25-44. Fang D D, Percy R G (eds). Cotton. American Society of Agronomy, Inc. 5585, Guilford Road, Madison, WI 53711-1086, United States of America. 796 pp.

Zanwar P R, Deosarkar D B, Yadav G A, Shelke L T. 2012. Evaluation of certain neonicotinoids against sucking pests in *Bt* cotton. Pestology 36(1): 21-24.

(Manuscript Received: October, 2023; Revised: April, 2024;
Accepted: June, 2024; Online Published: August, 2024)
Online First in www.entosocindia.org and indianentomology.org Ref. No. e24684