TOXICITY OF FOLIAR INSECTICIDES TO LADYBIRD BEETLE PREDATOR OF GREEN PEACH APHID, *MYZUS PERSICAE* (SULZER) ON POTATO VARIETIES

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ABSTRACT

Field experiments were conducted in Research Farm of Agricultural University, Peshawar, Pakistan during 2007-09 to develop IPM package for green peach aphid, Myzus persicae (Sulzer) on potato crop having minimum adverse effects on ladybird beetle. The population means of ladybird beetles per 10 plants showed significant effect (P < 0.05) for potato varieties (3.1 on Desiree and 3.6 on Kuroda), foliar insecticides (2.9 on Actara and 3.8 on Provado), and foliar insecticide doses (0.9 on labeled dose, 2.7 on reduced dose and 6.5 on zero dose). Both the insecticides at either dosage significantly reduced the ladybird beetle population as compared to Zero dose (6.53). However, plants treated with Provado reduced dose had significantly higher population of ladybird beetles (3.63) as compared to Actara reduced dose (1.67), Provado labeled dose (1.17) and Actara labeled dose (0.63) that did not differ statistically. On average; the yield in tons/hec was significantly higher from Kuroda (13.2) as compared to Desiree (11.6); Provado treated plants (12.9) as compared to Actara (12.0); and labeled (13.4) or reduced (13.4) doses as compared zero doses (10.5). The tuber yield obtained from the plants treated with Provado reduced doses (14.07) and Provado labeled doses (13.95), both being statistically equal, was significantly higher than Actara reduced doses (12.81) and Actara labeled doses (12.79).

Key Words: Ladybird beetle, coccinellids, Green peach aphid, *Myzus persicae*, thiamethoxam, imidacloprid, Actara, Provado, potato.


INTRODUCTION

Potato is one of the major staple food crops of the world (Mughal and Bismillah, 1988) and nearly one third of it is produced in developing countries of Asia (Beukerna and Van Der Zaag, 1990). Its production is always at risk from Green peach aphid (*M. persicae*) infestation that produces direct losses by distortion of leaves, and indirect losses up to more than 50% by transmission of viral diseases (Sjekhawat, 1990; Mau and Kessing, 1991; Karimullah et al. 1995a; Karimullah et al. 1995b; Blackman and Eastop, 2000; Capinera, 2001; Mowry, 2001; Saljoqi and van Emden, 2003b; Saljoqi, 2009).

The more sustainable approach in IPM of *M. persicae* include resistant variety, conservation of natural enemies, pesticides with lower toxicity to non target organisms, and virus free seed stock (Boiteau et al., 1995; Cloutier et al., 1995; Hapten, 2007; Edward, 2008). Potato varieties show potential, moderate and no resistance to *M. persicae* (Tobias and Olson, 2006) while *M. persicae* cultured on transgenic Bt and wild (non-Bt) potatoes are found suitable food for the most abundant ladybird beetle based on the rate of larval development, larval mortality and adult fresh weight. Females of ladybird beetle fed with *M. persicae* cultured on Bt potato, or on non-Bt potato or on a mixture of *M. persicae* from Bt potatoes and *Aphis craccivora* Koch, lay a little more eggs than those fed only with *A. craccivora* (Kalushkov and Hodek, 2005).

*M. persicae* number is reduced by up to 68% by natural enemies including coccinellids (Karley et al., 2003). In potatoes coccinellids feed on *M. persicae* and eggs of the Colorado potato beetle *Leptinotarsa decemlineata* Say (Moschetti, 2003). Aphids and ladybird beetle populations are aggregated during the peak population period (Park and Obrycki, 2004), as *M. persicae* are essential prey and support the development and reproduction of ladybird beetle. *M. persicae* significantly increase adult longevity, fecundity and fertility of ladybird beetle. The predator’s population growth parameters, $R_0$, $r_m$ and $\lambda$ are increased with *M. persicae*. The 4th instar larvae are the most voracious, particularly when fed on *M. persicae* (Cabral et al., 2006).
Natural enemies rarely keep the population of *M. persicae* below damaging level as such its management is primarily by insecticides (Radcliffe, 1998; Natwick et al., 2002). Pesticides, no matter how good it is, have non-target adverse effects and are thus extremely important in predator/prey systems for IPM (Dent, 2000). Systematic chemical applications has led to population levels of *M. persicae* that are hard to control, both because of the elimination of natural beneficial fungi, predators, parasitoids and the appearance of cross resistance to most families of insecticides (Devonshire and Moores, 1982; Radcliffe, 1998; Godfrey and Haviland, 2003). However, selective insecticides allowed conventional growers to achieve predator densities similar to those seen in organic fields (Koss et al., 2005).

Effectiveness of two insecticides namely Provado 1.6 F (imidacloprid) and Actara 25 WG (thiamethoxam) at labeled and reduced doses on Kuroda and Desiree potato varieties against *M. persicae* was reported in earlier study (Khan et al., 2011). In present study the impact of these variables on the population density of ladybird beetle was assessed. Impact/toxicity of the insecticides was based on minimum adverse/detrimental effects in term of reduction of the number of ladybird beetles per ten potato plants as compared to control. Difference in yield between Kuroda and Desiree due to various treatments was also recorded.

**MATERIALS AND METHODS**

**Plant Materials**

Two potato varieties Kuroda and Desiree found as partially resistant and susceptible, respectively, (Khan et al., 2011) were planted in furrows at the Research Farm of Agricultural University, Peshawar, Pakistan during spring 2008. Plant-to-plant and row-to-row distance was kept at 20 cm and 75 cm, respectively (Saljoqi and van Emden, 2003a). Well rotted farmyard manure at the rate of 30 t/ha, twenty days before planting (Mahmood, 1994), and DAP at the rate of 39 kg P/ha during land preparations were incorporated into the soil (Khurana et al., 2004; Shivay, 2010). Urea was applied after a month of sowing at the rate of 180 kg/ha (Khurana et al., 2004). Irrigation, hoeing, weeding and earthen-up were done when needed.

**Insecticides**

Provado 1.6F (imidacloprid) and Actara (thiamethoxam), each at two dosage rates (Table I), were applied as foliar spray seven weeks after sowing when *M. persicae* populations reached 10 to 12 aphids per 9 compound leaves on Kuroda variety (Wyman, 2005; Edward, 2008). Knapsack sprayer was used for insecticides application.

<table>
<thead>
<tr>
<th>Foliar Insecticide</th>
<th>Dose</th>
<th>Amount/rate of Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provado 1.6F</td>
<td>Zero dose</td>
<td>No insecticide (Control)</td>
</tr>
<tr>
<td></td>
<td>Labeled dose</td>
<td>277.98 ml of the product/hectare</td>
</tr>
<tr>
<td></td>
<td>Reduced dose</td>
<td>222.39 ml of the product/hectare</td>
</tr>
<tr>
<td></td>
<td>(Labeled dose reduced by 20%)</td>
<td></td>
</tr>
<tr>
<td>Actara 25WG</td>
<td>Zero dose</td>
<td>No insecticide (Control)</td>
</tr>
<tr>
<td></td>
<td>Labeled dose</td>
<td>131.70 gm of the product per hectare</td>
</tr>
<tr>
<td></td>
<td>Reduced dose</td>
<td>105.26 gm of the product per hectare</td>
</tr>
</tbody>
</table>

**Experimental Design**

Representing two potato varieties, two insecticides, three insecticides doses (including zero dose as control), and three replication; there were 36 subplots/experimental units, and setup in “Factorial Randomized Complete Block Design”. The size of each experimental unit was nine square meters and kept apart from other by 3 meters (Saljoqi and van Emden, 2003a).

**Data Collection**

Populations of Ladybird beetle were recorded on 1, 2, 3, 10 and 18 days of the post spray on ten plants per experimental unit while walking in a predetermined pattern (X) through the field.

**Yield**
The crop was harvested manually. The yield obtained for each treatment was measured in Kilograms and converted into tons per hectare for analysis.

**Statistical analysis**

The data were analyzed using MSTATC package by analysis of variance of ‘three factors randomized complete block design’. Means were compared using LSD test at 5% level of significance (P < 0.05).

**RESULTS AND DISCUSSION**

**Effect of Insecticides on Ladybird Beetle Population on Two Potato Varieties**

Population of ladybird beetles was significantly affected (P < 0.05) due to potato varieties, foliar insecticides and insecticides dosage rates Fig 1.

![Fig. 1. Effect of potato varieties, foliar insecticides and foliar insecticides doses on the population means of coccinellids “ladybird beetles” in potato crop](image)

Means followed by same letter(s) are not significantly different at 5% level of significance using LSD Test (P < 0.05)

Density of the ladybird beetles on Kuroda (3.6 beetle/10 plants) was significantly higher than Desiree (3.1 beetles/10 plants). Higher population of ladybird beetles on Kuroda may be linked with their preference for comparatively sluggish or sessile and relatively small aphids with thin cuticles that are easy prey (Balduf, 1939). Moreover, higher sensitivity of *M. persicae* to insecticides on Kuroda might result in lesser intoxication and in return higher populations natural enemies than Desiree (Mohamed and van Emden, 1989; Saljoqi and van Emden, 2003a; Liu et al., 2003; Khan et al., 2011). Scarcity of high quality prey (aphids) and the availability of other key resources essential for compatibility with the biological control agents may also be higher on Kuroda than on Desiree (Picard-Nizou et al., 1995; Cottrell and Yeargan, 1998; Elliott et al., 1998; Verkerk et al., 1998; Cortesero et al., 2000; Coll and Guershon, 2002; Sutherland and Poppy, 2004; Wäckers, 2005; Obrist et al., 2006; Lundgren, 2009; Lundgren et al., 2009). Fecundity of natural enemies are not affected when they are fed aphids reared on induced resistance potato plants that may be due to very low levels, or a complete lack, of Cry protein in the phloem consumed by the aphid (Davidson et al., 2006). The ladybird beetles do not respond to headspace chemicals from aphids alone. Aphid-induced plant chemicals could act as an arrestment or possibly an attractant stimulus to *C. septempunctata*. The effectiveness of *C. septempunctata* as natural enemies of *M. persicae* may be strongly affected by cultivar being grown (Girling and Hassal, 2008).

Density of the beetle was significantly lower on Actara treated plants (2.9 beetles/10 plants) than Provado (3.8 beetles/10 plants), which revealed that imidacloprid is comparatively less toxic to natural enemies (James and Coyle, 2001; Youn et al., 2003). Saljoqi et al. (2009) also recorded lower mortality or lesser toxic effect of imidacloprid to ladybird beetle (*C. septempunctata*), syrphidfly (*E. balteatus*), green lacewing (*C. carnea*) and *M. persicae* mummies being parasitized by *A. matricariae* when applied to manage *M. persicae* in potato crop.
Imidacloprid have low/non toxic effect on ladybird beetle (Elzen, 2001; Gautam and Tesfaye 2002; Varghese and Beevi, 2004; Walker et al., 2007).

The labeled doses of insecticides reduced the beetle population significantly (0.9 beetles/10 plants) than reduced doses (2.7 beetles/10 plants), as compared to highest (6.5 beetles/10 plants) on zero doses/untreated/control plants. The interaction insecticides x insecticides doses revealed significant effect (Fig 2). At zero dose of Provado and Actara the beetle’s density was similar (6.53/10 plants). Plants treated with Provado reduced dose had significantly higher population (3.63/10 plants) of ladybird beetle than Provado labeled (1.17/10 plants), Actara labeled (0.63/10 plants), and Actara reduced doses (1.67/10 plants) that were statistically not significantly different. It may be explained as that the susceptibility of natural enemies to insecticides might be due to their slow development (Radcliffe, 1998) however reduced doses and selective insecticides encouraged the activity of ladybird beetle (Moschetti, 2003; Galván et al., 2005). The lesser toxicity of the Provado reduced doses as compared to reduced and labeled doses of Actara suggested that selection of right insecticides and at lesser concentrations would help in conservation of natural enemies. According to Koss et al. (2005), selective soft/diluted insecticides allowed conventional growers to achieve predator densities similar to those seen in organic fields.

![Fig. 2. Interaction effect of foliar insecticides x doses (I x D) on the population means of coccinellids “ladybird beetles” in potato crop (averaged over varieties)](image)

Means followed by same letter(s) are not significantly different at 5% level of significance using LSD Test (P < 0.05)

**Effect of Insecticides on Yield of Two Potato Varieties**

The potato yields showed significant effect (P<0.05) due to foliar insecticides, dosage rates and the potato varieties (Fig. 3). Kuroda yield (13.2 tons hec⁻¹) was significantly higher than Desiree (11.6 tons hec⁻¹). Provado treated plants gave higher yield (12.9 tons hec⁻¹) as compared to Actara treated plants (12.0 tones hec⁻¹); similarly plants treated with labeled and reduced doses of insecticides gave higher yield (13.4 tones hec⁻¹) than untreated plants (10.5 tones hec⁻¹).
Fig. 3. Effect of potato varieties, foliar insecticides and insecticide doses on the yield means of potato tubers in tons/ha.

Means followed by same letter(s) are not significantly different at 5% level of significance using LSD Test (P < 0.05)

The interaction of insecticides x insecticides doses revealed significant effect (Fig 4). At zero dose of Provado (10.58 tones ha⁻¹) and Actara (10.34 tones ha⁻¹) potato yield was statistically similar however both of these were significantly lower treated plants. The tubers yield from plants treated with Provado labeled (13.95 tons ha⁻¹) and reduced dose (14.07 tons ha⁻¹) was significantly higher than the plants treated with Actara labeled (12.79 tons ha⁻¹) and reduced doses (12.81 tons ha⁻¹). However, Provado reduced and labeled doses did not differ for yield; similarly, Actara labeled and reduced doses did not differ for yield.

Fig. 4. Interaction effect of foliar insecticides x insecticide doses (I x D) on the yield means of potato tubers in tons/hectare.

Means followed by same letter(s) are not significantly different at 5% level of significance using LSD Test (P < 0.05)

The higher yields from Kuroda variety may be linked with healthy plants, lower population of *M. persicae*, non development of viral diseases associated with pests, and higher population of natural enemies. Similar results were achieved by Saljoqi and van Emden (2003a). Further, these results were in conformity with that of Raman and Midmore (1983) whereby foliar-applied insecticide reduced *M. persicae* pest damage and increased yields significantly. According to Abdalla et al. (1995) chemical control resulted in a significantly higher yield as compared with the untreated plants in both summer seasons.
CONCLUSION AND RECOMMENDATIONS

The higher population of ladybird beetles on Kuroda reveals that coccinellids are more attracted to resistant varieties; and the study of toxicity of foliar insecticides to ladybird beetle on comparatively susceptible Desiree and resistant Kuroda potato varieties provides solid and valuable basis. Significant reduction in ladybird beetles population by each insecticide (Provado 1.6F and Actara 25WG) at both the dosage suggests wise application/selection of insecticides. Statistically higher population of ladybird beetles on plants treated with Provado (imidacloprid) reduced doses as compared to labeled doses of Provado and either dose of Actara (thiamethoxam) reveals that imidacloprid/selective insecticide at reduced dose is comparatively friendlier to natural enemies. Higher yield from Kuroda treated with either dose of Provado as compared to either dose of Actara reveals that healthy/resistant plants and more effective foliar insecticide against M. persicae (Khan et al., 2011) with least adverse effect on natural enemies contributes to higher yield.

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