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Management of insecticide resistance in soybean aphid in the local condition of Chitwan district of Nepal

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Abstract
The study of management of insecticide resistance of soybean aphid (*Aphis glycine*) has been lacking in the local condition of Chitwan Nepal. Therefore, an experiment in the efficacy of different methods to reduce the resistance of soybean aphid was carried out during Novembre 2013 to February 2014 Agronomy farm of Institute of Agriculture and Animal Science (IAAS), Rampur, Chitwan. Single treatment of abamectin 1.8% EC (Emulsifiable Concentration) and three replication of the same insecticide namely appropriate (dose, time) spray of insecticide (R_1), lower dose than that of recommendation (R_2) and with minimal duration and interval than that of the recommendation (R_3) were major attributes of the study. The research was carried out in split plot design selecting soybean crops. The average numbers of Soybean aphid (SBA) population were found as 1700, 1900, 1900 after 4 days of first treatment in R_1 and R_2 while 7 days of first treatment in R_3 respectively. Initially each plot of replication had 2000 numbers of SBA on average. Similarly, the average numbers of Soybean aphids were noticed to be 1800, 2000 and 1850 after 8 days of first treatment in R_1 and R_2 while 15 days of first treatment in R_3 respectively. Lastly, the average number of aphids was found to be 3700, 750 and 690 8 days R_1 and R_2 while non-countable duration for R_3 after the fifth dose of spray insecticide respectively. The average yield was found to be 1, 2, and 2.3 (in ton/hectare) in R_1, R_2 and R_3 respectively. The value of lower dose applied (R_2) and reduced duration and interval than recommendation of insecticidal plot (R_3) were at par with each other in both the cases. Thus, the insecticide resistance of soybean aphid (*Aphis glycine*) could be managed either by altering (decreasing) the dose of insecticide (abamectin) or by reducing the times and interval of insecticide (abamectin) application in the district.

Keywords: Aphid, insecticide, population, resistance, soybean

Introduction
Aphids (Hemiptera: Aphididae) are considered as the most destructive insect in numerous crops. Aphid makes huge loss of crops (horticulture and agronomy) through sucking plant sap and spreading many diseases as vector. More than 7,757 aphid species have been recognized at global level till date (Misra & Kurl, 1979) [30]. Close interaction with plant and peculiar behavior of aphid such as polyphagous, intricate life cycle and micro generations have made researchers interesting for its investigations (Dixon, 1998) [7]. Faba bean, *Vica faba* L., (also known as fava or broad bean) is considered as important and traditional legume crops and fifth most important pulse crop of world production (Merga *et al.*, 2019) [29]. It is applied for human consumption as well as feed source for livestock (El-Wakeil and Talaat, 2009) [8].

The soybean aphid is an aboveground pest that feeds on phloem sap. The Soyabean aphid (SBA) is a heteroecious, holocyclic species that relies on different host species of buckthorn (genus *Rhamnus* L.) as a primary host and utilizes soybean as a secondary host (Takahashi *et al.*, 1993) [33]. Before emerging in the spring to make generations through sexual reproduction it overwinters and becomes inactive (Voegtlin *et al.*, 2005) [35]. In the late spring or early summer, the aphids develop into alates (winged morphs) and transmit itself to soybean plants, where they feed primarily on the ventral surfaces of young leaves (Clark *et al.*, 2006) [55]. This causes plant to be short with leaf yellowing and wrinkling, minimizing photosynthesis, poor pod fill, reduced seed size and quality with deduction of yield up to 40% (Ragsdale *et al.*, 2007; Beckendorf *et al.*, 2008; Fox *et al.*, 2014) [20, 2, 9].

In the parts of United States the Soybean aphid, *Aphis glycines* (Hemiptera: Aphididae) have distributed largely as a major insect pest of soyabean, *Glycine max* (L.) (Hurley and Mitchell, 2017) [21]. Through the transmission of viruses the Soybean aphid can have initiation of soybean cyst nematode, *Heterodera glycines* Ichinohe, infestations (e.g., *Soybean mosaic virus* and *Alfalfa mosaic virus*) (Hill *et al.*, 2001) [16] and potential facilitation of (McCarville *et al.*, 2012, Clifton *et al*., 2017) [27, 6].

Hanson *et al.* (2017) [12] provided the first evidence for soybean aphid resistance to insecticides including evidence of these insecticides failing to control the pest in North America. Through 2015 to 2016, soybean aphid populations from Minnesota and Iowa reflected resistance ratios up to 40-fold for pyrethroids (i.e., bifenthrin and lambda-cyhalothrin) (Hanson *et al.*, 2017) [12]. In the Asian countries excessive aphicide usage, particularly in populations of the species *Aphis gossypii*, *Myzus persicae*, *Metopolophium dirhodum*, *Aphis glycine* and *Aphis fabae*, have caused high level of insecticide resistance (Carletto *et al.*, 2010; Gong *et al.*, 2011; Bass *et al*., 2014; Khan Mirza *et al.*, 2020) [4, 10, 1, 23]. Soybean aphid has been actively managed since 2000 due to the potential for severe economic impact. Although various pest management strategies are available for example cultural, biopesticide, and biological control but at contemporary situation people largely depend on the foliar application of insecticide (Hodgson *et al.*, 2012) [18]. Application of insecticides in Nepal have heavily increased and the resulted in resistance in insect like Soybean aphid. During evolution, aphids (Soybean) have evolved various strategies to resist or tolerate insecticides.

While the soybean aphid faces the challenge of insecticide resistance some alternative methods to minimize the effect of resistance could be applied. These include treating field with insecticides at minimal period. At regular period the soybean aphids should be checked and manually eradicated in crops like soybean from vegetative growth through the R5 soybean growth stage (Hodgson *et al.*, 2004, Hodgson *et al.*, 2007) [19, 20]. Use of low dose of insecticides as prescribed could be applied to minimize the risk of insecticide resistance by soybean aphid.

In this study different methods of controlling soybean aphid resistance were compared and evaluated in the local condition of Chitwan.

Materials and Methods

The study was carried with one treatment of abamectin and three replications of same abamectin, i.e., appropriately as per recommendation, lower doze than that of recommendation and with minimal duration and interval than that of the recommendation. The research was carried out in split plot design during November 2013 to February 2014 in Agronomy farm of Institute of Agriculture and Animal Science (IAAS), Rampur, Chitwan. The recommended dose applied as per abamectin 1.8% EC was carried 500 ml/ha mixed with 750 liter of water as first replication. Abamectin 1.8% EC with 350 ml/ha mixed with 700 liter of water as lower doze of second replication. Thirdly, the same Abamectin 1.8% EC as per recommended doze applied with lower frequency of 3 application with 15 days interval. The recommended duration was in each 8 days interval for 5 applications in the crop field (Table1). Soybean crop was selected to understand the efficiency of each replication and treatment in reducing aphid resistance with insecticide. The size of the research field was 5*10-meter square. Five sample soybean plants form each five plots were selected for the study.

The recorded data were all tabulated and systematically arranged treatment wise under three replications using MS-Excel which were subjected to Analysis of Variance (ANOVA) and Duncan's Multiple Range Test (DMRT-0.05 level) for mean separations using Gen stat software.

Table 1: Detail of replication, treatment, and insecticide application

Treatment	Replication (R_1)	Replication (R_2)	Replication (R_3)
Abamectin 1.8% EC	Recommended dose of insecticide	Lower dose than recommended	Minimal times/interval than recommended
Application times	5	5	3
Interval of application (days)	8	8	15

Results and Discussion

Effect of insecticide in soybean (*Aphis glycine*) aphid population

It was found that before the application of insecticide (Abamectin) with 2000 (average numbers) aphid population the average numbers of Soybean aphid (SBA) population recorded as 1700, 1900, 1900 after 4 days of first treatment in R_1 and R_2 while 7 days of first treatment in R_3 respectively. Similarly, the average numbers of Soybean aphid observed to be 1800, 2000 and 1850 after 8 days of first treatment in R_1 and R_2 while 15 days of first treatment in R_3 respectively. In third application it was observed that the average numbers of SBA recorded to be 2100, 1500 and 1500 after 4 days of the treatment in R_1 and R_2 while 7 days of treatment in R_3 respectively. The average numbers of aphid found to be 2500, 1200 and 1500 after 8 days of third treatment in R_1 and R_2 while 15 days of treatment in R_3 respectively. The treatment carried for fourth and fifth times in R_1 and R_2 where average numbers of aphids recorded to be 3700, 750 and 690 after 8 days of treatment in R_1 and R_2 while null-interval taken for R_3 respectively (Figure 1).

The application of insecticides in soybean aphid with lower recommended dose and higher period of spray reduces higher numbers of insects while the application of recommended insecticide dose frequently increases numbers of aphids. This may be due to resurgence of insect and growth of resistance of insecticide in insect pest (Koch *et al.*, 2016) [25]. The investigation of Hartman *et al*. (2001) and Hill (2002) [15] reiterates the fact that Soybean aphid *(Aphis glycine*) increases the resistance of insecticides with their frequent application and is also due to the similar types of genetic makeup of the insect which promotes resistance in their body.

When there is likelihood of low population of aphid (SBA) and we apply the insecticides to check their population, then it not only results in return on investment for the application but also increases the threat for adverse consequences such as resurgence of the pest infestation by the impacts to natural enemies which enhances development of insecticide resistance through additional selection pressure (Bortolotto *et al.*, 2015, Koch *et al.*, 2016, 2018) [3, 25, 26].

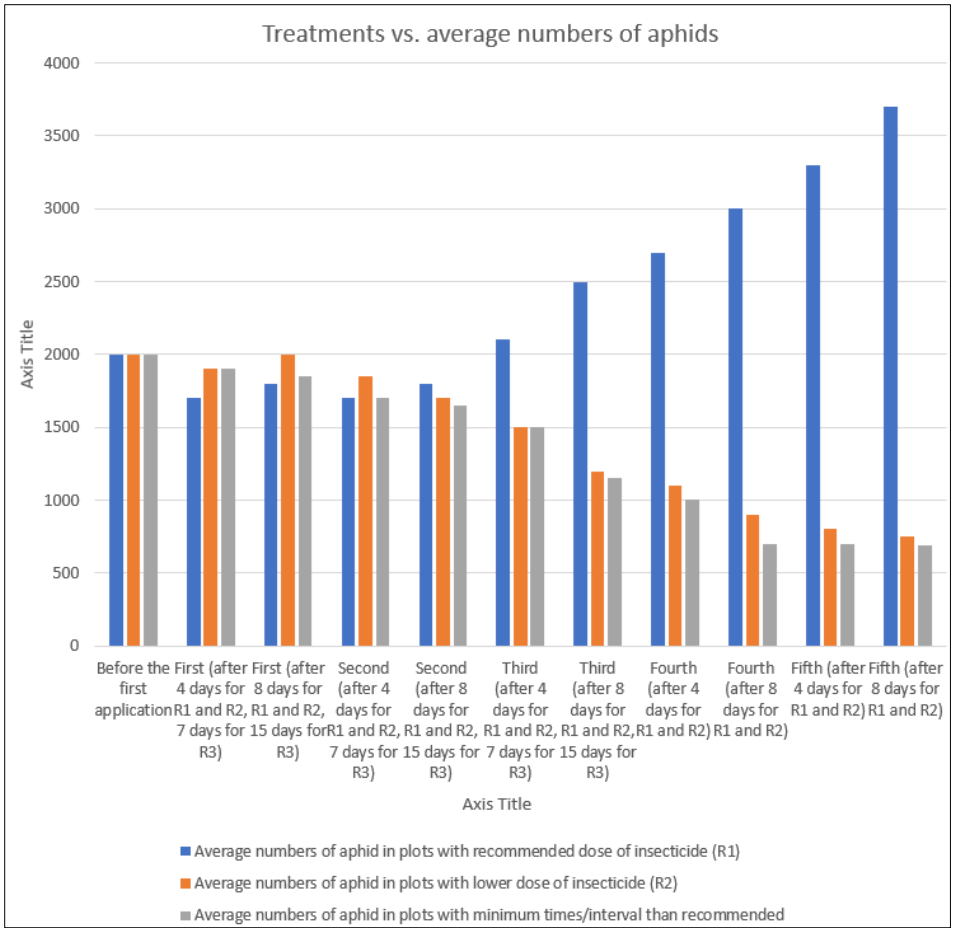

Fig 1: Average numbers of aphids with different replication of a treatment

Effect of insecticides in yield and yield attributes of soybean

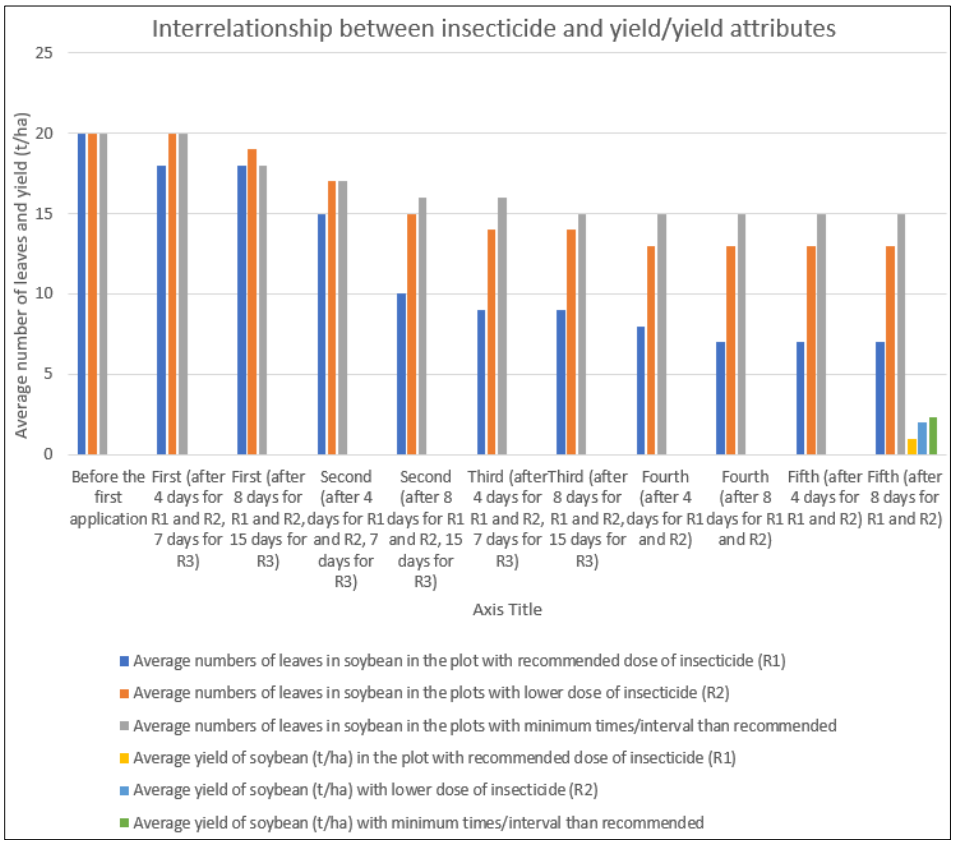

Fig 2: Effect of insecticide in yield and yield attributes of soyabean

It was found that the average numbers of leaves in soybean plant before the application of treatment were 20 in each three replications. After first application of treatment in 4 days for R_1 and R_2 the average numbers of leaves found to be 18 and 20 while 20 for R_3 after 7 days of the same treatment respectively. Similarly, average numbers of leaves found to be 18, 19, and 18 after 8 days for R_1 and R_2 and 15 days in R_3 after first application of treatment. Average numbers of leaves recorded to be 15, 17 and 17 after second spray of treatment in 4 days R_1 and R_2 and 7 days for R_3 respectively. Similarly, the average number of leaves found to be 10, 15 and 16 after second spray in 8 days R_1 and R_2 and 15 days for R_3 respectively. Finally, the average numbers of leaves found to be 7, 13 and 15 after 4 days of R_1 and R_2 and non-application of treatment in R_3 at the same period in fifth treatment of abamectin. Similar numbers of leaves found after 8 days for R_1 and R_2 and non-application of treatment in R_3 at the same period in fifth treatment.

The average yield of soybean was found 1 t/ha, 2 t/ha and 2.3 t/ha for the plots in R_1, R_2 and R_3 respectively (Figure 2). The genetic makeup (single aphid resistance gene) may be responsible in increasing their efficiency to damage the crop and thereby effect plant height, leaves including production. Soybean aphids (*Aphis glycine*) develops resistance themselves with such genes and hampers the production and productivity in crops like soybean (Kim *et al.*, 2008; Hill *et al.*, 2010; McCarville and O'Neal, 2012; Wiarda *et al.*, 2012) [24, 17, 27, 36].

Beckendorf *et al.* (2008) [2] and He *et al.* (1991) [14] insists that the increasing frequency of insecticides not only induce resistance in SBA but also reflects direct effect in crop quality and yield. According to some studies sit was analyzed that the defoliation levels of less than one third of leaf area not only affect soybean yield but also the quality of crop, especially in increasing population of aphids in soybean (Turnipseed, 1972) [34]. The defoliation decreases yield through the minimization of plant photosynthesis, reduced light interception, reduction of stored dry matter caused by leaf area loss including decrease of the filling period (Ingram *et al.*, 1981) [22]. Thus, there is the direct interrelationship between infestation of insect (aphids) with their resistance with insecticides and production of crops such as soybean (Salimi and Moradi, 2012) [32].

Many generations of soybean aphids have not only increased their resurgence but also resistance, especially in soybean aphid through the developed low-level resistance to insecticides by conservation of mutations resulting to their slow to rise (Guedes *et al.*, 2017) [11]. This has huge effect in crop biomass, phenotypes, and production at the end.

Conclusion

Single treatment of abamectin and three replications of the insecticide namely appropriate (dose, time) spray of insecticide, lower dose than that of recommendation and with minimal duration and interval than that of the recommendation were major attributes of the research. The research was carried out in split plot design during November 2013 to February 2014 in the Agronomy farm of Institute of Agriculture and Animal Science (IAAS), Rampur, Chitwan. Soybean crop was selected to understand the efficiency of each replication and treatment in reducing aphid resistance with insecticide. The numbers of aphids found to be higher in properly recommended plots in comparison (R_1) with lower dose applied (R_2) and reduced duration and interval than recommendation of insecticidal plot (R_3). Yield and yield attributes were also found non-significant in properly recommended plots in comparison (R_1) in comparison with lower dose applied (R_2) and reduced duration and interval than recommendation of insecticidal plot (R_3). The value of lower dose applied (R_2) and reduced duration and interval than recommendation of insecticidal plot (R_3) were at par with each other in both the cases. Thus, the insecticide resistance of soybean aphid (*Aphis glycine*) could be reduced either by altering (decreasing) the dose of insecticide (abamectin) or by reducing the times and interval of insecticide (abamectin) application in the district.

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