Bio-efficacy of Different Insecticides on Colorado Potato Beetle, _Leptinotarsa decemlineata_ (Coleoptera: Chrysomelidae) in Bamiyan Province, Afghanistan

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**ABSTRACT**

Potatoes are dominantly cultivated in Bamiyan province and play an important role in food safety inside the country. Colorado potato beetle is a major pest of potatoes that decreases the yield and quality of the potatoes. In this study evaluated the effect of different insecticides on the management of the Colorado potato beetle, _Leptinotarsa decemlineata_ (Coleoptera: Chrysomelidae), in Bamiyan province of Afghanistan. The study was carried out in Kahmard District of Bamiyan province, in 2018. The experiment was laid out in Randomized Complete Block Design (RCBD) using 700 ml/hectare of imidacloprid SL and 900 ml/hectare of cypermethrin EC, carbaryl EC, deltamethrin EC, and chlorpyrifos SL with three replications. The data were recorded 1 day before the application of each insecticide and at 3, 5 and 7-days intervals post-application. The statistical analyses showed that cypermethrin EC was the most effective in comparison to other insecticides for reducing the Colorado potato beetle population resulting in an increase in yield. Non-treated plots had a significantly higher number of Colorado potato beetle in comparison to insecticide-treated plots. However, no significant difference was seen within the insecticide-treated plots. Insecticide-treated plots had significantly higher yields in comparison to non-treated ones.

**INTRODUCTION**

Potato ( _Solanum tuberosum_ L.) is one of the four major crops in the world after the wheat, corn and rice that is widely produced and consumed around the world (Voll and Börnke, 2010; Jiang _et al._ 2010). In terms of total production quantity and production, it is the number one product in the world related to a yield of 322 million tons from 19.9 million hectares (Raymundo _et al._., 2014; Lübeck, 2010). It is one of the most widely grown crops, especially in developing countries. In 2008, the United Nations celebrates "World Potato Year" to recognize the essential importance of potatoes as the primary food of mankind and the position of potatoes in world agriculture, economics and food security (Lübeck, 2010; Bovell-Benjamin, 2007; Coombs _et al._, 2003). Potato grows in more than 150 countries from latitude 65 N to 50 S and up to 4000 meters above sea level. The current edition of the World Catalog of Potatoes lists more than 4,200 different potato varieties from over 100 countries, given that this remarkable change depends on a relatively narrow
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genetic base, a remarkable achievement of 150 years of traditional potato production (Voll and Börnke, 2010; Raymundo et al., 2014). The potato in Afghanistan is one of the important food crops widely grown in the central and northern parts of the country (Kugbei, 2011). In recent years, the International Center for Agricultural Research in Dry Areas (ICARDA) and the International Potato Center (CIP) have introduced the high-yielding potato variety Kufri Chandramukhi (KCM) in Baharak district of Badakhshan province, Afghanistan (Buerkert et al., 2006; Srinivas et al., 2012). Although most of Afghanistan's provinces have good agro-climatic conditions for producing potatoes, more than seventy percent of Afghanistan's potatoes are produced in Bamiyan province (Spit et al., 2017). Many kinds of insect pests attack potatoes that affect the yield and quality of tubers and if control measures are not taken regularly they are capable of decreasing the total yield by 30 to 70 percent. Colorado potato beetle (CPB) is among the many leaf-feeding insects that attack potatoes and is known as the most destructive insect of potatoes (Felton et al. 1992; Kennedy, 2009; Alyokhin et al., 2008). A lot of researchers have reported the damage caused by the Colorado potato beetle at various stages of potato growth. Colorado potato beetle, *Leptinotarsa decemlineata* (Coleoptera: Chrysomelidae), is one of the most dangerous and devastating, leafless insect pests of potatoes (Cañas et al., 2002; Ghidiu 1990). Unless this pest is controlled, it can significantly reduce the potato yield. In addition to potato, the CPB can also cause damage to other related crops. The Colorado potato beetle, native to Mexico, was recorded in the United States in 1811 and feeding on native plants, buffalo bur (*Solanum rostratum*), near the Iowa-Nebraska border (Outchkourova et al., 2003; Lawrence et al., 2008; Alyokhin et al., 2006). It was first reported as a potato pest in Nebraska in 1859, and its host range, including potatoes, allows the beetle to spread rapidly eastward and move through farmland and garden plantations. By 1874, it had spread to the east coast of the United States (O’Neil et al., 2016). Potato beetle now occurs in most of North America in most parts of Canada, Mexico, and throughout the United States, Nevada and the Pacific Northwest, between latitudes 15 to 55 °C. Since 1922 the pest has spread to the European countries and the former Soviet Union and now it has been found all around the world. Although geographic populations are limited in their ability to use specific plant species as hosts, the preferred host for most of their populations is potatoes. Depending on the latitude and longitude and availability of host plants, it can typically produce one to three generations per year (Pariera Dinkins et al. 2008). Adults typically eat 130 to 1200 mm of potato foliage daily and are highly fertile, with approximately 3,000 yellow eggs deposited in clusters of 10 to 50 eggs on the lower surface of the host leaves the duration of several weeks (Ashouri, 2001). Colorado potato beetle is primarily a potato pest, but it can also attack tomato (*Solanum esculentum*) and eggplant (*S. melongena*) (Wright and Ramos, 2002; Johnson, 2009). In potatoes, the decline in yield is related to both the rate of leaf excretion and the stage of plant growth during which it occurs (Zhu et al., 2011; Poprawski et al., 1997). The decreased yield of tomatoes and eggplant is caused by damage to fruits and also compensation (Scott et al., 2003; Hussein et al., 2012). The current research was conducted to study the population of Colorado potato beetle in Kahmard district of Bamiyan province and to find out the efficacy of various insecticides for the management of CPB.

**MATERIALS AND METHODS**

1. **Location and the Potato Cultivars:**

A local potato variety “Safed gul” was obtained from the farmers and planted on 5 March 2018, in the Kahmard district of Bamiyan pronounce of Afghanistan with a latitude and longitude 35° 22’’ north, 680 6’ east. The experiment was designed in a
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Complete Randomized Block Design (CRBD) with six treatments and three replications. The total number of plots was 18 and each plot size was 1m x 3m. The distance between plant-plant was kept at 60cm. The distance between treatments was 20m to prevent the moving of Colorado potato beetle. The distance between treatments was cultivated wheat and Total cultivation methods were performed locally.

2. Fertilizers and Insecticides:

The rate of DAP & Urea was used as 100 kg/ha and 90 kg/ha, respectively. The insecticides were purchased from the local markets and applied at different rates. Insecticides were used when the population of Colorado potato beetle reached the economic threshold level (ETL). The insecticides application rate were as follows: imidacloprid SL 700 ml/hectare, cypermethrin EC 900ml/hectare, carbaryl EC 900 ml/hectare, deltamethrin EC 900 ml/hectare and chlorpyrifos SL 900 ml/hectare. Only water was applied as a control treatment. Insecticides were applied with a knapsack sprayer two times during the growing season.

3. Determining the Colorado Potato Beetle Population:

The number of Colorado potato beetles was counted two times before the spraying. After the application of insecticides, the number of Colorado potato beetles was recorded at 3, 5 and 7-days intervals. Before and after the application of insecticides, the number of Colorado potato beetles was recorded at regular intervals from randomly selected five plants from each sampling unit.

4. Yield Assessment:

After the end of the growth period and complete drying of the potato leaves, the performance of all cultured treatments was examined separately. Potato tubers were mechanically harvested and the obtained weight in the calculation area was evaluated at hectare.

5. Data Analysis:

The mean data from 3 replications were analyzed with a one-way analysis of variance (ANOVA) using Statistical Analysis Software (SAS) (SAS Institute, 2002) and the means were compared with the least significant difference (LSD) for significant differences between the variables. The bio-efficacy percentage was calculated by using the method reported previously by Shiberu and Negeri, (2014).

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\text{Reduction efficacy } \% = \frac{\text{Control count} - \text{Post spray count}}{\text{Control count}} \times 100
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RESULTS

Colorado potato beetle populations were recorded before and after the insecticides’ application in the experimental area. The analyses of variance indicated that there were no significant differences between treatments before the application of the insecticides \((F=2.11, df=5, P=0.1469)\) however, a significant difference was observed after the application of insecticides in comparison to control \((F=76.79, df=5, P=0.001)\) (Fig.1). Had a highly significant effect on the densities.

The data showed that the efficacy of cypermethrin EC was a little better among all applied insecticides for decreasing the population of Colorado potato beetles after two times application of the insecticides and followed by imidacloprid SL while the remainder of insecticides had a similar effect on significantly reduced Colorado potato beetles. The analysis of reduction efficacy showed that the treated plots had a significantly higher percentage in comparison to the control plot \((F=209.51, df=5, P=0.001)\) and, no significant difference between insecticides-treated plots were observed (Fig. 2). The results of reduction efficacy % show that the number of CPB per plant after two times application of insecticides was slightly higher in plots treated with cypermethrin EC and followed by
imidaclorid SL. Potato weights were measured in ha. The results of Tukey's experiment showed that the performance of treatments using insecticides was significantly higher than control ($F= 376.13, df= 5, P= 0.001$). The highest yield was recorded in plots treated with cypermethrin EC and followed by deltamethrin (Fig. 3).

**Fig. 1.** Average number of Colorado potato beetles pre/post application of the insecticides. Different letters show the significant difference between the treatments at $P<0.05$. Bars indicate the standard error.

**Fig. 2.** Reduction percentage of Colorado potato beetle populations after using the insecticides. Different letters indicate significant difference between treatments after the application of the insecticide by using Tukey LSD. Bars indicate standard error of the means.
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![Average yield per kg / ha ± SE](image)

**Fig. 3.** Average yield of potatoes in experimental plots treated with insecticide in compare to non-treated ones. Different letters indicate significant differences between treatments after application of the insecticides by using Tukey LSD. Bars indicate standard error of the means.

**DISCUSSION**

The result of the preliminary assessment of the study area showed that the Colorado potato beetle infestation was high and specifically damage was increased to the crop in the Bamiyan province of Afghanistan from late May to June. Costa et al., 2001; applied botanical insecticides i.e. Piper nigrum and Piper tuberculatum which belong to the family of Piperaceae for the management of different larval and adult stages of Colorado potato beetle in the laboratory and field conditions and indicated that 4 days old larva is the most susceptible than other larval stages and adult in both conditions. San Miguel and Scott, 2016; evaluated the efficacy of Cry 111A δ-endotoxin of bacillus thuringiensis Berliner and Beauveria bassiana for the management of Colorado potato beetle and indicated that the effect of Beauveria bassiana is better than δ-endotoxin. Duan et al., 2009; reported that the foliar application of the Colorado potato beetle dsRNA actin is very effective for the management of Colorado potato beetle, indicating that actin-dsRNA treatment protects potato plants for at least 28 days under greenhouse conditions and finds that dsRNA is readily available. It is not removed by water after drying on leaves. Šmid et al., 2015; applied non-targeted effects of transgenic potato Bt (Newleaf) Cry3Aa protein expression obtained from Bacillus thuringiensis (BT) Berliner subsp. tenebrionis and conventional insecticides (Permethrin) for the management of Colorado potato beetle and showed that the effect of the selected insecticides was not significantly different.

Lawrence et al., 2008; utilized the Clitocybin, a fungal cysteine protease inhibitor, exerts its insecticidal effect on the Colorado potato beetle larvae by inhibiting their digestive cysteine proteases and appears to successfully prevent the growth of Colorado potato beetle larvae. Johnson et al., 2009; applied unformulated conidia of Beauveria bassiana with Perillus bioculatus and without Perillus bioculatus and compared their efficacy with current methods of chemical insecticide control for the management of
Colorado potato beetle in the field condition. However, the reduction percentage in the plot treated with *Beauveria bassiana* was 76.6, in chemical insecticides (sphenolate plus piperonyl butoxide and oxamyl plus carbofuran) 50.2 and *Beauveria Perillus* 78. Racca *et al.*, 2014; applied entomopathogenic nematode on potato foliage to manage Colorado potato beetle larvae and found that agar formulation increased nematode survival by providing an appropriate environment and preventing nematode body drying and increasing attack and also provide for nematode gets this chance to invade their host on the foliage. A lot of researchers reported that excessive use of insecticides as an important contributor to resistance development has been extensively recorded in Colorado potato beetle reaching throughout the world. To date, resistance to Colorado potato beetles has been documented against an extensive parameter of insecticides, including organochlorines, organophosphates, arsenic, carbamates, pyrethroids and even neonicotinoids (Kalsi and Palli, 2017; Pariera Dinkins *et al.*, 2008; Wraith and Ramos, 2002; Scott *et al.*, 2003; Palli, 2014). Outchkourov *et al.*, 2003; conducted studies on Colorado potato beetle in the laboratory and field conditions by rearing Colorado potato beetle on eggplant, and concluded that the effect of insecticides (permethrin) was significantly better when reared on eggplant than on potato and tomato. The present study examined the effectiveness of five insecticides including imidacloprid SL, cypermethrin EC, carbaryl EC, deltamethrin EC and chlorpyrifos SL on Colorado potato beetle, the insecticides were selected among different insecticides classes, the results demonstrated that cypermethrin EC has a higher efficacy followed by imidacloprid SL.

**Conclusion**

Although Colorado potato beetles can acquire quick resistance against insecticides, it was found in the present study that the use of insecticides can significantly reduce the damage to Colorado potato beetle. This research concludes that cypermethrin EC was the most effective among other insecticides used for reducing the Colorado potato beetle resulting in an increase in yield. Therefore, using insecticides such as cypermethrin EC and imidacloprid SL at a suitable time and dose can significantly prevent damage to the Colorado potato beetle.

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