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Determination of Persistence and residual toxicity of different insecticides against pink stem borer, *Sesamia inferens* on maize plant

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Abstract
The persistence and residual toxicity of insecticides of different formulations under poly house condition were determined on maize crop during spring 2013-14 and 2014-15 based on 'PT' values and LT_{50} values. The maximum 'PT' value was obtained in case of Carbofuran (1003.20, 1000.92) followed by Spinosad (848.85, 952.12) while, minimum was in Buprofezin (587.49, 562.22) during study years. The LT_{50} values were found higher in case of Carbofuran which was recorded 8.62 and 8.65 days during 2013-14 and 2014-15, respectively. While Buprofezin required the shortest time of 5.14 and 5.65 days to kill 50 per cent population of pink stem borer during 2013-14 and 2014-15, respectively.

Keywords: Maize, persistence, pink stem borer, residual toxicity

Introduction
Maize (*Zea mays* L.) or corn is a crop of the family Poaceae grown primarily for its kernel. Development of new agricultural technology helped in the expansion of maize cultivation throughout the year in different parts of the country (Panwar and Sharma 1998) [11]. At the same time it led to the appearance of new array of constrains in maize cultivation including the attack of insect pests which were not problematic earlier (Kumar *et al.* 2005) [8]. In India, maize production is greatly affected by the infestation of two insect pests, spotted stem borer, *Chilo partellus* Swinhoe (Lepidoptera: Pyralidae) and pink stem borer, *Sesamia inferens* Walker (Lepidoptera: Noctuidae).

The pink stem borer is emerging as an important pest of wheat in India due to change in tillage system. It causes severe damage by forming dead hearts at seedling stage and white ears at ear head stage. (Singh, 2012) [14]. Siddiqui and Marwaha (1993) [13] reported that *S.inferens* damages every part of the maize plant except root. The larvae were found to inflict damage to the unopened leaves by remaining in leaf whorls. They also cause damage to stem, tender tassel and immature cob.

Indiscriminate use of chemical pesticides in the past has created a number of problems like insecticide resistance, insecticide residues, pest resurgence, environmental pollution and direct and indirect hazards to human beings etc. To avoid or minimize these adverse effects, recently, emphasis has been given to explore new techniques for the management of insect pest with minimum use of pesticides at appropriate time or at vulnerable stage of insect biology.

Materials and Methods
Present studies were carried out during spring seasons of the year 2013-14 and 2014-15. The laboratory investigations were carried out in poly house, Agriculture college campus, IGKV, Raipur (C.G.). The persistence and residual toxicity resulting from application of insecticides, *viz*., Chlorantraniliprole 18.5 SC, Carbofuran 3G, Cartap hydrochloride 4G, Imidacloprid 70WS, Fipronil 0.3G, Emamectin benzoate 5WG, Buprofezin 25%SC, Spinosad 45 SC, Thiamethoxam 25WG were determined on maize crop against 2-3 days old larvae of pink stem borer which were used as test insect. The test insect was reared on natural food for getting regular supply of culture. The sprayed plants were taken at regular intervals from field. Twenty larvae of *Sesamia inferens* were released individually in each sprayed material after 1-2 hours in the whorl with the help of zero size camel hair brush. The same procedure was followed after 3, 5, 7, 9, 11, 13, 15, 17 and 19 days after application of insecticides. The released ten 2-3 days old larvae were allowed to feed for 24 hours.

A parallel control was run by providing untreated whorls of maize. Mortality counts were made 24 hours after releasing the larvae on treated whorls.

The survival of larvae in different treatment was investigated by releasing freshly hatched larvae in the whorl of treated plants. The larvae were released on maize plant at alternate days, till the larvae in treatment pot and control pot become equal. Based on survival in untreated check, corrected mortality percentage was calculated. From the data 'PT' values were calculated by multiplying the average toxicity (T) with the period (P) for which toxicity persisted.

Statistical Analysis

The percent mortality of pink stem borer larvae in different treatments was worked out. Percent mortality for each day sampling observations was corrected (Abbott, 1925) [1] as given below:

$$P' = \frac{P - C}{100 - C} \times 100$$

Where,

P' =corrected mortality percentage in the test insect

P =Observed mortality percentage in the test insect

C = Percentage mortality in the control.

The data were subjected to probit analysis (Finney, 1971) [3] with the help of LeoOra POLO-PC® software for the determination of LT_{50} values. The residual toxicity of each insecticide was also worked out as per the criteria suggested by Pradhan and Venkatraman (1962) in which persistence toxicity (PT) was taken as an index i.e. PT= Average toxicity (T) X Period for which toxicity persisted (P).

Where, P=Period for which some toxicity observed (time up to which some mortality obser

T = Average residual toxicity (mean corrected per cent mortality of the period P)

Result and Discussion

The persistence and residual toxicity of insecticides of different formulations under laboratory condition were determined on maize crop during spring 2013-14 and 2014-15 based on 'PT' values and LT $_{50}$ and the results obtained on 'PT' values are presented in Table 1 and 2. It is clear from the table that the maximum 'PT' value was obtained in case of Carbofuran (1003.20, 1000.92) followed by Spinosad (848.85, 952.12) while, minimum was in Buprofezin (587.49, 562.22) during study years. (Fig.1)

The relative performance of different treatments with respect to their 'PT' values were as follows Carbofuran (1003.20, 1000.92) > Spinosad (848.85, 952.12) > Chlorantraniliprole (834.35, 805.40)> Emamectin benzoate (823.36, 803.11) > Cartap hydrochloride (802.95, 800.25)> Fipronil (693.32, 680.71)> Thiamethoxam (668.59, 659.97)> Imidacloprid (598.73, 590.15)> Buprofezin (587.49, 562.22) during 2013-14 and 2014-15 respectively. The data revealed that Buprofezin and Imidacloprid persisted for shortest period of 11 days while, Carbofuran persisted for the longest period of 19 days during both the years. (Table 1 and 2).

However more appropriate results could be derived by comparing LT_{50} values (lethal time required to give 50 per cent mortality of the test insect).The LT_{50} values were found higher in case of Carbofuran which was recorded 8.62 and 8.65 days during 2013-14 and 2014-15, respectively (Table 1 and 2).While Buprofezin required the shortest time of 5.14 and 5.65 days to kill 50 per cent population of pink stem borer during 2013-14 and 2014-15, respectively. The insecticides in the decreasing order of LT_{50} values can be arranged as Carbofuran (8.62, 8.65) >Spinosad (7.71, 7.51)> Chlorantraniliprole (7.11, 7.41) Emamectin benzoate (7.10, 6.82) > Cartap hydrochloride (6.85, 6.62)>Fipronil (6.64, 6.45)> Thiamethoxam (6.50, 6.08)> Imidacloprid (5.93, 5.93)> Buprofezin (5.14, 5.65) during 2013-14 and 2014-15, respectively. (Fig.2)

The present findings are in agreement with the findings of Ganguli (1994) [4], who reported that the Carbofuran 3G (7.5 kg/ha applied in the whorl in 15 days maize crop) was the most persistent amongst all the tested insecticides and also concluded that Carbofuran 3G persisted up to 17 days and 15 days under laboratory and field conditions and recorded highest 'PT' value and minimum reduction in mortality during subsequent days of application. Similarly, Catchot (2010) [2] found that the newer insecticides displayed efficacy equal to or greater than standard insecticides (Indoxacarb, Lambda-cyhalothrin, Methoxyfenozide, Novaluron, and Spinosad) currently recommended for control of fall armyworm.

In residual efficacy studies Hardke *et al.* (2011) [5] also stated that the exposure of fall armyworm larvae to Chlorantraniliprole and Cyantraniliprole treated tissue resulted in significantly greater mortality compared to those exposed to non-treated tissue and Lambda-cyhalothrin-,flubendiamide-, novaluron-, and methoxyfenozide-treated tissues at 7 DAT. Chlorantraniliprole and Cyantraniliprole were the only compounds that resulted in >40% mortality at 28 DAT. These results indicate that newer insecticides are equal to or more efficacious against fall armyworm than traditional insecticides. This was further partially confirmed by Jansson *et al.* (1996) [6] whose findings suggested that Abamectine (LC_{50}=5.85ppm), Malathion (LC_{50}=6.33ppm) and Spinosad (LC_{50}=55.46ppm) were intermediary in toxicity while, Emamectin benzoate was the least toxic (LC_{50}-225.75) against the test insect.

As Spinosad was toxic to insects by ingestion or contact, and its action on the insect nervous system was at the nicotinic acetylcholine and gamma-amino butyric acid (GABA) receptor sites Sparks *et al.* (2001) [15], it might need maximum time to cause 50 per cent mortality. Kelly *et al.* (1996) [7] reported that Emamectin benzoate was taken up by the insects via ingestion and contact, albeit ingestion was the primary route of intoxication that needed much exposure period. This was further confirmed by Lasota *et al*. (1996) [9] who recorded greater Emamectin toxicity in ingestion versus residual contact bioassay method.

Mohamed (2009) [10] studies revealed that organophosphates have superior efficacy against *Sesamia cretica* Led. over Emamectin benzoate and bio-insecticides compounds. Diazinon LC_{50} value was 0.67 ppm, after 72 hrs from initiation of the test followed by 0.69ppm, 1.03ppm, 2.99ppm,4.23ppm and 7.78ppm for Profenofos, Emamectin benzoate, *Bacillus thuringiensis*, Spinosad and Azadirachtin respectively, While, the toxicity index (T.I) after 120 hrs showed that both of organophosphate insecticides (Diazinon and Profenophos) gave the most toxic effect, (the toxicity index were T.I = 100) followed by emamectin benzoate (T.I = 43.82), *Bt* (*Kurstaki*) (T.I = 22.40), Azadirachtin (T.I = 16.14) and Spinosad (T.I =15.83), respectively.

Veda Parimala and Uma Maheswari (2011) [16] carried out an investigation to evaluate the relative toxicity of selected newer insecticides *viz.*, Deltamethrin, Spinosad, Abamectin and Emamectin benzoate in comparison with the Organophosporus insecticide Malathion to the maize weevil, *Sitophilus zeamais* Motschulsky, in an attempt to find out a safer and effective seed protectant. The LC_{50} values after 24 hours period of exposure revealed that deltamethrin had low LC_{50} value of 6.85 followed by Abamectin (7.26) and Malathion (7.30) indicating their high toxicity. Emamectin benzoate has 404.60 followed by Spinosad with 100.12 as LC_{50} values that were found less toxic.

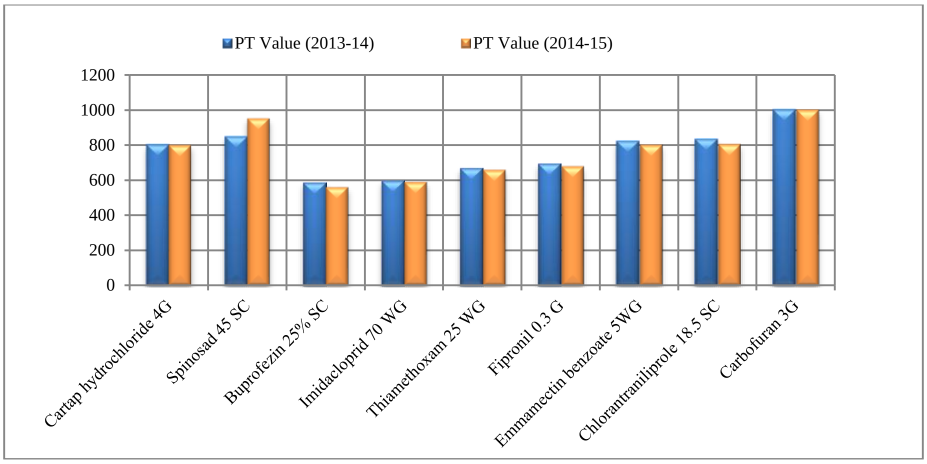

Fig 1: Persistence toxicity values (PT) of insecticides against neonate larvae of *S. inferens* on maize crop under poly house condition during spring 2013-14 and 2014-15

Table 1: Residual Toxicity (LT_{50}) of insecticides against neonate larvae of *S.inferens* on maize crop during spring 2013-14

Treatments	Regression Equation	LT_{50} (Days)	Fiducial limit
Cartap hydrochloride 4G	–1.798 – 0.305 x	6.85	10.267 ± 4.085
Spinosad 45 SC	–3.292 –0.694 x	7.71	9.608 ± 5.936
Buprofezin 25% SC	–2.895 – 0.638 x	5.14	8.56 ± 2.284
Imidacloprid 70 WG	–4.609 – 1.036 x	5.93	7.68 ± 3.96
Thiamethoxam 25 WG	–3.980 – 0.775 x	6.50	7.881 ± 5.031
Fipronil 0.3 G	–4.131 – 0.854 x	6.64	8.64 ± 4.60
Emmamectin benzoate 5WG	–1.708 – 0.429 x	7.10	13.802 ± 3.400
Chlorantraniliprole 18.5 SC	–2.834 – 0.414 x	7.11	12.24 ± 3.92
Carbofuran 3G	–2.041 – 0.459 x	8.62	14.020 ± 5.22

Table 2: Residual Toxicity (LT_{50}) of selected insecticides against neonate larvae of *S.inferens* on maize crop during spring 2014-15

Treatments	Regression Equation	LT_{50} (Days)	Fiducial limit
Cartap hydrochloride 4G	–2.406 – 0.510 x	6.62	9.45 ± 4.179
Spinosad 45 SC	–3.311 – 0.693 x	7.51	9.334 ± 5.75
Buprofezin 25% SC	–5.422 – 1.175 x	5.65	6.73 ± 4.46
Imidacloprid 70 WG	–4.609 – 1.036 x	5.93	7.183 ± 4.573
Thiamethoxam 25 WG	–4.259 – 0.879 x	6.08	7.384 ± 4.708
Fipronil 0.3 G	–4.956 – 1.001 x	6.45	7.672 ± 5.159
Emamectin benzoate 5 WG	–1.837 – 0.437 x	6.82	11.140 ± 3.882
Chlorantraniliprole 18.5 SC	–1.716 – 0.431 x	7.41	12.602 ± 4.331
Carbofuran 3G	–2.118 – 0.465 x	8.65	12.81 ± 5.74

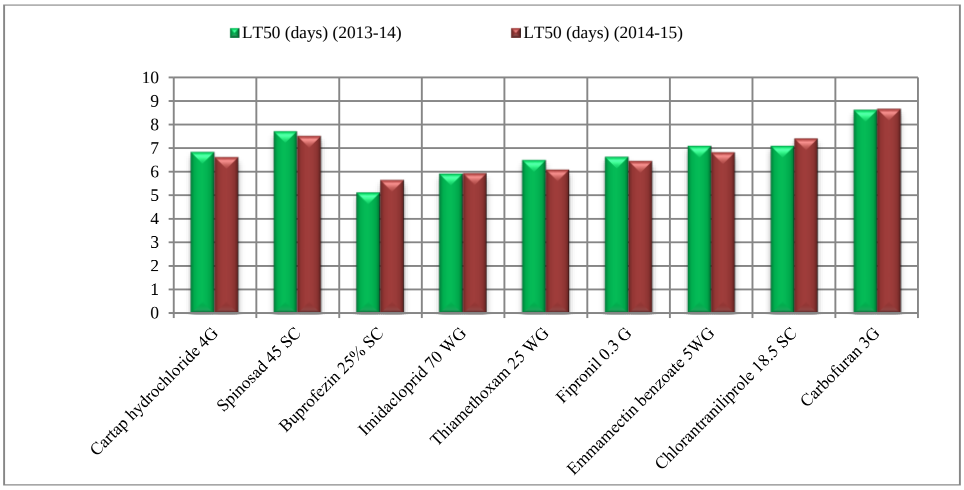

Fig 2: Residual Toxicity (LT_{50}) of insecticides against neonate larvae of *S. inferens* on maize crop under laboratory condition during spring 2013-14 and 2014-15

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