Efficacy of Insecticides against Sweet Potato Whitefly, *Bemisia tabaci* (Genn), (Homoptera:Aleyrodidae) on Black gram (*Vigna mungo* L.)

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Abstract

These experiments were conducted to evaluate the efficacy of chemical insecticides (used alone, combinations and different dosages) for the control of sweet potato whiteflies, *Bemisia tabaci* on black gram during winter and rainy season at Yezin Agricultural University Farm. A randomized complete block design was used with 13 treatments and five replications. Insecticide spray was initiated when adult whiteflies population exceeded the Economic Threshold Level (ETL) of 5 adults per leaf. In winter season, the highest season-long mean number of whiteflies population 3.85 adults/leaf was found in T_{13} (control plot) and followed by T_4 (5 times spray) 3.31 adults/leaf. The lowest season long mean number of whiteflies population 2.18 adults/leaf was found in T_7 (4 times spray) followed by T_{10} (4 times spray) 2.33 adults/leaf. In rainy season, the highest season-long mean number of whiteflies 1.85 adults/leaf was found in T_6 (4 times spray) followed by T_{13} 1.80 adults/leaf and the lowest 1.04 adults/leaf was found in T_7 (2 times spray) followed by T_4 (5 times spray) 1.24 adults/leaf. By comparing both seasons, the highest season-long mean number of natural enemies was observed in T_7 and the lowest in T_{10}. Therefore, the result indicated that Pymetrozine 20% + Thiamethoxam 20% WG can be used as suitable insecticide with low population of whitefly and less harmful effect on natural enemies at vegetative stage of black gram. Appropriate time of insecticides application, less harmful effect on natural enemies and proper selection of suitable insecticides are essential in formulating an Integrated Pest Management (IPM) program for whiteflies.

Key words: chemical insecticides, sweet potato whitefly, natural enemy

Introduction

Black gram, *Vigna mungo* is a very nutritious grain legume and widely spread in Asia. It was sown in tropical and sub-tropical region in Myanmar such as Ayeyarwady, Bago, Mandalay, Sagaing and Yangon Divisions (Mandal 2010). Black gram is the top exported crop in Myanmar. It was native to India from where it had spread to American, African, European and Asian countries (Loh and Stacey 2003). Black gram may also be used as a fodder for cattle and the by-products are also consumed by other species (Fuller 2004). *Vigna mungo* could be recycled as cover crop and green manure. It has been used as a beneficial effect on soil nutrient status in dry season (Parashar 2006). The growing area was 1,098,000 ha with the average yield of 1.47 MT ha^{-1} in Myanmar (MOAI 2016).

On an average, 2.5 to 3.0 million tons of pulses were lost annually due to pest problems. The annual yield loss due to the insect pests had been predicted at about 30 per cent in black gram (Rabindra et al. 2004). Black gram is attacked by diverse species of insect pests. Among them, sweet potato whitefly (*Bemisia tabaci*) is one of the most important pests in black gram. Brown and Nelson 1986 found that *B. tabaci* had caused problems to the crop as a result of direct feeding damage and indirect damage by acting as a vector for several viral plant pathogens such as begomoviruses and closteroviruses (Duffus 1996). Among the virus diseases, mung bean yellow mosaic disease caused by mung bean yellow mosaic virus (MYMV) stands very devastating in Southeast Asia (Poehlman1978). This virus was transmitted by sweet potato whitefly (*B. tabaci*) (Alegbejo 2000 and Simon et al. 2003).

Indirect feeding damage of whitefly has also been resulted from the accumulation of honeydew.

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This honeydew serves as a substrate for the growth of black sooty mold on leaves and fruit. The mold reduces photosynthesis and lessens the market value of the black gram (Berlinger 1986). The whitefly infected plants part becomes yellowish as well as the leaves convert wrinkle and curl downwards eventually fallen off. This happens mainly due to viral infestation where the whitefly acts a mechanical vector of many viral diseases.

Gogi et al. 2006 described that chemical control was an important practice and had been used as rapid method of pest control in Integrated Pest Management program to overcome losses caused by insect pest to crop. IPM tactic could lead to moderate amount of insecticide applications if it was compared to the farmers' prophylactic treatment. Hence, the use of pesticides still remains as one of the most important control measures for plant protection. It is expected that this situation will continue in the future (Gwo-Chen Li et al. 2002). Consequently, the whitefly, *B. tabaci* had developed resistance to numerous conventional insecticides throughout the world (Dittrich and Ernst 1990, Denholm et al. 1996). Nowadays, chemical control could be the most efficient and easiest way to combat insect pests of vegetables and flowers. Today, scientists continue to develop safer alternatives to pesticides. It is timely to find out the efficacy of different insecticides against whitefly on black gram under the natural agro-ecological conditions. In these regards, the experiments were carried out with the following objectives:

1. To explore the efficacy of different insecticides against sweet potato whitefly on black gram
2. To investigate the impact of insecticides on natural enemies of black gram insect pests

Materials and Method

The field experiments were conducted at Yezin Agricultural University Farm during winter season (November 2016 to February 2017) and rainy season (May to August 2017).The experiment was comprised of 13 treatments and five replications and laid out with Randomized Complete Block Design (RCB). The plot sizes were 9 m x 7.5 m and adjacent plots were interspaced with 1 m of emptied land. The total sown area was 0.3 hectare. Row and plant spacing was 45 cm x 10 cm. The land was prepared with two ploughing and two times of harrowing. The black gram (Yezin-6) was sown on well prepared soil for both seasons. Treatments were T_1 = Pymetrozine (Pymet) 50%WG-192 g ha^{-1}, T_2 = Pymet 50% WG-288 g ha^{-1}, T_3 = Pymet 50% WG-384 g ha^{-1}, T_4 = Pymet 10% + Fenobucarb (Feno) 20% SC-720 ml ha^{-1}, T_5 = Pymet 10%+Feno 20% SC-1080 ml ha^{-1}, T_6 = Pymet 10% + Feno 20% SC-1440 ml ha^{-1}, T_7 = Pymet 20%+ Thiamethoxam (Thiam) 20%WG-360 g ha^{-1}, T_8 = Pymet 20% + Thiam 20% WG -540 g ha^{-1}, T_9 = Pymet 20% + Thiam 20% WG-720 g ha^{-1}, T_{10} = Thiam 25% WG - 384 g ha^{-1}, T_{11} = Feno 50% EC-1075 ml ha^{-1}, T_{12} = Acetamiprid (Aceta) 20%SL-360 ml ha^{-1} and T_{13} = Control plot (water only).

The application of insecticides for the control of whitefly was done according to Economic Threshold Level (ETL) (5 adults/leaf) developed in India by Ahmad et al. 2001.

Data Collection

The data collection was started at two weeks after sowing (2 WAS) and it was continued at weekly intervals until 12 WAS (nearly harvest).The number of whiteflies adults and the number of natural enemies were recorded from 5 randomly selected plants per plot.

Meteorological data such as rainfall and temperature were taken from Department of Agricultural Research (DAR) at Yezin.

Data Analysis

Data were analysed by using Statistix (Version 8.0) stat software and mean separation was done by using Tukey' HSD test at 5% level.

Results and Discussion

Effect of different insecticides on the infestation of sweet potato whitefly in winter season

Mean numbers of whiteflies treated with different insecticides and frequency of spray in winter season were presented in Table 1 and Figure 1, respectively. The numbers of whiteflies population above ET level were observed from 3 WAS to 8 WAS (6 weeks duration) in some treatments. Therefore, the insecticide sprays were done for these treatments.

The whitefly population was low and it was less than 2 adults in all treatments at 2 WAS and became more than 2 adults in most of the treatments in the following week at 3 WAS. After that population sharply increased at 4 WAS and exceeded ETL almost in all treatment except T_1, Pymet 50%WG 192 g ha^{-1}where the population exceeded at 6 WAS (Table 1). The peak population was numerically observed at 4 WAS for T_3, T_4, T_9,T_{11},T_{12}, and T_{13}

Table 1. Effect of different insecticides on population fluctuation of sweet potato whitefly in winter season (Nov 2016 to February 2017)

No	Treatment	Dosages	2 WAS	3 WAS	4 WAS	5 WAS	6 WAS	7 WAS	8 WAS	9 WAS	10 WAS	11 WAS	12 WAS
T_1	Pymet 50%WG	192 g	1.40 abc	2.00bc	3.80 a	3.80 cd	6.00 a	6.20 a	1.40abc	1.40 a	2.00 a	0.40ab	0.20 a
T_2	Pymet 50%WG	288 g	1.80 ab	2.40 b	5.00 a	5.40abcd	3.60 a	8.00 a	1.40abc	1.60 a	1.60abc	0.00 b	0.00 a
T_3	Pymet 50%WG	384 g	0.80 bc	2.60 b	7.00 a	4.00 cd	5.40 a	7.40 a	2.80ab	2.20 a	1.60abc	0.20ab	0.00 a
T_4	Pymet 10% +Feno20%SC	720 ml	0.80 bc	0.40 c	7.80 a	7.80ab	5.40 a	7.20 a	2.80ab	1.60 a	1.80ab	0.40ab	2.00 a
T_5	Pymet 10% + Feno 20%SC	1080 ml	0.60 bc	1.20bc	5. 80a	4.80bcd	4.80 a	6.80 a	2.20abc	2.00 a	1.20abc	0.40ab	0.40 a
T_6	Pymet 10% + Feno 20%SC	1440 ml	0.80 bc	2.40 b	5.40 a	7.20abc	3.20 a	7.20 a	2.20abc	1.40 a	1.40abc	0.40ab	0.20 a
T_7	Pymet + Thia-m20%WG	360 g	1.00 bc	2.20bc	5.00 a	3.80 cd	3.00 a	4.60 a	1.40abc	1.40 a	1.60abc	0.00 b	0.00 a
T_8	Pymet + Thia-m20%WG	540 g	0.80 bc	2.40 b	5.80 a	4.60bcd	5.40 a	6.40 a	2.00abc	2.00 a	1.00bc	0.40ab	0.00 a
T_9	Pymet + Thia-m20%WG	720 g	0.60 bc	2.20bc	6.40 a	3.20 d	2.20 a	7.00 a	1.00bc	2.20 a	1.40abc	0.00 b	0.20 a
T_{10}	Thiam 25%WG	384g	0.80 bc	0.80bc	5.40 a	3.00 d	5.40 a	4.60 a	1.20bc	2.00 a	1.60abc	0.40ab	0.40 a
T_{11}	Feno 50%EC	1075 ml	0.40 c	1.40bc	8.00 a	5.80abcd	2.60 a	4.80 a	1.20bc	1.20 a	0.80 c	0.00 b	0.00 a
T_{12}	Aceta 20%SL	360 ml	1.80 ab	2.00bc	8.80 a	4.20 cd	2.20 a	6.20 a	0.80 c	1.20 a	0.80 c	0.00 b	0.00 a
T_{13}	Control	-	2.60 a	4.80 a	8.40 a	8.60 a	4.00 a	6.40 a	3.20 a	1.80 a	1.40abc	0.80 a	0.40 a

Means followed by the same letter in the same column are not significantly different at 5% level by Tukey' HSD test.

whereas at 7 WAS for T_2, T_3, T_4 T_6 and T_9 respectively. Between 3 WAS and 8 WAS the population of whitefly was found to be fluctuating although it was upward trend in many cases. After that the whitefly population decreased never reaching ETL until the final record. Similar trend was observed with T_{13} where no insecticide was applied.

The mean number of whitefly T_{13} was significantly different in all treatments except T_1, T_2 and T_{12} in 2 WAS. In 3 WAS, the mean number of whitefly T_{13} was significantly different in each other treatments. In 4 WAS, 6 WAS, 7 WAS, 9 WAS and 12 WAS, there was not significantly different in all treatments. In 5 WAS, T_{13} were significantly higher than except T_2, T_4, T_6, T_{11}. In 8 WAS, the mean number of whitefly population were significantly higher than T_9, T_{10}, T_{11},T_{12} except T_1, T_2, T_3, T_4, T_5, T_6, T_7, $T_{8,}$ T_{13}. In 10 WAS, the mean number of whitefly population were significantly higher than T_8, T_{11},T_{12} except T_1, T_2, T_3, T_4, T_5, T_6,T_7. In 11 WAS, the mean number of whitefly population in T_{13} was significantly higher than T_2, T_7, T_9, T_{11}, T_{12} except of T_1, T_3, T_4, T_5, T_6, T_8, T_{10}.

At 2 WAS, the lowest number of whiteflies infestations (0.4 adult) was observed in $T_{11,}$ Feno 50% EC-1075 ml ha^{-1} and the highest population (2.6 adults) was observed in $T_{13,}$ control.

In 3 WAS, the lowest population number of whiteflies (0.4 adult) was found in $T_{4,}$ Pymet 10% SC + Feno 20% SC with dosage 720 ml ha^{-1} and the highest (4.8 adults) was observed in T_{13}, Control. In this week, the numbers of whiteflies were observed above the ETL in some sub-plots of the treatments T_3, Pymet 50% WG- 384 g ha^{-1}, $T_{6,}$ Pymet 10% + Feno 20% SC - 1440 ml ha^{-1} and $T_{9,}$ Pymet + Thiam 20%WG - 720 g ha^{-1} although the mean numbers of whiteflies population were not exceeded the ETL (Table 1).

In 4 WAS, the lowest population of whiteflies (3.8 adults) was found in $T_{1,}$ Pymet 50% WG - 192 g ha^{-1} and the highest population level (8.8 adults) was recorded in $T_{12,}$ Aceta 20% SL-360 ml ha^{-1}.

In 5 WAS, the highest population level of whitefly was observed T_{13}, Control plot with 8.6 adults and the lowest (3.0 adults) was $T_{10,}$ Thiam 25% WG- 384 g ha^{-1}.

In 6 WAS, the mean number of whiteflies was the highest in $T_{1,}$ Pymet 50%WG - 192 g ha^{-1}, (6.0 adults) and the lowest (2.2 adults) was found both in T_9, (Pymet +Thiam) 20%WG -720 g ha^{-1} and $T_{12,}$ Aceta - 20% SL -360 ml ha^{-1}.

In 7 WAS, the highest population (8.00 adults) was $T_{2,}$ Pymet 50% WG -288 g ha^{-1} and the lowest (4.6 adults) was observed both in $T_{7,}$ Pymet + Thiam 20% WG-360 g ha^{-1} and T_{10}, Thiam 25% WG - 384 g ha^{-1}. In 8 WAS, the highest population was found in $T_{13,}$ Control (3.2 adults) and the lowest (0.8 adult) was observed in $T_{12,}$ Aceta 20% SL- 360 ml ha^{-1}. In this week, the numbers of whiteflies were recorded above ETL in treatments T_1, T_3, T_4, T_5 and T_6.

In 9 WAS, the highest populations (2.2 adults) were T_3, Pymet- 50%WG -384 g ha^{-1} and T_9, Pymet+Thiam 20 % WG – 720 g ha^{-1} and the lowest (1.2 adults) were observed in T_{11}, Feno 20% EC - 1075 ml ha^{-1} and T_{12}, Aceta 20% SL- 360 ml ha^{-1}. In this week, the numbers of whiteflies were not

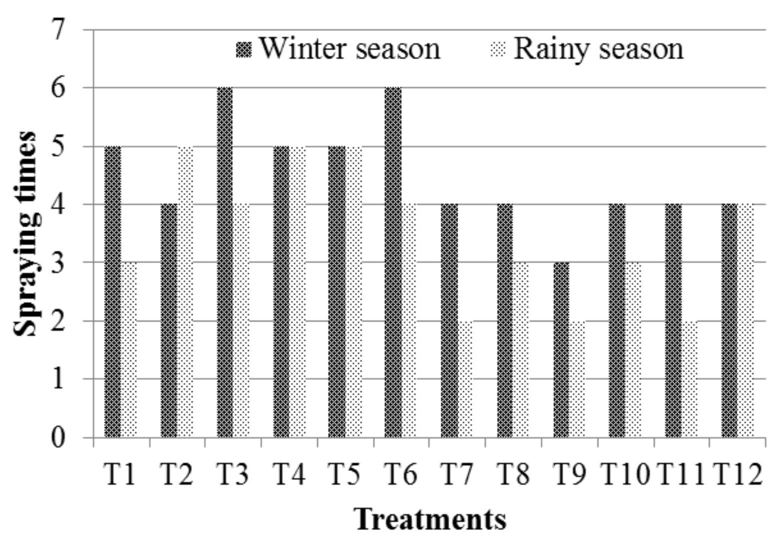

Figure 1. Different spraying times for each treatment

found above ETL in all treatments.

In 10 WAS, the maximum population (2.0 adults) was T_1, Pymet 50% WG-192 g ha^{-1} and the minimum (0.8 adult) was found in both T_{11}, Feno 50% EC- 1075 ml ha^{-1} and T_{12}, Aceta 20% SL-360 ml ha^{-1}.

In 11 WAS, the highest population level of whiteflies (0.8 adults) was observed in T_{13}, Control and no whitefly was found in T_2, T_7, T_9, T_{11} and T_{12}.

In 12 WAS, the highest population level was T_4, (2.0 adults) and T_2, T_3, T_7, T_8, T_{11} and T_{12} had no whiteflies.

In 4 WAS, 5 WAS, 6 WAS and 7 WAS, the mean numbers of whiteflies were recorded above ETL in all treatments except T_9 plots. In this study, the whiteflies population exceeded ETL 3 times in treatment T_9, 4 times in T_2, T_7, T_8, T_{10}, T_{11}, and T_{12}, 5 times in T_1, T_4 and T_5, and 6 times in T_3 and T_6.

In this study, the higher numbers of whiteflies were occurred during 3 WAS to 8 WAS (vegetative and beginning of flowering stage), whitefly population decreased from 8 WAS to maturity stage. Alegre et al. 1994 observed that the greatest populations of sucking insect pests were occurred at vegetative stage of the crop. Singh and Kumar 2011 reported similar finding that maximum population of whitefly was found in vegetative and flowering stage of weeks thereafter, the population declined from maturity to harvesting stage. All these findings suggested that insecticides should be applied only at the vegetative stage on black gram for whitefly control.

Effect of different insecticides on population fluctuation of sweet potato whitefly in rainy season

In rainy season, the whitefly population was very low and no whiteflies were recorded at 2 WAS. The infestation was low, mostly less than 2 adults per leaf throughout the growing season. It was more than 3 adults per leaf in some cases. However, it never reached ETL except one occasion at 9 WAS for T_{13} (Table 2).

The level of infestation for all treatments was not significantly different from one another for almost every week (from 2 WAS to 12 WAS) except 5 WAS and 9 WAS. At 5 WAS, the highest number (3.2 adults per leaf) was observed with T_9 and it was significantly higher than those of other treatments except T_1. Again T_1 was not significantly different from those of all other treatments except T_2 where the population was '0' (no infestation) (Table 2).

The results obtained from this study suggested that two times insecticide application was needed to control whitefly on black gram in raining season.

In this study, the mean numbers of whiteflies were not significantly different among 2 WAS, 3 WAS, 4 WAS, 6 WAS, 7 WAS, 8 WAS, 10 WAS, 11 WAS and 12 WAS (Table 2). In 5 WAS, the mean numbers of whiteflies were significantly different in T_1, T_2 and T_9 but the other treatments T_3, T_4, T_5, T_6, T_7, T_8, T_{10}, T_{11}, T_{12} and T_{13} were not significantly different. In 9 WAS, T_4 and T_{13} were significantly different and the other treatments were not significantly different.

Compare with the winter season; the whitefly population was drastically decreased in this season. In 2 WAS, there was no population of whiteflies. At 3 WAS, the mean numbers of whiteflies were not significantly different among the treatments. However numerically the highest populations were observed in T_3 (1.6 adults) and T_8 (1.6 adults) and the lowest population was occurred 0.4 adults in T_7 and T_{13}. In 4 WAS, 1.6 adults was the highest population in T_2, T_9 and the lowest population was observed in T_7 and T_{10} with 0.4 adults. In 5 WAS, the highest population was observed 3.2 adults in T_9 and no whitefly was found in T_2. In 6 WAS, the highest population was occurred 3.0 adults in T_5 and the lowest population was found 1.0 adult in T_2 and T_{10}. In 7 WAS, the highest population was observed 3.6 adults in T_{13} and the lowest population was found 1.4 adults in T_9. In 8 WAS, the highest population was found 3.8 adults in T_6 and T_{12} and the lowest population was occurred 1.0 adult in T_9. In 9 WAS, the highest population was observed 5.0 adults in T_{13} and no population was found in T_4. In 10 WAS, the highest population was occurred 2.4 adults in T_6 and T_9 and the lowest population was found 0.8 adults in T_2. In 11 WAS, the highest population was observed 2.4 adults in T_{10} and the lowest population was occurred 0.4 adult in T_5. In 12 WAS, the highest population was found 1.6 adults in T_1 and the lowest populations were occurred 0.2 adult in T_7 and T_{10}.

The mean number of whitefly adults above ETL (5 adults/leaf) was observed only in T_4 at the initial sampling date 3 WAS. Insecticide applications were conducted from 3 WAS to 11 WAS for some treatments that exceeded whitefly adults above ETL. Insecticide spraying were found in T_1 with three times (5 WAS, 6 WAS and 10 WAS), T_2 with five times (4 WAS, 7 - 9 WAS and 11 WAS), T_3 with four times (7 WAS and 9–11WAS), T_4 with

Table 2. Effect of different insecticides on population fluctuation of sweet potato whitefly in rainy season (May to August 2017)

No	Treatment	Dosages	2WAS	3WAS	4WAS	5WAS	6WAS	7WAS	8WAS	9WAS	10WAS	11WAS	12WAS
T_1	Pymet50%WG	192 g	0.00	1.20 a	1.20 a	2.40 ab	2.20 a	1.60 a	1.20 a	2.60 ab	2.00 a	1.00 a	1.60 a
T_2	Pymet 50% WG	288 g	0.00	1.00 a	1.60 a	0.00 c	1.00 a	2.40 a	2.80 a	2.00 ab	0.80 a	1.80 a	0.40 a
T_3	Pymet 50% WG	384 g	0.00	1.60 a	0.80 a	0.40 bc	2.40 a	2.40 a	1.20 a	2.20 ab	1.20 a	1.20 a	1.20 a
T_4	Pymet 10% + Feno20% SC	720 ml	0.00	1.40 a	0.60 a	0.40 bc	1.40 a	2.40 a	3.60 a	0.00 b	2.00 a	1.20 a	0.60 a
T_5	Pymet 10% + Feno20% SC	1080 ml	0.00	0.80 a	1.20 a	0.20 bc	3.00 a	1.80 a	3.20 a	2.60 ab	2.00 a	0.40 a	0.60 a
T_6	Pymet10% + Feno20% SC	1440 ml	0.00	0.80 a	0.80 a	0.40 bc	2.60 a	3.40 a	3.80 a	3.00 ab	2.40 a	2.00 a	1.20 a
T_7	Pymet 20% + Thiam20% WG	360 g	0.00	0.40 a	0.40 a	0.40 bc	1.20 a	1.80 a	2.80 a	1.40 ab	1.60 a	1.20 a	0.20 a
T_8	Pymet 20% + Thiam20% WG	540 g	0.00	1.60 a	1.20 a	0.40 bc	1.60 a	1.80 a	3.40 a	1.80 ab	1.00 a	0.60 a	0.40 a
T_9	Pymet 20% + Thi-am20% WG	720 g	0.00	1.20 a	1.60 a	3.20 a	1.60 a	1.40 a	1.00 a	3.20 ab	2.40 a	1.20 a	1.20 a
T_{10}	Thiam 25% WG	384g	0.00	1.20 a	0.40 a	0.60 bc	1.00 a	1.80 a	3.20 a	2.60 ab	1.20 a	2.40 a	0.20 a
T_{11}	Feno 50% EC	1075 ml	0.00	1.00 a	0.80 a	0.80 bc	1.60 a	2.40 a	1.40 a	3.20 ab	1.60 a	1.60 a	0.40 a
T_{12}	Aceta 20% SL	360 ml	0.00	0.80 a	0.60 a	0.40 bc	1.40 a	2.00 a	3.80 a	2.00 ab	1.80 a	0.80 a	1.00 a
T_{13}	Control	-	0.00	0.40 a	0.60 a	0.60 bc	2.80 a	3.60 a	2.60 a	5.00 a	1.60 a	1.60 a	1.00 a

Means followed by the same letter in the same column are not significantly different at 5% level by Tukey' HSD test.

five times (3 WAS, 6 - 8 WAS and 10 WAS), T_5 with five times (6 - 10 WAS),T_6 with four times (7 - 9 WAS and 11 WAS), T_7 with two times (7 - 8 WAS), $T_8$with three times (7–8 WAS and 10 WAS), T_9 with two times (5 WAS and 9 WAS),T_{10} with three times (7–9 WAS), T_{11} with two times (8 –9 WAS) and T_{12} with four times (7–10 WAS).

Compare with the winter season, the mean numbers of whiteflies population in rainy season were lower than the winter season. This may be due to unusually heavy rainfall data of June and July (86 mm) and these rainfall data were higher than the other months in Yezin area. This condition couldn't favor the multiplication of whitefly. In 2011, Mane and Kulkarni reported that the population was decreased due to heavy rainfall and high humidity on black gram crop. These present findings already had in conformity with the results demonstrated by Seif 1980, Horowitz 1986, Gupta et al. 1998 and Bashir et al. 2001.

This result was similar to the finding of Singh 1990 who concluded that hot weather with little or no rainfall was conducive for the multiplication of *B.tabaci* population. Henneberry et al. 1995 reported that the whitefly population may be declined after rainfall. Whitefly eggs and nymphs were also reduced in rainy season (Castle 2001).

Season-long mean number of sweet potato whitefly and natural enemies (NE) in winter and rainy seasons

The season-long mean number of whitefly population and natural enemies were shown in Table (3) and Figure (2). In winter season, the lowest mean number of whiteflies (2.18 ± 0.05 adults/leaf) in T_7 was significantly lower than those of T_3, T_4 and T_{13}, however, it was not significantly different from those of T_1, T_2, T_5, T_6,T_8, T_9, T_{10}, T_{11} and T_{12}. The highest mean number of whitefly (3.85 ± 0.1 adults/leaf) in T_{13}, control treatment was significantly higher than those of other treatments except those of T_3 and T_4. The mean number of whiteflies (3.31 ± 0.05 adults/leaf) in T_4 was significantly different from T_9, T_{10} and T_{11}.

During rainy season, the lowest season-long mean number of whiteflies (1.04 adults) was observed in T_7 and it was significantly lower than those of T_6 and T_{13} but not significantly different from those of all other treatments. The highest season-long mean number of whiteflies (1.85 adults/leaf) was observed in T_6 followed by T_{13}, (1.80 adults/leaf).

In winter season, the highest season-long mean

Table 3. Season-long mean number of sweet potato whitefly per leaf in winter and rainy seasons

Treatment	Dosages	Winter Season (Mean ± SE)	Rainy Season (Mean ± SE)
T_1- Pymet 50%WG	192 g	2.60 ± 0.01 bcd	1.55 ± 0.01 ab
T_2 - Pymet 50%WG	288 g	2.80 ± 0.00 bcd	1.25 ± 0.01 ab
T_3- Pymet 50%WG	384 g	3.09 ± 0.03 abc	1.33 ± 0.01 ab
T_4 - Pymet10%+Feno 20%SC	720 ml	3.31 ± 0.05 ab	1.24 ± 0.02 ab
T_5 -Pymet10% +Feno 20%SC	1080 ml	2.75 ± 0.00 bcd	1.45 ± 0.00 ab
T_6 -Pymet 10%+ Feno 20%SC	1440 ml	2.89 ± 0.01bcd	1.85 ± 0.04 a
T_7-Pymet 20% +Thiam 20%WG	360 g	2.18 ± 0.05 d	1.04 ± 0.03 b
T_8-Pymet 20%+ Thiam20%WG	540 g	2.80 ± 0.00 bcd	1.25 ± 0.01 ab
T_9- Pymet 20% +Thiam20%WG	720 g	2.40 ± 0.03 cd	1.64 ± 0.02 ab
T_{10}-Thiam 25%WG	384g	2.33 ± 0.04 cd	1.33 ± 0.01 ab
T_{11}- Feno 50%EC	1075 ml	2.38± 0.03 cd	1.35 ± 0.01 ab
T_{12} -Aceta 20%SL	360 ml	2.55 ± 0.02 bcd	1.33 ± 0.01 ab
T_{13} –Control		3.85 ± 0.10 a	1.80 ± 0.03 a
Pr>F		*	ns
CV%		23.94	36.71

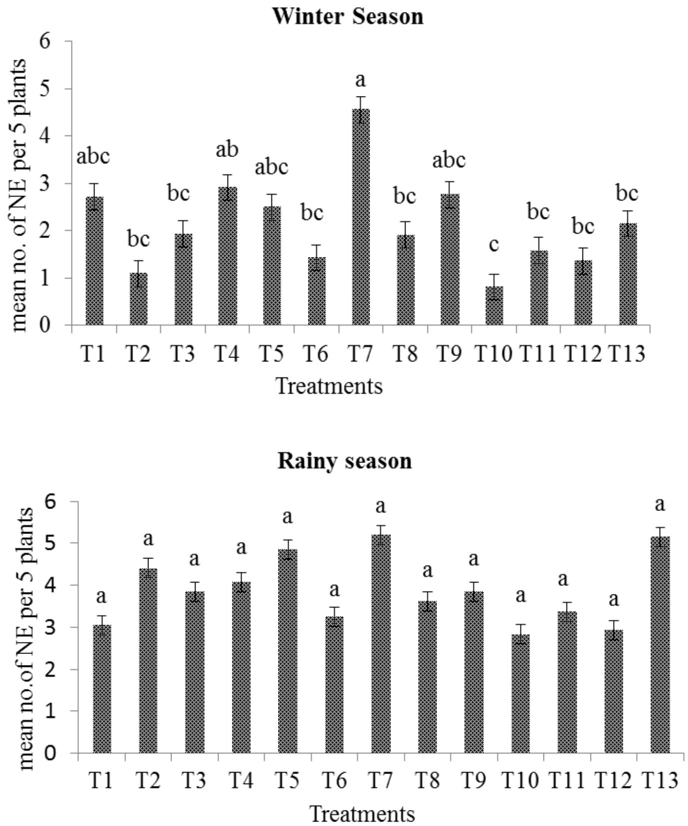

Figure 2.Season-long mean number of natural enemies per 5plants in winter and rainy season

number of NE (4.55 NE/ 5 plants) in T_7 was significantly different higher than those of T_2, T_3, T_6, T_8, T_{10}, T_{11}, T_{12} and T_{13}. The lowest mean number (0.81NE/ 5 plants inT_{10}) was significantly lower than those of T_4 and T_7. The second largest mean number (2.91 NE/5 plants) was observed in T_4. In winter season, 6 species of natural enemies; ladybird beetles, ground beetles, ants, dragon fly, lynx spider and predatory bug (miridae) were observed.

Season-long mean numbers of natural enemy in rainy season were presented in Figure (2). The mean numbers of natural enemies were not significantly different among the treatments in rainy season. However, the highest season-long mean number of NE (5.20 NE/ 5 plants) was observed inT_7 and the lowest season-long mean (2.83 NE/ 5 plants) was occurred in T_{10}. The second largest mean number (5.15NE/ 5 plants) was observed in T_{13}, control plot, followed by T_5 - 4.85 NE/ 5 plants. During rainy season, ladybird beetles, ants, dragonfly, predatory bug (miridae) and ground beetle were occurred. Total mean number of natural enemy population (3.88 natural enemies) in rainy season was higher than that of natural enemy (2.13 NE) in winter season (Figure 3).

In both seasons, the treatment $T_{7,}$ Pymetrozine + Thiamethoxam 20% WG-360 g ha^{-1} was observed with decreased whitefly population and increased natural enemy population. The results clearly showed that Pymetrozine + Thiamethoxam 20% WG at lower dosages reduced whitefly population without affecting natural enemies. Obviously, weather conditions were more encouraging for development of natural enemies. Thus, this weather can convert more favorable for pests and sometimes for predators. The rainy season was found to have less sucking insect pest population compared with winter season for growing of black gram. By observation of Muhammad 2013, the predators were more active at vegetative or flowering stages and their maximum activities were recorded on the plants having maximum activities of insect pest. In rainy season, the total mean numbers of natural enemies were higher than the winter season as shown in Figure (3). Purves et al. 2016 suggested that the

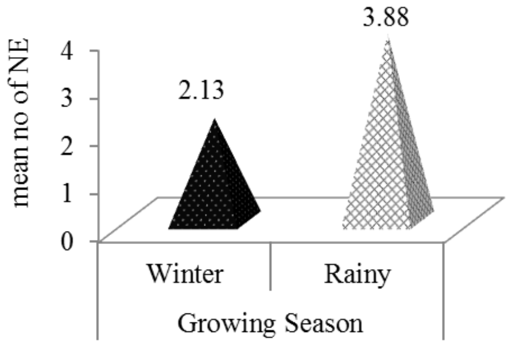

Figure 3. Total Mean number of natural enemies per 5 plants during winter and rainy season

prey population numbers declined, the predator population increased. The result suggests that this new generation insecticides can reduce the population of whitefly without harming the survival of predators to some extent.

Conclusion

The results of this experiment clearly showed that the use of ready-mixed Pymetrozine 20% WG + Thiamethoxam 20% WG - 360 g ha^{-1} lower suppress population of whitefly without affecting natural enemies population. The results also indicated that the application of insecticides should be done from 4 WAS to 7 WAS during winter and only at 7 WAS and 8 WAS in rainy season which mean that there is no need to apply insecticides throughout the growing season. Therefore, Pymetrozine 20% WG + Thiamethoxam 20% WG at the dosage of 360 g ha^{-1} found to be a promising insecticide for the control of whiteflies on black gram. According to the results, this combined insecticide at low dosages can also be suggested as a potential candidate in the helpfulness of integrated pest management strategies.

Acknowledgements

First of all I am greatly indebted to my supervisor, Daw Phyu Phyu San, Lecturer, Department of Entomology and Zoology, Yezin Agricultural University for her strongly careful deliberation and regular supervision from the beginning of this experiment study to the preparation of manuscript. My deep appreciation goes to our Professor Dr. Thi Tar Oo, Head of Department of Entomology and Zoology for her administrative support to conduct this research in Yezin Agricultural University Farm. I would like to express my gratefulness to Dr Myint Thaung for critical comment for my paper. Finally, I wishto bright thankful to Myanma Awba Enterprise for partial financial support to conduct my study.

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