"Comparative study of chemicals with botanicals against spotted stem borer, *Chilopartellus*(Swinhoe) on Maize (*Zea mays* L.)"

ABSTRACT: The Stem borer,*Chilopartellus*(Swinhoe)is regarded as one of the most significant and prevalent insect pests of maize and the mystic aspect of feeding makes it challenging to control.~~ha~~Hence current study was conducted to evaluate comparative study of chemicals with botanicals against *Chilopartellus.* Eight treatments ~~were tested under field conditions namely~~viz.,Azadirachtin10,000ppm, Neem oil 3%, Karanj oil 3%, Neem oil 3% + Imidacloprid 17.5%SL, Karanj oil 3% + Imidacloprid 17.5%SL,Imidacloprid 17.5%SL, Spinosad 45%SC and untreated controlwere tested under field condition~~in Randomized Block Design with three replications.~~ Among ~~all~~ the treatments, lowest larval population of *Chilopartellus*per plantwere recorded in Karanj oil 3% + Imidacloprid 17.5%SL (1.99) followed by Karanj oil 3% + Imidacloprid 17.5%SL (2.42),Imidacloprid 17.5%SL (2.71), Spinosad 45%SC (3.17), Neem oil 3% (3.73), Karanj oil 3% (3.95) and Azadirachtin10,000ppm (4.44) were foundsuperior over the ~~T_0~~ untreated control which recorded (7.24-----?). The highest yield was recorded in Karanj oil 3% + Imidacloprid 17.5%SL with 39.20 q/hectare and most economic treatment wasImidacloprid 17.5%SL with highest cost benefit ratio (1:2.2).

Keywords: *Chilopartellus*, Maize stem borer, ~~Maize,~~ Management, ~~Control,~~ Insecticides, Biopesticides, Efficacy

1. INTRODUCTION:

Maize (*Zea mays* L.) is the world's leading crop and is widely cultivated as cereal grain that was domesticated in Central America. It is one of the most versatile emerging crops having wider adaptability. Globally, maize is known as queen of cereals because of its highest genetic yield potential(Directorate of Maize Research, ICAR-------?). It is a crop that used to produce a variety of foods and fodder using diverse plant parts, such as grain, leaves, stalks, tassels, and cobs(~~Singh *et al.*, 2006~~). It is an important source of vitamins, minerals, lipids, protein, starch, and fiber. It is also highly nutritious for use in cattle and poultry feed(~~Prasanna *et al.*, 2001, Farnham *et al.*, 2003~~).In terms of nutrition, maize

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Comment [R9]: Provide reference number as per the format of the jounal grains include 4% oil, 70% carbohydrates, 2-3% crude fiber, and 10% protein in addition to vitamins A and E, riboflavin, and nicotinic acid. Zein is low in calcium and lacking in the necessary acids tryptophan and lysine(Joshi 2015).InAsia, maize consumed as human food contributes over 20% of food calories(Shiferawet al., 2011).The global consumption pattern of maize is: feed-61%, food-17% and industry- 22%. It has attained a position of industrial crop globally as 83% of its production in the world is used in feed, starch and bio-fuel industries. Further, using maize directly or indirectly more than 3000 products are being made providing a wide opportunity for value addition. Because of its myriad uses, it is a prime driver of the global agricultural economy. With a yield of 1423 million MT, it is grown on 188 million haectare of land in 170 countries across the globe. Worldwide China has maximum area under maize followed by the USA, both together representing 39% of world maize area. Since 2005, India ranks 4th in terms of area with 9.89 million hactare land under maize. (Indian Institute of Maize Research, ICAR 2024).Production of Maize in the country during 2023-24 is estimated at record 224.82 lakh tones.(PJTSAU, 2024). The insect pest complex that affects maize in India is an area that has not received extensive study. Notable insect pests are *Helicoverpaarmigera* (Hubner),and*Mythimnaseparata* (Walker).*Spodopterafrugiperda(----)*, *Atherigonasoccata* (Rondani), *Rhopalosiphummaidis* (Fitch), and*Chilopartellus* (Swinhoe)(Chouraddi*et al.*,2017). Scientists have undertaken numerous investigations and come to the conclusion that the maize stem borer, *C. partellus*is alsoa significant pest of pearl millet (*Pennisetumtyphoideum* (Rich),andsorghum (*Sorghum bicolor* L.), and maize (*Zea maize* L.) across Asia and Africa. (Panwar,2005). Similarly, Itthe pestwas also noticed infesting Rice (*Oryza sativa*), Sugarcane (*Saccharum officinarum*) and several millets, grasses. (Kauma *et al.*, 2008).*Chilopartellus*, a member of the Pyralidae family of insects, is a notable biotic barrier to maize cultivation worldwide.(Pingali.,2000).It is most significant pests in Asia and Africa.(Arabjafari and Jalali.,2007).Approximately 139 distinct insect pest species attack maize; among these, *C. partellus* is a major pest in various agroclimatic zones of India. (Shukla and Kumar, 2005).It is very difficult to control the stalk borer, because of cryptic and nocturnal habits of adult moth (Singh *et al.*,2014).

Chilopartellus ley oval-shaped, creamy white eggs having length of around 0.8 mm. (Panchal and Kachole,2013). It takes 4–8 days for the eggs to develop into larvae. (Panchal and Kachole, 2013)and takes 28–35 days for the larvae to develop into pupa. Larvae in theirfinal instar measure 25–30 mm long, and their bodies have rows of dark spots. Pupae are

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long, cylindrical and dark brown colored, males are smaller than females. 5-12 days after pupation, adults emerge from pupae. The moths are pale brown colored with an approximate wingspan of 20-30 mm. These moths have 3- 8 day lifespan.When they attain maturity, they mate and lay eggs.The life cycle of *C. partellus* takes 25- 50 days to complete (Panchal and Kachole, 2013).BecauseAsmaize has more sugars and amino acids than other gramineous hosts, it is more vulnerable to harm from stem borer infestation (Souza, 2002)and the larva. Itstarts to infest the crop three to four weeks after sowing and continues to do so until the crop reaches maturity. (Sarup *et al.*, 1978) The leaf-eating and stem-tuning activity of the larvae of *Chilopartellus*are the most common symptom ofdamage to maize plants. In anatural field conditions. the first signs of infestation are characteristic leaf lesions and scarification caused by the first and second instars of *C. partellus* (Sithole, 1990). After hatching, stem borer larvae move over the plant, gather in the ftunnel, and feed on the curled leaves for a few days before approaching the stalk and stem.(Mushore, 2005). When the infestation is severe, the larvae, either in the leaf whorl or in the stem, can cut through the meristematic tissues; the central leaves dry up to produce the 'dead heart' symptom(De Groote,2002).A dead heart is caused by the borers burrowing upward after entering the stem at the surface of the soil. (Kfir *et al.*, 2002). Exit holes and tunnels in the main stem inhibit plant growth and promote bacterial and fungal diseases (Ndiritu1999, Songa*et al.*, 2001).Dead hearts reduce translocation, ear damage, lodging, initial leaf senescence and in severe cases complete crop failure (Naz *et al.*, 2003, Gupta *et al.*, 2010).The yield losses exhibit significant regional variations, with a range of 25-40% depending on the pest population density and crop phenological stage of infection(Khan *et al.*, 2015).

2. MATERIALS AND METHODS

The study was conducted induring*Kharif*,season2023 at cCentral rResearch farm, SHUATS, Prayagraj,India. Experimental design emoloyedwas a Randomized Block Design (RBD) consisting of eight different treatments including untreated control,andeach treatment was replicated thrice. The Plot size was 2m×1m and treatments were assigned randomly. The treatments included Azadirachtin10,000ppm(1ml/l)Neem oil 3% (30ml/l), Karanj oil 3% (30ml/l), Neem oil 3% + Imidacloprid 17.5%SL (30ml/l+0.25ml/l), Karanj oil 3% + Imidacloprid 17.5%SL (30ml/l+0.25ml/l),Imidacloprid 17.5%SL (0.5ml/l), Spinosad 45%SC (0.5ml/l) and untreated control. Two sprays were carried out at aninterval of 15 days during the experimentation to assess the effectiveness of chemicals and botanicals on thec*Chilopartellus* larval population. Five plants were randomly selected in each treatment

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and observations were taken on larval populationone day before spraying ~~application~~ and three, seven and fourteen-days after spraying. Chemicals and ~~B~~botanicals were applied at their recommended doses at economic threshold level (ETL = 10% infestation).

~~The Larval population observation of the maize stem borer was calculated according to the following equation:~~

$$Larval\ Population = \frac{Number of Larvae}{Total number of\ \ Plants}$$

The healthy marketable yield from different treatments were collected separately and weighed. There were two sprays throughout the research period and the treatment cost and common cost of cultivation per hactere was calculated. Total income was realized by multiplying the total yield per hectare by the prevailing market price; while the net benefit was obtained by subtracting the total cost of plant protection from total income. The C:B was calculated by following formula.

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$$Cost\ Benefit\ Ratio = \frac{Grossreturn}{Totalcostofcultivation}$$

3. RESULTS AND DISUSSION

3.1 Comparative efficacy of chemicals with botanicals against spotted stem borer, *Chilopartellus*(Swinhoe) after first spray:

The data on the larval population of spotted stem borer on ~~mean (~~3[rd], 7[th] and 14[th] DAS~~) days~~ after first spray revealed that all the treatments were significantly superior over control. Among all the treatments lowest larval population of spotted stem borer was recorded in T_5 Karanj oil 3% + Imidacloprid 17.5%SL (2.48) followed by T_4 Neem oil 3% + Imidacloprid 17.5%SL (2.91), T_6 Imidacloprid 17.5%SL (3.13), T_7 Spinosad 45%SC (3.66), T_2 Neem oil 3% (4.20), T_3 Karanj oil 3% (4.44) and T_1Azadirachtin 10,000ppm (5.00) ~~is~~which were found to be lessast effective.~~then~~When comparingall the treatments , which were~~and is~~significantly superior over the control (6.93). Among all the treatments (T_5 Karanj oil + Imidacloprid, T_4 Neem oil + Imidacloprid, T_6 Imidacloprid), (T_6 Imidacloprid, T_7 Spinosad), (T_7 Spinosad, T_2 Neem oil), (T_2 Neem oil, T_3 Karanj oil) and (T_3 Karanj oil, T_1 Azadirachtin) were found statistically significant at par with each other.

3.2 Comparative efficacy of chemicals with botanicals against spotted stem borer, *Chilopartellus*(Swinhoe) after second spray:

The data on the larval population of spotted stem borer on mean (3[rd], 7[th] and 14[th] DAS) days after spray revealed that all the treatments were significantly superior over control. Among all the treatments lowest larval population of spotted stem borer was recorded in T_5 Karanj oil 3% + Imidacloprid 17.5%SL (1.50) followed by T_4 Neem oil 3% + Imidacloprid 17.5%SL (1.93), T_6 Imidacloprid 17.5%SL (2.30), T_7 Spinosad 45%SC (2.68), T_2 Neem oil 3% (3.26), T_3 Karanj oil 3% (3.46) and T_1 Azadirachtin 10,000ppm (3.88) ~~is~~werefound to be less~~ast~~effective.~~then~~When comparingall the treatments, which were~~and is~~ significantly superior over the control (7.55). Among all the treatments (T_2Neem oil~~,~~and T_3Karanj oil) were found statistically significant at par with each other.

3.3 Comparative efficacy of chemicals with botanicals against spotted stem borer, *Chilopartellus*(Swinhoe) after first and second spray (Overall mean).

The data on the larval population of spotted stem borer on mean (3[rd], 7[th] and 14[th] DAS~~) days~~ after first and second spray revealed that all the treatments were significantly superior over control. Among all the treatments lowest larval population of spotted stem borer was recorded in T_5 Karanj oil 3% + Imidacloprid 17.5%SL (1.99) followed by T_4 Neem oil 3% + Imidacloprid 17.5%SL (2.42), T_6 Imidacloprid 17.5%SL (2.71), T_7 Spinosad 45%SC (3.17), T_2 Neem oil 3% (3.73), T_3 Karanj oil 3% (3.95) and T_1 Azadirachtin 10,000ppm (4.44) is found to be least effective then all the treatments and ~~is~~wassignificantly superior over the control (7.24). Among all the treatments (T_5 Karanj oil + Imidacloprid, T_4 Neem oil + Imidacloprid, T_6 Imidacloprid), (T_4 Neem oil + Imidacloprid, T_6 Imidacloprid, T_7 Spinosad), (T_7 Spinosad, T_2 Neem oil, T_3 Karanj oil) and (T_2 Neem oil, T_3 Karanj oil T_1 Azadirachtin) were found statistically significant at par with each other.

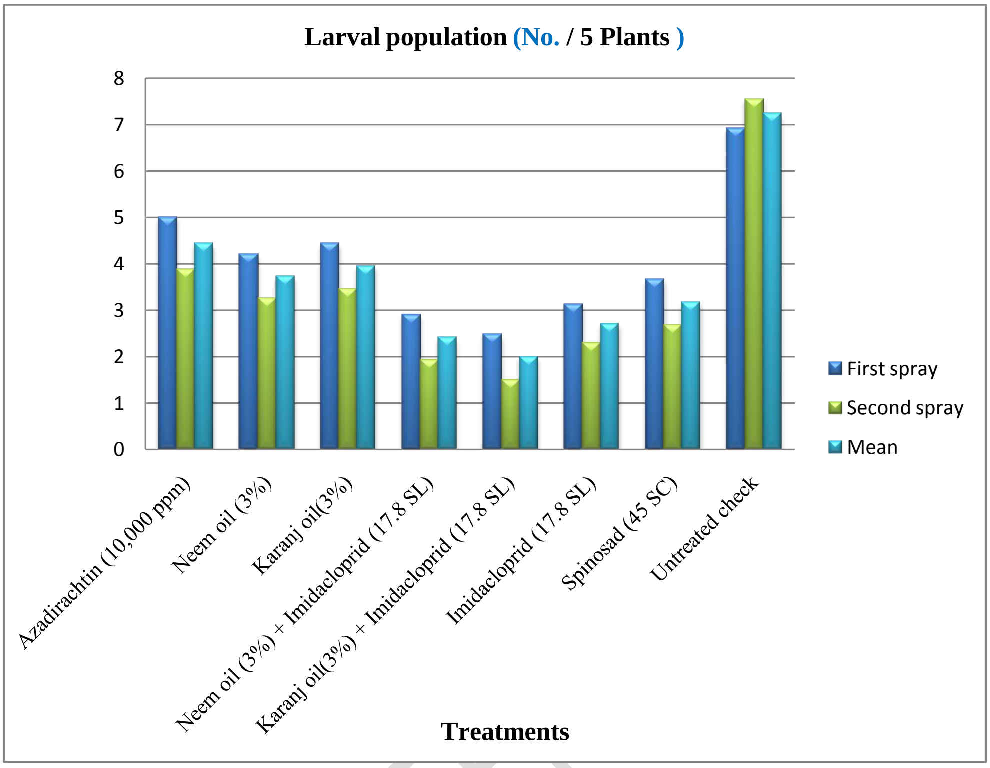

Figure1. : Comparative efficacy of chemicals with botanicals against spotted stem borer, *Chilopartellus*(Swinhoe) after first and second spray

The yields among all the treatments were significant. The highest yield was recorded in T_5 Karanj oil 3% + Imidacloprid 17.5%SL with 39.20 q/hac followed by T_4 Neem oil 3% + Imidacloprid 17.5%SL with 36.50 q/hac, T_6 Imidacloprid 17.5%SL with 34.40 q/hac, T_7 Spinosad 45%SC with 32.50 q/hac, T_2 Neem oil 3% with 30.70 q/hac, T_3 Karanj oil 3% with 29.85 q/hac, T_1Azadirachtin 10,000ppm with 27.40 q/hacand T_0 untreated control 19.35 q/hac were recorded which was least yield.

Among all the treatments studied, the best and most economic treatment was T_6 Imidacloprid 17.5%SL (1:2.2), followed by T_5 Karanj oil 3% + Imidacloprid 17.5%SL (1:2.0), T_7 Spinosad 45%SC (1:1.9), T_4 Neem oil 3% + Imidacloprid 17.5%SL (1:1.7), T_1 Azadirachtin 10,000ppm (1:1.7), T_3 Karanj oil 3% (1:1.6), T_2 Neem oil 3% (1:1.5) and T_0 untreated control (1:1.4).

Table 1.:Comparative efficacy of chemicals with botanicals against spotted stem borer, *Chilopartellus*(~~Swinhoe)~~ on Maize ~~*(Zea mays L.)*~~”

S. No.	Treatments	Dosage	LarvalPopulationof*chilopartellus/ 5 plants-?*										Yield (q/ha)	C:B Ratio
				Firstspray				Secondspray				Overallmean		
			1DBS	3DAS	7DAS	14DAS	Mean	3DAS	7DAS	14DAS	Mean			
T_1	Azadirachtin (10,000 ppm)	1 ml/lit	5.80	5.60^{b}	4.40^{b}	5.00^{b}	5.00^{b}	4.13^{b}	3.60^{b}	3.93^{b}	3.88^{b}	4.44^{b}	27.40	1:1.7
T_2	Neem oil (3%)	30 ml/lit	5.93	5.06^{c}	3.26^{d}	4.26^{c}	4.20^{cd}	3.40^{d}	3.13^{c}	3.26^{c}	3.26^{c}	3.73^{bc}	30.70	1:1.5
T_3	Karanj oil (3%)	30 ml/lit	5.60	5.33^{bc}	3.66^{c}	4.33^{c}	4.44^{bc}	3.73^{c}	3.26^{bc}	3.40c	3.46^{c}	3.95^{bc}	29.85	1:1.6
T4	Neem oil (3%) + Imidacloprid (17.8SL)	30ml/lit + 0.25 ml/lit	5.80	3.86^{e}	2.13^{e}	2.73^{e}	2.91^{f}	2.20^{f}	1.66^{e}	1.93^{f}	1.93^{f}	2.42^{de}	36.50	1:1.7
T_5	Karanj oil (3%) + Imidacloprid (17.8SL)	30ml/lit + 0.25 ml/lit	6.06	3.40^{f}	1.73^{f}	2.33^{f}	2.48^{f}	1.66^{g}	1.33^{e}	1.53^{g}	1.50^{g}	1.99^{e}	39.20	1:2.0
T_6	Imidacloprid (17.8SL)	0.5 ml/lit	5.73	4.06^{e}	2.33^{e}	3.00^{e}	3.13^{ef}	2.46^{f}	2.13^{d}	2.33^{e}	2.30^{e}	2.71^{de}	34.40	1:2.2
T_7	Spinosad (45 SC)	0.5 ml/lit	5.73	4.46^{d}	3.00^{d}	3.53^{d}	3.66^{de}	2.86^{e}	2.46^{d}	2.73^{d}	2.68^{d}	3.17^{cd}	32.50	1:1.9
T_8	Control		6.06	6.60^{a}	6.93^{a}	7.26^{a}	6.93^{a}	7.40^{a}	7.60^{a}	7.66^{a}	7.55^{a}	7.24^{a}	19.35	1:1.4
F-Test			NS	S	S	S	S	S	S	S	S	S		
S.Ed.(±)			NS	0.15	0.18	0.13	0.32	0.13	0.13	0.16	0.13	0.81		
CD (0.05)			NS	0.32	0.38	0.28	0.67	0.28	0.28	0.33	0.28	0.95		

DBS-DaybeforeSpraying,DAS-DayafterSpraying,NS- Nonsignificant,S-Significant

4. CONCLUSION :*Chilopartellus*, a lepidopteran stem borer, damages the worldwide maize ecosystem economically. Due of its cryptic nature of feeding, it is challenging to control with chemical Insecticides. The excessive use of chemical insecticides and its associated detrimental effects have been widely criticized. Insects quickly develop resistance to chemical insecticides when they are frequently exposed to them but botanical inseticides contain a variety of naturally occurring active ingredients with unique modes of actions, such as antifeedant, repellent, ovipositiondeterrent~~,~~ and synergistic effects, making resistance difficult to develop.Therefore, when chemical and botanical insecticides are used together, they have substantially greater efficacy than when they are applied separately because of their synergistic and complimentary effects.Keeping in the view present research was conducted and results shows that combinations of chemicals with botanical insecticides, Karanj oil 3% + Imidacloprid 17.5%SL followed by Neem oil 3% + Imidacloprid 17.5%SL shows highest efficacy with highest yield 39.20 and 36.50 q/hacare respectively against spotted stem borer but economically best treatment was Imidacloprid (17.8SL) which show~~s~~edhighest cost benefit ratio (1:2.2). Combinations of chemicals with botanicals have lower cost benefit ratio to some extent compared to chemicalsbecause of the high dosages and expense of botanicals but it wasconsidered as a feasible alternative of chemicals and reduces adverse acute and chronic effects in environment along with bioaccumulation and biomagnifications.

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