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Field resistance of *Spodoptera litura* (Fab.) to conventional insecticides in India

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ABSTRACT

The present study was carried out to evaluate conventional insecticide resistance in populations of *Spodoptera litura* (Fab.) from seven different soybean-growing districts (Dharwad. Belgaum, Pune, Parbani, Adilabad, Hyderabad and Indore) of India. Experimental results revealed among the three chemical insecticides bioassayed, quinolphos 25 EC registered the highest LC_{50} value (29.7 mg a.i./L) followed by chlorpyrifos 20 EC (18.3 mg a.i./L) while the lowest LC_{50} value was found for lambda-cyhalothrin 5 EC (1.3 mg a.i./L) in a susceptible population of *S. litura* larvae. Evaluation of the seven different populations of *S. litura* from India showed that populations from Adilabad and Pune exhibited elevated LC_{50} values for chlorpyrifos [(1622.0 mg a.i./L) and (1137.0 mg a.i./L)], quinolphos [(1892.0 mg a.i./L) and (1744.0 mg a.i./L)] and lambda-cyhalothrin [(56.4 mg a.i./L) and (41.6 mg a.i./L)], respectively. Seven different *S. litura* populations collected varied in their resistance ratio (RR) for three conventional insecticides used in this study. For chlorpyrifos RR values ranged from 3 to 88 fold, for quinolphos RR values ranged from 3 to 63 fold and for lambda-cyhalothrin RR values ranged from 2 to 42 fold in the seven different *S. litura* populations compared to the susceptible population. Based on the raised LC_{50} values, the resistance is quite concerning for organophosphates (chlorpyrifos and quinolphos). The present study is a warning bell suggesting the cautious use of organophosphates and lambda-cyhalothrin in soybean.

1. Introduction

The tobacco caterpillar, *Spodoptera litura* Fab. (Lepidoptera, Noctuidae) is well known as a serious cosmopolitan pest with extensive host range of economically important crops such as cotton, groundnut, soybean, tomato, sweet potato, and many other crops (Sahayaraj and Paulraj, 1998). *Spodoptera litura* was the first lepidopteran to develop insecticide resistance in India (Srivastava and Joshi, 1965). By 1965, resistance to Benzene Hexa Chloride (BHC) was reported in field populations from Rajasthan (Srivastava and Joshi, 1965) and by early 1970s to endosulfan and carbaryl in Haryana (Verma et al., 1971) and West Bengal (Mukherjee and Srivastava, 1970). In the early 1980s, populations in the south Indian state of Andhra Pradesh were shown to be highly resistant to lindane, endosulfan, carbaryl and malathion (Ramakrishnan et al., 1984). High level of resistance to different groups of synthetic pyrethroids has also been detected in the field strains of *S. litura* (Mayuravalli et al., 1985; Dhingra and Swarup, 1990). *Spodoptera litura* has been reported to develop resistance to insecticides belonging to organophosphates and pyrethroids groups (Armes et al., 1997; Kumar and Ragupathy, 2001; Kranthi et al., 2002). Since the *Spodoptera litura* was found in soybean field crops of India, its damage has increased continually. Its control has depended mostly on application of various conventional and newer insecticides (Conventional insecticides: Insecticides, which were usually or commonly used from long back by large group of farmers to bring down the insect pest population or Insecticides belonging to antiquated type of mode of action on insects and which were applied at higher doses. Newer insecticides: Insecticides belonging to newer chemistry, applied at lower doses with novel mode of action on insects). As a result, many field populations of *Spodoptera litura* have developed high resistance against wide variety of insecticides including organophosphate, carbamate, pyrethroids and some selected newer chemistry insecticides (spinosad, indoxacarb, abamectin, emamectin fipronil) with field control failure observed very frequently (Ahmad et al., 2007a, 2007b, 2008; Saleem et al., 2008). The management of *Spodoptera litura* has therefore become increasingly difficult all over the world and the most

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commonly used insecticides are ineffective in controlling it. The development of resistance is a result of the selection pressure exerted on sprayed populations increasing the frequency of resistant individuals (Torres-Vila et al., 2002), but several factors including temperature are also involved in influencing the evolution of insecticides resistance (Raymond and Marquine, 1994). Previous exposure and selection with spinosad insecticide can confer resistance to newly introduced insecticides like indoxacarb, acetamiprid through cross-resistance in diamond back moth (Sayyed et al., 2008), reducing the effectiveness of many new insecticides. There are some data available on the newer insecticide resistance in *S. litura* from cash crops and vegetables growing countries such as Pakistan (Ahmad et al., 2008; Shad et al., 2012). Due to these resistance reports, it seems that *S. litura* is not being managed effectively with the commonly used insecticides.

Reports showing poor efficacy of the conventional and newer chemistry insecticides against *S. litura* both in cultivated crops and vegetables. Therefore, to supply accurate information for management of resistance and prevent its outbreak in the future, we surveyed *S. litura* larval resistance to the conventional insecticides from major soybean growing agro-climatic zones (central plateau and hills region, western plateau and hills region and southern plateau and hill region) of the India to ascertain whether or not the resistance was indeed evolving. This study is expected to be helpful in devising management strategies to overcome the insecticide resistance problems and to manage *S. litura* under field conditions in the future.

2. Materials and methods

2.1. Collection of larvae

The larvae of *S. litura* population collected from different demographic regions of India *viz*., Karnataka (Belgaum and Dharwad), Maharashtra (Pune and Parbhani), Telangana (Hyderabad and Adilabad) and Madhya Pradesh (Indore) during *kharif* 2014–15. All populations were collected by walking through a one-hectare block of soybean crop in a zig-zag manner to get mixed population from various locations and brought to laboratory. The larva were reared on castor leaves in the laboratory at 25 ± 3 °C and 65 ± 5% RH in plastic trays for two generations before the bioassays were carried out. Castor leaves were replaced in trays after 24 h and pupae were collected. Moths were shifted to glass cages with mesh sides for ventilation and fed on a solution containing 10% honey soaked onto cotton wool ball (Ahmad et al., 2007b). The neonate larvae were fed with castor leaves. The field-collected populations were reared in the laboratory to acclimate to laboratory conditions and to obtain sufficient insect numbers for bioassay. A laboratory susceptible population of *S. litura* was obtained from National Bureau of Agriculture Insect Resources (NBAIR), Bengaluru at pupal stage was designated as susceptible population. This *Spodoptera litura* strain was obtained by single pair crosses of field-collected population of *S. litura* and reared in the laboratory for six years without exposure to insecticides.

2.2. Bioassays

Three conventional insecticides used in present study were chlorpyrifos 20 EC (Krush, Biostadt India Ltd., Mumbai, India), quinolphos 35 EC (Tricel, Excel Crop care Ltd., Mumbai, India) and lambda-cyhalothrin 5 EC (Karate, Syngenta Chemicals Pvt. Limited, Hyderabad, India). Bioassays were conducted with early third-instar larvae of *S. litura* using a standard leaf disk method (Ahmad et al., 2007b; Litchfield and Wilcoxon, 1949). Serial dilutions as mg/L of the active ingredient of the test compounds were prepared using 0.1 per cent triton X-100 in water. Dose range tested for serial dilution of both chlorpyrifos 20 EC and quinolphos 35 EC insecticides was 10–2000 mg a.i/L, whereas for lambda-cyhalothrin 5 EC it was 1–100 mg a.i/L. Castor leaves were cut into small, 9 cm diameter pieces and dipped into the insecticide solution for 10 s. These leaves were air dried at ambient temperature for 5–10 min by spreading on a towel paper. Leaves were dipped in sterile distilled water and 0.1% triton X-100 only to use as controls. Leaves treated with insecticides were then transferred to each petri dish lined with moistened filter paper. Least six concentrations and three replications (10 larvae per replication) were used to estimate mortality at each concentration, total number of tested larvae per concentration were 30. The bioassays were kept at a temperature of 25 ± 3 °C, 65 ± 5% relative humidity and photoperiod of 16:8 (light: dark). Mortality data were scored 48 h after exposure to insecticides. Larvae were considered dead if they failed to make a coordinated movement when prodded with a brush.

2.3. Data analysis

Data obtained were corrected for control mortality using Abbott's formula (Abbott, 1925) wherever necessary and were analyzed by probit analysis through SPSS 16.0 software to estimate LC_{50} values and their 95% fiducial limits (FLs). Resistance ratios (RRs) were determined as LC_{50} values of field strain/LC_{50} values of Laboratory. LC_{50} values were considered significantly different when they did not overlap with each other at their respective 95 per cent fiducial values (Litchfield and Wilcoxon, 1949). A regression was setup based on probit analysis. In statistical package SPSS 16.0, following columns (variables), the response frequency, total observed, and covariates were selected with mortality, total insects and concentrations of insecticides, respectively. Finally an option was selected to transform concentrations to log base 10. The slope for regression line was compared with 't' test using SPSS 16.0 software. A cross-resistance was determined among the tested insecticides by pairwise correlation coefficients of LC_{50} values of the field populations by the Karl Pearson correlation using SPSS 16.0 software.

3. Results

3.1. Toxicity of conventional insecticides to susceptible (laboratory) population

The results of bioassays for conventional insecticides against laboratory population of *S. litura* showed that there was no overlap of toxicity between tested insecticides. Among insecticides tested (Chlorpyrifos 20 EC, Quinolphos 25 EC and Lambda-cyhalothrin 5 EC), Quinolphos was less toxic (29.7 mg a.i/L) than Chlorpyrifos (18.3 mg a.i/L) and Lambda-cyhalothrin (1.3 mg a.i/L). From LC_{50} values, most toxic insecticide was Lambda-cyhalothrin than Chlorpyrifos and Quinolphos.

3.2. Toxicity of conventional insecticides to field populations

Log dose probit analysis was carried out for commonly used conventional insecticides for control of *S. litura* larvae in soybean ecosystem. Chlorpyrifos 20 EC, Quinolphos 25 EC and Lambda-cyhalothrin 5 EC were most commonly used across seven different geographic populations of *S. litura* representing major soybean growing areas of India. The results were presented insecticide wise. Resistance ratio (RR) was worked out by comparing LC_{50} of a particular location population to the LC_{50} of the susceptible population. All the LC_{50} values presented in this paper are in milligrams of active ingredient per liter (mg a.i/L) units.