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POPULATION STUDIES OF BRINJAL FRUIT BORER (SHOOT BORER), *LUCINODES ORBONALIS* WITH REFERENCE TO THEIR CHEMICAL MANAGEMENT MEASURE

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ABSTRACT

Population studies of *Lucinodes orbonalis* on aubergine was investigated and their chemical measures were also observed. Cultivated plants were regularly monitored and results were obtained on the basis of comparison of two year population. Different insecticides were sprayed and record the percent control of insect population. The maximum percent control of *Lucinodes orbonalis* after treatment in the year 2019 was recorded is 95.94% with Deltamethrin whereas in the year 2020 it was recorded as 95.83% with Endosulphan. The minimum percent control was recorded in the year 2019 is 68.72% with Monocrotophos whereas it was recorded as 67.51% with the same pesticide in 2020. Percent control of *Lucinodes* orbonalis population in the year 2019 after treatment with Cypermethrin, Alpha-cypermethrin, Permethrin and Endosulphan was recorded with 94.14%, 92.70%, 78.45% and 94.14% respectively whereas in the year 2020 it was recorded as 94.90%, 93.64%, 95.13% and 84.16% with Deltamethrin, Cypermethrin, Alpha-cypermethrin and Permethrin respectively. Therefore Deltamethrin and Endosulphan was proved to be more effective among them all but Cypermethrin and Alpha-cypermethrin were also prove to be best.

Key words: Population studies, Aubergine, Brinjal fruit and shoot borer, deltamethrin, endosulphan.

INTRODUCTION

Aubergine play an important role in our food source by providing raw material to our food (Rodriguez-Jimancz *et al.,* 2018; Naeem and Ozgen, 2000). It is cultivated 8,427 per hectare with total annual production of 84,255 tons in Pakistan (Rehman *et al.,* 2019). The yield of aubergine still stands below average due to several pest infestation (Ghosh and Senapati, 2003), excessive and improper use of fertilizer (Maghfoer *et al.,* 2014), shortage of water supply and other environmental problem (Amalia *et al*., 2020). Among all other pest of aubergine *Lucinodes orbonalis* is the most important pest among them (Gautam *et al.,* 2019) which causes reduction in crop yield upto 90% (Javed *et al*., 2017; Misra, 2008; Jagginavar *et al*., 2009). It also recognize as a pest of other Solanaceae group (CABI, 2007; Padwal and Srivastava, 2017). It causes severe loss by boring into aubergine fruits and shoots and results in the destruction of fruit tissues (Asing *et al*., 2007), thus results in formation of damage fruits which is unfit for the market (Gautam *et al.,* 2019). Different abiotic factors also play a significant role in population fluctuation of insects (Kingsolver, 1989; Amarasekare and Sifuentes, 2012; Estay *et al*., 2014) but the use of synthetic pesticides are more effective and cheaper source to control pest (Srinivasan, 2008). Different group of pesticides have been recommended to control *Lucinodes orbonalis* (Shivale *et al*., 2017; Mazari *et al*., 2020) but in the presence studies we have to evaluate the effect of Cypermethrin, Alpha-Cypermethrin, Deltamethrin, Permethrin, Endosulphan and Monocrotophos on population of *Lucinodes orbonalis*.

MATERIALS AND METHODS

Present study was performed at farmer's field near suburb of Karachi. Experiment was carried out in randomized complete block design having seedlings of brinjal in plot size of 3mx3m on ridges, keeping plant to plant and row to row distance of 35cm. Initial monitoring of insects were performed when plant start bearing fruits (May) and then insecticides were sprayed. Insecticide were sprayed in Kharif season of 2018 and 2019 (April and May). Insecticides used were Deltamethrin (2.5 E.C), Cypermethrin (10 E.C) Alpha-Cypermethrin (5 E.C), Permethrin (50 EC), Endosulphan (35 EC) and Monocrotophos (40 wsc). Fifty fruits were randomly selected from treated and control plots, and monitored the number of insect damage to plant. Data were collected 24hrs, 72hr and 1 week after spray. Percent control was obtained through Henderson's Tilton formula i.e.

$$\textbf{Correction \%} = \left(1 - \frac{\text{n in Co before treatment} * \text{n in T after treatment}}{\text{n in Co after treatment} * \text{n in T before treatment}}\right) \times 100$$

Where, n = Insects population, T = Treated population and Co = control population. Data were then analysed statistically. Two ways ANOVA and Duncan's multiple range test was performed to consider results statically significant. The formula of Duncan's multiple range test is as follows:

$$\mathbf{RP = q\alpha\ (P, \upsilon)\sqrt{MSE/r}}$$

Where, P=Duncan's parameter, α =significant level, υ =degree of freedom, MSE=mean square error and r=no. of observations.

RESULTS AND DISCUSSION

The results showed that the population of *Lucinodes orbonalis* in both year were comparatively lowest over control after treated with pesticides. From the results the observations recorded after 24h, 48h and 1 week have showed that in the year 2019 (Table 1). Deltamethrin shows least population growth followed by Cypermethrin, Alpha-cypermethrin and Endosulphan and in the year 2020 (Table 2) Endosulphan shows best results which is followed by deltamethrin, cypermethrin and alpha-cypermethrin. Whereas other pesticides viz., permethrin and monocrotophos are less effective than others but superior over control in both years. The percent control by deltamethrin 2.5 EC in 2019 is observed as 55.68%, 87.30% and 95.94% for 24 h, 48h and 1 week, respectively and this percent control with same pesticide in 2020 is 44.82%, 82.60% and 94.90% for 24h, 48h and 1 week, respectively, both results were significantly higher than control ($P<0.05$). The percent control by endosulphan 35 EC is 81.23%, 90.94% and 94.14% for the year 2019 and in year 2020 it was 66.14%, 87.35% and 95.83% for 24h, 48h and 1 week, respectively which is also significantly higher than control ($P<0.05$). The results of Eswara and Srinivasa (2005) were also similar with our results in which endosulphan and deltamethrin shows least fruit borer damage i.e. 10.28% and 11.11%, respectively. Similarly cypermethrin 10 EC also shows significantly good results ($P<0.05$) which are 46.87%, 80.6% and 94.14% in 2019 and 37.93%, 80.86% and 93.64% in 2020 for 24h, 48h and 1 week, respectively. These results are in accordance with Ali *et al*. (2016), in which cypermethrin decreased the infestation to least minimum level than other infestation. Alpha-cypermethrin 5 EC also shows significant results ($P<0.05$) which is 35.71% (24h), 77.83% (48h) and 92.70% (1 week) in 2019 and 39.81% (24h), 84.18% (48h) and 95.13 (1 week) in year 2020. These findings were in agreement with by Murali *et al.* (2017) in which population of brinjal fruit borer were affected by alphacypermethrin. In case of Permethrin 50 EC the results in 2019 shows 34.38% in 24h, 59.27% in 48h and 78.45% in 1 week and in year 2020 it was 61.57% in 24h, 70.18% in 48h and 84.16% in 1 week. Whereas the population control in treated plants with Monocrotophos 40 wsc shows insignificant results ($P>0.05$) that is in 2019 it was 25% in 24h, 51.90% in 48h and 68.72% in 1 week and in year 2020 it was 20.68% in 24h, 52.17% in 48h and 67.51% in 1 week. So permethrin was found to have moderately effective than monocrotophos. These findings are in agreement with Yein (1985) who observed that Permethrin at 0.25 kg a.i. /ha, Deltamethrin at 0.05 kg a.i. /ha and Endosulphan at 0.75 kg a.i. /ha were superior over Monocrotophos and Malathion to control the population of Lucinodes orbonalis on brinjal. Our control population also shows increased with time. This observation was also in accordance with Nishad *et al*. (2019) in which population of *Lucinodes orbonalis* gradually increased with time.

Endosulphan is an organochlorine compound (Harikumar *et al.*, 2014). The more effectiveness of endosulphan is due to the presence of six chlorine atom (Agnihotri *et al*; 2011) and also the presence of sulphur atom (Lee *et al.*, 2019). The chlorinated part of endosulphan change the neurophysical and chemical properties of nerve cell membrane, creates a change in movement of sodium and potassium channels run through the membrane (Ravindran *et al*., 2016) and the sulphate part inhibits the neurotransmitter (Daniel and Eldefrani, 1987) as sulphate itself also use as insecticide (Hartzell and Lathrop, 1925) and regarded as equally toxic as parent compound (US, EPA, 2007a). It was previously observed that when sulphur added to insecticide it can reduce the presence of larvae in plant (Guerreiro *et al.*, 2013). Henschler *et al.* (1977) works on compounds that has more number of chlorine atoms. He results that toxicity of any chlorinated compound directly relate to the number of chlorine atom present in that compound. The work of Zahedi and Farahati (2011) also confirmed this study that the intermolecular hydrogen bonding in any compound with more number of chlorine atom increases the strength and ability of that compound. Like endosulphan, deltamethrin also shows devastating results as deltamethrin are considered as most powerful synthetic pyrethroid (Aldridge, 1990) and is upto three orders more active than some pyrethroid (Bradbury and Coats, 1989; Kolaczinski and Curtis, 2004). Similarly Cypermethrin and Alpha-cypermethrin shows good results as well but less to deltamethrin and endosulphan. Likewise permethrin appears to be better but shows less ability than other used pyrethroids. The more effectiveness of deltamethrin is due to the presence of bromine atom (Kevin, 2012; Haya, 1989) instead of chlorine atom present in cypermethrin, alpha-cypermethrin and permethrin. While bromine is 1.5 times less toxic than chlorine (Frank Lees, 2012) but is more soluble than chlorine (Custard *et al.*, 2017) and due to intense use of chlorinated pesticides, insects show some resistance to chlorinated compound to some extent (Kliot and Ghanim, 2012). The toxic effects of pyrethroid to insects is because they are calcium channel agonist (Zeng *et al*., 2017) and is extremely lipophilic (Bloomquist and Soderlund, 1989) and easily penetrate the cuticle of insects (Davies *et al;* 2007). Moreover, pyrethroid also effects on voltage gated sodium channels VGSC (Meijer *et al*., 2014; Soderlund, 2012), potassium channels (Yu-Tao *et al*., 2009) and ATPase (Kakko *et al.*, 2004) and thus results in control of insect pest as insects have more sensitive sodium, potassium and calcium channels than other animals (Bradbury and Coats, 1989). The insecticidal activity of pyrethroid depends on the more capability to disrupt these channels (Kaur *et al.*, 2010; Shafer *et al*., 2005). As aubergine plant needs and receive more amount of pesticide sprays after chili (Kodandaram *et al.*, 2015), monocrotophos is cheap (Krause *et al.*, 2013) and easily available (Venkateswara *et al.*, 2005) dangerous pesticide (Jokanovic and Kosanovic, 2010), therefore due to their continuous and indiscriminate use in fields (Dey *et al.*, 2013), it increases the selection pressure in insects and form resistance to pesticide (Kariyanna *et al.*, 2020) thus show less effectiveness.

Table 1. Percent control of the population of *Lucinodes orbonalis* on Aubergine fruit in the year 2019.

S.No.	Pesticides Formulations	Dose/ Square meter	Insect Pop. before treatment	Insect Pop. after treatment			% Control		
							24h	72h	1 week
1.	Cypermethrin 10 E.C	20 g	12	17	15	11	46.87	80.6	94.14
2.	Alpha-Cypermethrin 5 E.C	10 g	07	12	10	8	35.71	77.83	92.70
3.	Monocrotophos 40 wsc	200g	10	20	31	49	25.00	51.90	68.72
4.	Deltamethrin 2.5 E.C	6.25g	11	13	9	7	55.68	87.30	95.94
5.	Permethrin 50 E.C	200g	08	14	21	27	34.38	59.27	78.45
6.	Endosulphan 35 E.C	350g	12	6	7	11	81.23	90.94	94.14
7.	Control		09	24	58	141			

Table 2. Percent control of the Population of *Lucinodes orbonalis* on Aubergine fruit in the year 2020.

S.No.	Pesticides Formulations	Dose/ Square meter	Insect Pop. before treatment	Insect Pop. after treatment			% Control		
							24h	72h	1 week
1.	Cypermethrin 10 E.C	20 g	10	15	11	08	37.93	80.86	93.64
2.	Alpha-Cypermethrin 5 E.C	10 g	11	16	10	07	39.81	84.18	95.13
3.	Monocrotophos 40 wsc	200g	12	23	33	51	20.68	52.17	67.51
4.	Deltamethrin 2.5 E.C	6.25g	09	12	09	06	44.82	82.60	94.90
5.	Permethrin 50 E.C	200g	14	13	24	29	61.57	70.18	84.16
6.	Endosulphan 35 E.C	350g	11	09	08	06	66.14	87.35	95.83
7.	Control		12	29	69	157			

CONCLUSION

Results shows that all pesticides used were significant except Monocrotophos which shows insignificant results. Results also shows that Endosulphan and Deltamethrin were statistically better than Cypermethrin, Alpha-cypermethrin and Permethrin, although they also show good results but the Endosulphan and Deltamethrin were the most effective pesticide among them all. Overall results also indicate that our used pesticides shows comparatively better control of brinjal fruit borers (shoot borer) on aubergine.

REFERENCES

Agnihotri, P., A. B. Mahidrakar and S.M. Gautham (2011). Complete chlorination of endosulphan and lindane using Mg/Pd bimetallic system. *Water Environment Research*, 83(9):865-873.

Ali, F., Anees-ur-Rehman, I. Khan, Zakirullah and A. Ali (2016). Study on the population trend of brinjal fruit and shoot borer and its susceptibility to different insecticide. *ARPN Journal of Agriculture and Biological Science*s, 11(7): 262-66.

Aldridge, W.N. (1990). An assessment of the toxicological properties of Pyrethroids and their neurotoxicity. *Toxicology*, 21(2): 89-104.

Amalia, L., R. Budiasih, E.R. Ria, R.W. Widodo and U. Kuswati (2020). Fermented composed of N-fertilizer for enhancing the growth and productivity of purple eggplant on vertisols. *Open Agriculture*, 5(1): 84-91.

Amarasekare, P and R. Sifuentes (2012). Elucidating the temperature response of survivorship in insects. *Functional Ecology*, 26: 959-968.

Asing, S. Mojumder, M.N.U. Ahamad, B.U. Azad and D. Sikdar (2007). Characterization of alpha-amylase of eggplant fruit and shoot borer larvae. *The Chittagong University Journal of Biological Sciences*, 2(1): 137-150.

Bloomquist, T.R and D.M. Sodurlund (1989). Neurotoxic action of pyrethroid insecticide. *Annual Review of Entomology*, 34: 77-96.

Bradbury, S.P and J.R. Coats (1989). Toxicokinetics and toxicodynamics of pyrethroid insecticides in fish. *Environmental Toxicology and Chemistry*, 8: 373-380.

CABI (2007). Crop protection compendium. CAB International, UK. http://www.cabicopendium.org/cpc

Coats, J.R. (1990). Mechanism of toxic action and structure activity relationship for organochlorine and synthetic pyrethroid insecticide. *Environmental Health Perspect*, 87: 255-262.

Custard, K.D., A.P.W. Raso, P.B. Shepson, R.M. Staebler and K.A. Pratt (2017). Production and release of molecular bromine and chlorine from coastal snowpack. *ACS Earth Space Chemistry*, 1(3): 142-151.

Daniel, B. G. and A.T. Eldefrani (1987). Cyclodiene insecticides inhibits GABA receptor regulated chloride transport. *Toxicology and Applied Pharmacology*, 88(3): 313-321.

Davies, T.G.E., L.M. Field, P.N.R. Usherwood and M.S. Williamson (2007). DDT, Pyrethrins, Pyrethroids and insect sodium channels. *IUBMB Life*, 59(3): 151-162.

Dey, K.R., P. Choudhury and B.K and B.K. Dutta (2013). Impact of pesticide use on the health of farmers: A study in Barak Valley, Assam (India). *Journal of Environmental Chemistry and Ecotoxicology*, 5(10): 269-277.

Estay, S.A., M. Lima and F. Bozinivic (2014). The role of temperature variability on insect performance and population dynamics in a warming world. *Oikos*, 123: 131-140.

Eswara, R.S.G and N. Srinivasa (2005). Efficacy of insecticides against brinjal fruit and shoot borer, *Lucinodes orbonalis*. *Pestology*, 29(1): 31- 33.

Frank Lees (2012). *"Lees' Loss Prevention in the process Industries"*. 4th edition, vol: 2. (Sam Mannan). Butterworth-Heinemann. Chap#18: 1679-1790.

Gautam, M., S. Kafle, B. Regmi, G. Thapa and S. Paudel (2019). Management of brinjal fruit and shoot borer in Nepal. *Acta Scientifica Agriculture*, 3(9): 100-102.

Ghosh, S.K and S.K. Senapati (2003). Estimation of loss in yield of brinjal due to pest complex under terai region of west Bengal. *Environment and Ecology Research*, 21(4): 764-69.

Guerreiro, J.C., P.H. Camdere and A.C. Busoli (2013). Efficiency of insecticides associated as sulphur in the control of Spodoptera frigiperda in corn. *Scienta Agraria Paranaensis*, 12(4): 275-285.

Harikumar, P.S., K. Jesitha, T. Megha and K. Kokkal (2014). Persistence of endosulphan in selected areas of Kasaragod district, Kerala. *Current Science*, 106(25):1421-1429.

Hartzell, A. and F.H. Lathrop (1925). An investigation of sulphur as an insecticide. *Journal of Economic Entomology*, 18(2): 267-279.

Haya, K (1989). Toxicity of pyrethroid insecticide to fish. *Environmental Toxicology and Chemistry*, 8: 381-391.

Henderson, C.F and E.W. Tilton (1955). Test with acaricides against the brow wheat mite. *Journal of Economic Entomology*, 48: 157-161.

Henschler, D.A., G. Bonse and P.J. Gehring (1977). Metabolic activation of chlorinated ethylene: dependence of mutagenic effect on electrophilic reactivity of the metabolically formed epoxides. *Archives of Toxicology*, 39: 7-12.

Javed, H., T. Mukhtar, K. Javed and A. Mohsin (2017). Management of eggplant shoot and fruit borer by integrating different non chemical approaches. *Pakistan Journal of Agriculture Science*, 54(1): 65-70.

Jagginavar, S.B., N.D. Sunitha and A.P. Birada (2009). Bioefficacy of flubendiiamide 480SC against brinjal fruit and shoot borer. *Journal of Agriculture Sciences*, 22: 712-13.

Jayaraj, R., P. Megha P and P. Sreedev (2016). Organochlorine pesticide and their toxic effects on living organism and their fate in the environment. *Interdisciplinary Toxicology*, 9(3): 90-100.

Jokanovic, M., M. Kosanovic (2010). Neurotoxic effects in patients poisoned with organophosphorus pesticides. *Environmental Toxicology and Pharmacology*, 29: 195-201.

Kakko, I., T. Toimela and H. Tahti (2004). The toxicity of pyrethroid compounds in neural cells culture studies with total ATP, mitochondrial enzyme activity and microscopic photographing. *Environmental Toxicology and Pharmacology*, 15: 95-105.

Kariyana, B., A. Prabhuraj, M. Mohan, M. Bheemanna, K. Basavaraj, Y. Pampanna and J.R. Dewan (2020). Insecticide usage pattern and evolution of resistance in eggplant borer in India. *Plant Archives*, 20(2): 1255-1261.

Kaur, M., S. Dhatt, S. Ajmer, J. Sadhu and S.S. Gosal (2010). Genetic transformation of cry IAC gene to counter fruit and shoot borer of brinjal. *Crop Improvement*, 37(2): 200.

Kevin Woodward (2012). *"Toxicological effects of veterinary medicinal products in humans"*. Vol: 1. RSC Publishing. Chap# 6:160.

Kingsolver, J.G. (1989). Weather and the population dynamics of insects: Integrating physiological and population ecology. *Physiological Zoology*, 62(2): 314-334.

Kliot, A and M. Ghanim (2012). Fitness cost associated with insecticide resistance. *Pest Management Science*, 68(11): 1431-7.

Kodandaram, M.H., A.B. Rai, K. Sireesha and J. Halder (2015). Efficiency of cyantraniliprole, a new anthranilic diamide insecticide against *Lucinodes orbonalis*. *Journal of Environmental Biology*, 36:1415-1420.

Kolaczinski, J.H and C.F. Curtis (2004). Chronic illness as a result of low level exposure to synthetic pyrethroid insecticide: a review of debate. *Food and Chemistry Toxicology*, 42: 697-706.

Krause, K.H., C.V. Thriel and J.G. Hengstler (2013). Monocrotophos in Gandaman Village: India school lunch deaths and need for improved toxicity testing. *Archives of Toxicology*, 87: 1877-1881.

Lee, H.K., J. Lee, J.H. Kim (2019). X-ray crystal structure of endosulphan sulphate. *Applied Biological Chemistry*, 62: 57-58.

Maghfoer M.D., R. Soelistyono and N. Herlina (2014). Growth and yield of eggplant on various combination of n-source and number of main branch. *Agrivita*, 36(3): 285-94.

Mazari, S.N., A.S Soomro and H.I. Soomro (2020). Population fluctuation of brinjal fruit and shoot borer in brinjal fruit under field conditions at Larkana, Pakistan. *International Journal of Entomology Research*, 5(3): 152-155.

Meacham, C. A., P.D. Brodfuehrer, J.A Watkins and T.J. Shafer (2008). Developmentally regulated sodium channel subunit are differently sensitive to α- cyano containing pyrethroids. *Toxicological and Applied Pharmacology*, 231: 273-281.

Meijer, M., M.L. Dingemans, M.V.D. Berg and R.H.S. Westerink (2014). Inhibition of voltage-gated calcium channel as common mode of action for (mixtures of) distinct classes of insecticides. *Toxicological Sciences*, 141(1): 103-111.

Acute disturbance of calcium homeostasis in PC12 cells as a novel mechanism of action for (sub) micromolar concentrations of organophosphate insecticide. *Neurotoxicology*, 43: 110-116.

Misra, H.P (2008). New promising insecticides for the management of brinjal fruit and shoot borer. *Pest Management of Horticulture and Ecosystem*, 14:140-147.

Murali, S., S.K. Jalali, A.N. Shylesha, T.M. Shivalinga Swamy and R. Gandhi Gracy R (2017). Documentation of pyrethroid resistance against brinjal fruit and shoot borer. *Indian Journal of Current Microbiology and Applied Sciences*, 6(8): 3260-70.

Naeem, Y.M and S.U.O. Ozgen (2000). Nutritional content and health benefits of egg plants. *Turkish Journal of Agriculture and Food Science Technology*, 7(sp3): 31-36.

Nishad, M. K., K. Mukesh K., D.R. Kishore and S. Moses (2019). Population dynamics of brinjal fruit and shoot borer during the cropping season and its correlation with weather parameter. *Journal of Entomology and Zoology Studies*, 7(1): 1571-75.

Padwal, G.K and C.P. Srivastava (2017). Sexual dimorphism in brinjal shoot and fruit borer. *Journal of Experimental Zoology India*, 20(2): 851-53.

Ravindran, J., P. Megha and P. Sreedev (2016). Organochlorine pesticide and their toxic effects on living organism and their fate in the environment. *Interdisciplinary Toxicology*, 9(3): 90-100.

Rehman, S., I.A. Hafiz, I. Ali and N.A. Abbassi (2019). Growth and yield response of different brinjal cultivation to irrigation in different conditions. *Journal of Horticulture Science and Technology*, 2(3): 78-84.

Rodriguez-Jimenez, J.R., C.A. Amaya-Guerra, J.G. Baez, C. Aguilera-Gonzalez, Y.U. Orona and G. Nino-Medina (2018). Physiochemical, functional and nutracentical properties of eggplants flour obtained by different drying methods. *Molecules*, 23(12): 3210.

Shafer, T.J., D.A. Mayer, K.M. Crofton (2005). Developmental toxicology of pyrethroid insecticide: critical review and future research needs. *Environmental Health Perspectives*, 113: 123-136.

Shivale, D., M. Patil M and S. Parimi (2017). Insecticides resistance in field population of *Lucinode*s *orbonalis* in India. *The Canadian Entomologist*, 149(3): 399-407.

Soderlund, D.M (2012). Molecular mechanism of pyrethroid insecticide neurotoxicity recent advances. *Archieve Toxicology*, 86: 165-181.

Srinivasan, R (2008). Integrated pest management for eggplant fruit and shoot borer in South East Asia: past present and future. *Journal of Biopesticides*, 1(2): 105-11.

Venkateswara, R.J., K. Parvathi, P. Kavitha, N.M. Jakka and R. Pallela (2005). Effects of chlorpyrifos and monocrotophos on locomotor behavior and acetylcholinesterase activity of subterranean termites. *Pest Management Sciences*, 61(4): 417-21.

Yein, B.R (1985). Field efficacy of some insecticides against fruit and shoot borer of brinjal. *Journal of Research, Assam Agricultural University*, 6(1): 31-34.

Yu-Tao, T, W.L. Zhao, Y. Yang, Y. Zhuo and Z. Tao (2009). Effect of alpha-cypermethrin and theta cypermethrin delayed rectifier potassium current in rat hippocampal nerve. *Neurotoxicology*, 30, 269-273.

Zahedi, M.T and R. Farahati (2011). Calculation of intramolecular hydrogen bonding strength and natural bond orbital analysis of naphthazarin with chlorine substitution. *Computational and Theoretical Chemistry*, 977(1-3): 195-200.

Zeng, R., X. Yu, X. Tan, S. Ye and Z. Ding (2017). Deltamethrin effect the expression of voltage gated calcium channel alpha 1 subunit and the locomotion, egg-laying, foraging behavior of *Caenorhabditis elegans*. *Pesticide Biochemistry Physiology*, 138: 84-90.

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