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Occurrence, Seasonal abundance and Infestation Level of Fall Armyworm (*Spodoptera frugiperda* (J.E. Smith) - (Lepidoptera: Noctuidae) in Sudan

Oumgema Eltoum Toto[1], Sief El Din Mohamed Khair[2], Mahdi Abd El-Rahman Ahmed[1] and Loai Mohamed Elamin Elawad[2*]

[1] Shambat Research Station, Agricultural Research Corporation (ARC) - Sudan
[2] Department of Plant Protection, College of Agricultural Studies, Sudan University of Science and Technology, Khartoum State, Sudan.

[*]Corresponding author: Loai Mohamed Elamin Elawad

E-mail: loaielamin@gmail.com

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Abstract

A field survey was done in three different agricultural areas in Sudan (Khartoum, Sinnar and New Halfa) to determine the occurrence, seasonal abundance and population density of Fall Armyworm (FAW),(*Spodoptera frugiperda*) during the periods from July 2018 - June 2019 and from June 2019 – July 2020. Synthetic pheromone traps produced by Russell IPM, UK were used to estimate the presence, seasonal abundance and infestation level of FAW. The traps were checked every week during the period of experiment. The Analysis of collected data from three agricultural areas (Shambat, ELfaki Hashim and Soba) in Khartoum State showed that the significant highest population peak number of Fall Armyworm (FAW) was recorded in late Autumn months (August and September) followed by early winter months (November and December). While, the number of the insect decreased in late winter months (January and February) and the prolong declined was achieved in summer months (March and June). In Sinnar and New Halfa the FAW population was affected by the fluctuation of rain fall, the highest number occurred in rainy months (July to September). In general high infestation rate and damage were recorded in plants sown in autumn season (August and September) and early winter season (November and December) while low infestation rate was recorded in the late winter (January and February). From March to June FAW infestation had declined gradually to an undetectable level. In conclusion these results approved that FAW is the predominant and destructive pest during fall and winter seasons and infestation level depends on the weather condition and sowing date.

Keywords: Pheromone traps, Predominant pest, Population density, Infestation

Introduction

The invasive fall armyworm (FAW) *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae), is economic insect pest, native to the tropical regions of the western United States to Argentina. FAW has a wide host range, with over 80 plants recorded, but clearly prefers grasses, also causes significant damage on staple food and cash crops, like maize, rice, sorghum, sugarcane and cotton (John, 1999, Pogue, 2002, CABI, 2016, IITA, 2016 and FAO, 2017) posing a serious threat to food security and live hood of a millions of smallholder farmers in the region (Montezano *et al*., 2018). The larvae feeding on the leaves and cobs leads to yield losses of up to 80 % (Goergenet *al*., 2016) .Under sever infestation larvae are frequently observed migrating in large number to new fields similar to the true armyworm (Pannuti *et al*., 2015). A recent report estimated the costs of losses for maize due to the pest above 31.38 billion USD annually, about 19% of the continents annual maize production (CABI, 2017). The pest has invaded over 20 countries in Sub-Sahara Africa since its introduction into Africa in 2016 (Goergen*et al*., 2016), and covered most of the Southern and Eastern African countries by December, 2017. In South Sudan, the pest was first, spotted in Imatong State, one of the most productive areas in the South Sudan, in May/June, 2017, several maize fields were devastated with damage reaching over 90% (Binyason *et al*., 2017).In Sudan outbreak of FAW has been reported in Gadaref, Blue Nile, White Nile, and Gezira States in 2017 (Omer *et al*., 2017).

Management Strategies depending on regularly monitoring of leaves and whorls for presence of larvae and signs of crop damage, monitor masses of larvae migrating between fields. Pheromone traps can be used to determine incidence of adult moths and disrupt mating during the whorl stages, early planted maize can avoid periods of heavy infestation later in the season .Hence, and there is an urgent need for effective

FAW early detection tools which facilitate timely management decisions and practical control strategies those are effective, cheaper and ecologically-sustainable. In Sudan, there is no enough information on ecology and management of FAW. Thus, this study was designed to compile information in the distribution of fall armyworm in studied area in order to initiate control strategy regarding whether or not to apply insecticide to control this devastating pest.

Material and Methods

Survey locations:

Extensive surveys were carried out on seven locations distributed in three States of Sudan. (Khartoum, Sinner and New Halfa) from July 2018 – June 2019 and from June 2019 – July 2020 .Three sites were chosen in Khartoum (Soba, Shambat and ELfaki Hashim) whereas two sites were chosen in Sinnar (Sinnar North and Dar Alnaim) and New Halfa (Sedera and Sasaraib).

Collection methods and sampling:

In this experiment synthetic pheromone traps produced by Russell IPM, UK were used to estimate the presence, seasonal abundance and infestation level of FAW. The trap consists of plastic funnel with cage lure holder, which incorporates rubber septa with the FAW sex pheromone. Each trap was placed 0.1- 0.3 m above crop height with the help of supporting posts. The trap Raised as the crop grows to adjust the new height. One trap was used per site. Traps were placed on 22 July 2018 and checked at 1 week intervals until 21 June 2019.This 12 month test period allowed observations over major and minor cropping seasons (winter, summer and autumn). Four reading for month were taken. Trapped moths were separated from other species

and counted. The average catch per trap/site was monthly recorded. Samples of catches adult moth were sent to the insect Taxonomy Unit, Agricultural Research Corporation, Wad-Medani for identification.

Infestation assessment:

To assess the infestation levels of FAW in each site, each field was divided into five equal plots. In each plot, scouting was done by inspecting 20 plants, moving along a W-shape design (Prasanna *et al*., 2018).The middle of the field was also inspected making100 plants surveyed per field. Selected plants were checked for the presence of FAW using the following indicators: (i) presence of fresh feces in the leaf funnel. (ii) Presence of larvae on leaves or in the leaf funnel. Larva was identified according to the inverted Y-Shape in the head and the set of four dots forming a square on the upper surface of the last segment of its body (Tefera *et al*., 2011); (iii) irregular damage (cuts) on leaves and (iv) presence of egg masses. Other plants known to be *S. frugiperda* hosts were also inspected.The inspected plants were cut from the ground level and dissected to record the number of *S. frugiperda*, stem borers, egg batches and any other insect's present. The average number of infested plant was recorded every week. Other data about the field and crop (variety, planting date, irrigated or rain-fed, fertilizers used, crop growth stage and general health of the crop) were corded.

Sowing date experiment:

A field experiment was conducted at Shambat Research Station farm Khartoum, North, all around the year, to investigate the effect of sowing date on FAW damage on maize. Twelve sowing date from June 2019- July 2020 were adopted. The plot size was 20 m^2 consist of 4 ridges, 4m apart and 5m long and the spacing between plant was 0.2 m. Untreated seed of maize (Hedeba2) were sown on the specific date and thinned to two plant/hole at two week after emergence. All other cultural practices were done as recommended by ARC for maize production.

The numbers of infested plant were recorded two times, at four and six week (whorl stage) after plant emergence of each sowing date. The percentage of damage was calculated by dividing the number of infested plant by the total number of plant in the inner ridges and multiply by hundred. The average of two counts was used for comparison.

Infestation level measurement:

Infestation level measurement was done according to Prasanna *et al.* (2018). Five plants were randomly selected per plot and each plant was scored visually based on a rating scale from 1 to 5 used for scoring of damage severity. From each plant, five leaves (2 lower, 1middle and 2 upper) were scored as follows:

1. Healthy maize without damage.
2. 1–10% leaf damage or presence of damage from fall armyworm limited to characteristic windows or <5 mm diameter and or destruction of only the leaf cuticle.
3. 11–25% leaf damage with presence of chewed areas >5 mm, funnel leaves still intact.
4. 26–50% leaf damage with presence chewed areas larger than 1 cm, the funnel slightly damaged or less severe.
5. >50% leaf damage, plant stunting and funnel damaged severely.

Statistical Analysis:

The obtained data was transformed to $\sqrt{x}$ +0.5 and arcsine when needed and were subjected to ANOVA statistical analysis using Genstat program. Duncan's Multiple Range Test (DMRT) was used for mean separation.

Results and Discussion

Insect population and infestation level in Khartoum State:

The results in table (1) and figure(1) showed the trap captures of FAW in three different agricultural areas in Khartoum

State (Shambat, ELfakiHashim and Soba) during the period from July, 2018 to June, 2019.The highest number of FAW caught per traps/site were recorded in Shambat and Soba during late autumn months (August-September) which showed a significant difference when compared with other months, while in ELfaki Hashim the maximum population were recorded in early winter (November-December). In general the peak number of FAW population was recorded during autumn season (August-September) and followed by early winter season (November-December) .The population gradually decreased in late winter (January and February) with a prolonged decline in summer season (March to June). The lowest number of FAW captured by traps along the period from June, 2018 to July, 2019 was in Soba area. This finding agreed with (Vonny and Thomas, 2009) who found that the outbreaks of FAW typically happen in the fall, and are worse when rains are frequent and temperatures are cooler.

The infestation levels shown in table (1) and figure (2) closely match the trap captures (insect population numbers), which are varies from area to another. In general the significant infestation level was observed in late autumn season (August-September) in the three different areas (Shambat, ELfaki Hashim and Soba) followed by early winter season (November-December) and the late winter (January and February) and the lowest infestation % occurred in summer season (March to June).From the above mentioned results we approved that FAW occurrence and infestation % was mainly affected by weather condition (mainly humidity and temperature) and sowing date.

Insect population and infestation in Sinnar and New Halfa:

The results presented in table (2) and figures (3) and (4) indicate that FAW population in Sinnar and New Halfa were controlled by rain fall, the highest catches occurring during the rainy months and the significant population and heavy infestation of pest were recorded during (July to September). Sinnar showed the highest population number during all period from July, 2018 to June, 2019, this may be due to heavy rainy season when compared to New Halfa. The population of pest decrease very fast during winter season (November to January) unlike that in Khartoum which showed higher population number during winter season, that means the economic damage of pest in Sinnar and New Halfa occurred only in autumn season.

Effect of sowing dates on incidence and severity of *S. frugiperda*:

Results in table (3) showed that the highest infestation % and severity rate were recorded from July- October. The highest significant incidence and severity recorded in August, 2019 (72%) followed by those in September and October (62%) and reach (50%) in December and ranging from 29% to 1% from January and May, 2020, respectively. There are no significant differences were recorded between July, September and October, while a significant difference was observed in August.

As many other lepidopterous insect, FAW showed resistance to many chemical insecticides worldwide, therefore, adoption of integrated management program is very important to minimize the economic damage caused by this pest, these may include: early monitoring and field scouting by using pheromone and light traps (Cruz *et al*., (2012), early planting and/or early maturing varieties (John, 1999), Also introduction of natural enemies from native countries is necessary to maintain the number of this destructive pest below the injury level.

Table 1: Traps catches and infestation levels of *S. frugiperda* in Khartoum State, during the period from July, 2018 to June, 2019.

Month	Average of males caught per traps/ site			Infestation level (%) per site		
	Shambat	ELfaki Hashim	Soba	Shambat	ELfaki Hashim	Soba
July	396c	264d	96c	31d	20d	17d
August	507a	314b	219a	88a	63a	49a
September	499a	320b	225a	91a	60a	52a
October	381c	308c	95c	51c	41b	26c
November	434b	393a	187b	66b	56a	38b
December	446b	405a	184b	64b	85a	41b
January	304d	278cd	66d	49c	38b	29c
February	196e	194e	74d	39d	26c	15d
March	40f	10g	2.5f	20e	11e	3.5e
April	9.2g	8.0g	2.7f	2.8f	1.8f	2.8e
May	2.0g	2.0g	1.7f	2.5f	1.0f	1.0e
June	201e	159f	47e	1.2f	2.2f	2.3e
SE±	14.8	32	9.0	4.6	12.7	2.9
CV%	7.3	10	11.9	15.5	22.4	16.9

*** Means followed by the same letter (s) are not significantly different at (P<0.05).**

Table 2: Traps catches of males of *S. frugiperda* in Sinnar and New Halfa during, the period from July, 2018 to June, 2019.

Month	Average of males caught per traps/ site			
	Sinnar		New Halfa	
	Sinnar North	Dar Alnaim	Sedera	Sasaraib
July	356b	233b	258c	310b
August	690a	707a	472a	403a
September	704a	699a	384b	388a
October	209c	222b	140d	216c
November	97d	117c	45e	195d
December	86.5d	119c	36e	35f
January	16.2e	11.8d	5.5f	11g
February	13e	5.3d	3.2f	8.5g
March	1.0e	1.0d	1.2f	1.0g
April	1.5e	3.0d	1.0f	3.0g
May	1.0e	1.0d	1.0f	1.0g
June	90d	92.2c	44.8e	98.3e
SE±	32	32	20	5.5
CV%	24.9	26.5	24.5	5.6

*** Means followed by the same letter (s) are not significantly different at (P<0.05).**

Table 3: Effect of sowing dates on incidence and severity of *S. frugiperda* on Maize grown in Shambat area, during June, 2019- July, 2020.

Month	Mean incidence (% of infested plant)	Mean severity (on a scale of 1 to 5)
June	33d	2.8d
July	57b	4.5a
August	72a	5.2a
September	62b	4.7ab
October	62b	4b
November	51c	4b

December	50c	3.3c
January	29e	2.9c
February	26e	2.3d
March	8f	0.8e
April	5f	0.1e
May	1f	0.2e
SE±	4.8	0.41
CV%	11.8	13.8

*** Means followed by the same letter (s) are not significantly different at (P<0.05).**

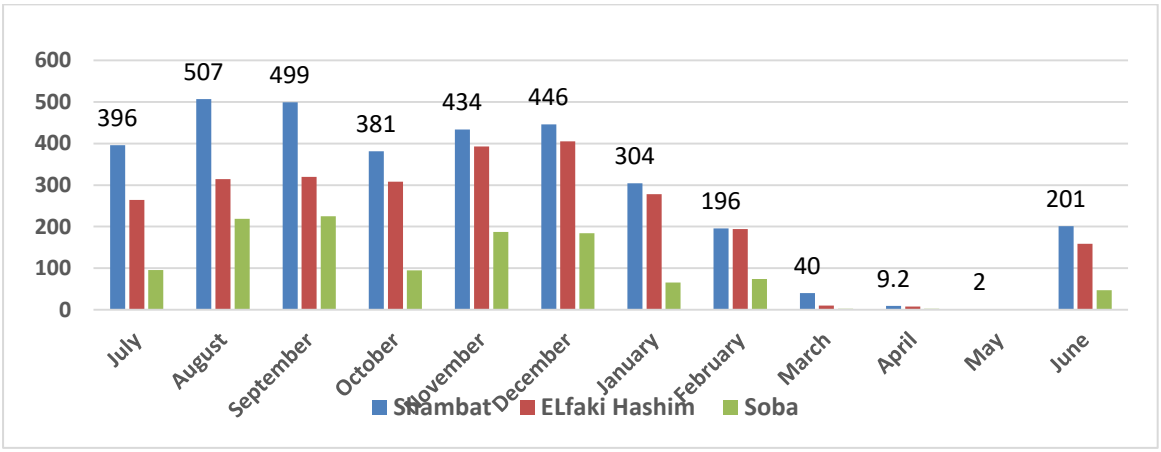

Fig.1: Traps catches of *S. frugiperda* in Khartoum State during the period from July 2018 to June 2019

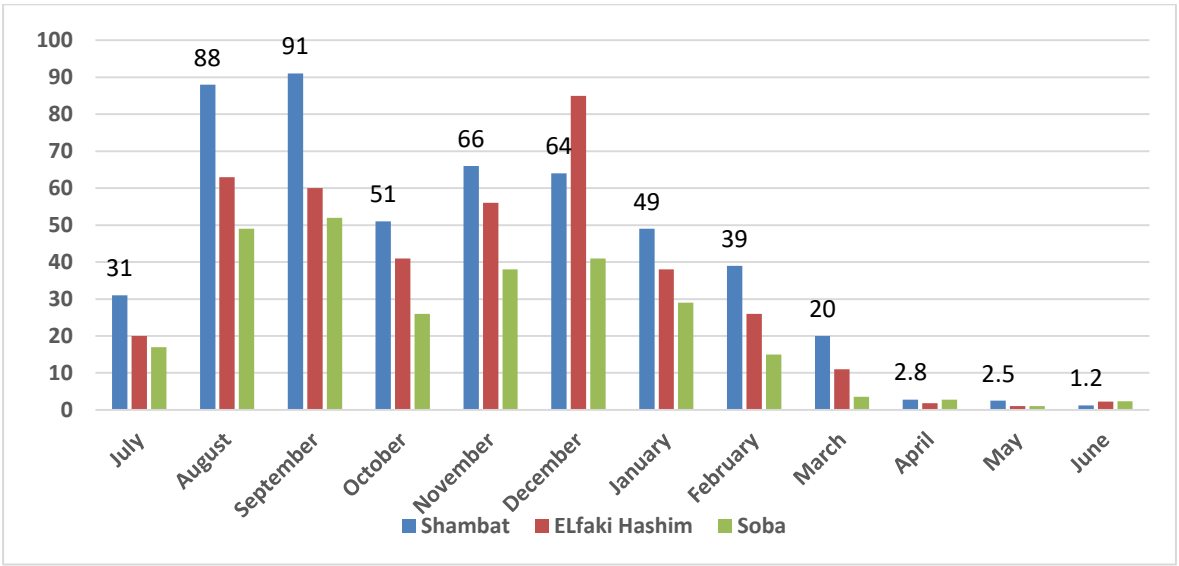

Fig 2: Infestation level of *S. frugiperda* in Khartoum State during the period from July, 2018 to June, 2019

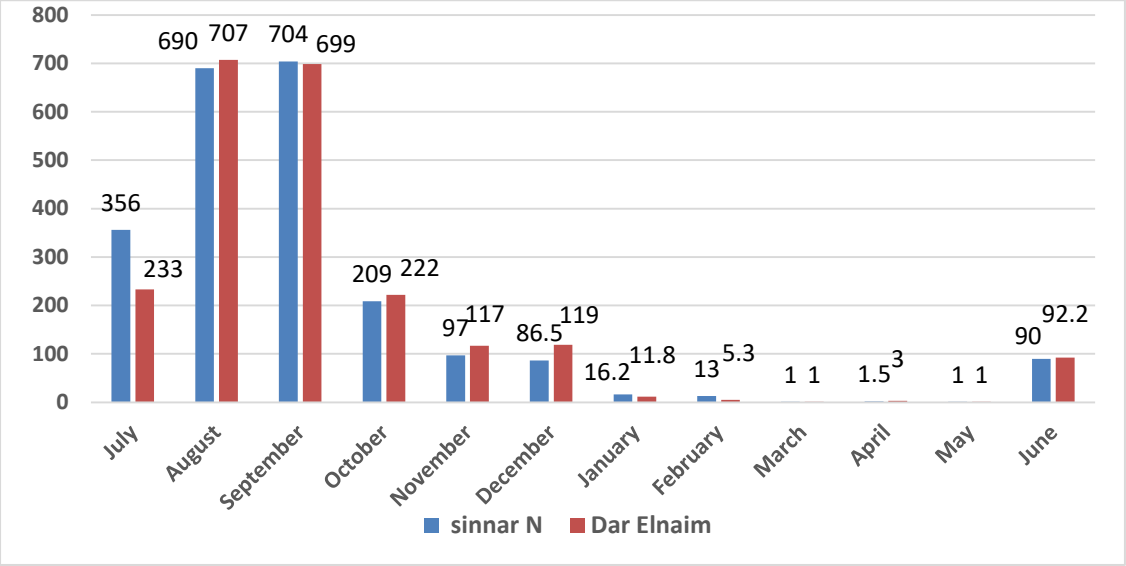

Fig 3: Traps catches of males of *S. frugiperda* in Sinnar State during the period from July, 2018 to June, 2019

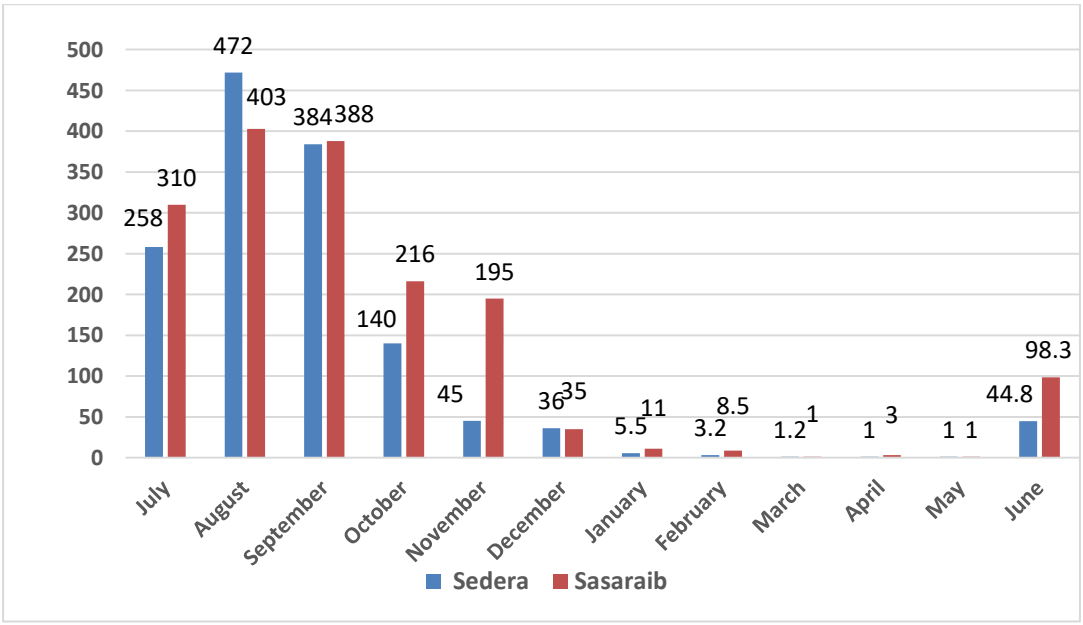

Fig 4: Traps catches of males of *S. frugiperda* in New Halfa State during the period from July, 2018 to June, 2019

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التواجد والكثافة الموسمية ومستوى الإصابة لدودة الحشد الخريفية (*Spodoptera frugiperda*) في السودان

أم جمعة التوم توتو[1] و سيف الدين محمد خير[2] ومهدي عبد الرحمن أحمد[1] و لؤي محمد الأمين أحمد العوض [2]

محطة بحوث شمبات– هيئة البحوث الزراعية– السودان

قسم وقاية النبات– كلية الدراسات الزراعية– جامعة السودان للعلوم والتكنولوجيا– السودان

المستخلص

تم إجراء مسح حقلي في ثلاث مناطق زراعية في السودان (الخرطوم، سنار وحلفا الجديدة) للتأكد من تواجد دودة الحشد الخريفية (*Spodoptera frugiperda*) ومعرفة تعدادها وكثافتها الموسمية ومستوى الإصابة خلال موسمين (يوليو 2018م – يونيو 2019م) و(يونيو 2019 – يوليو 2020م) . تم إستخدام المصائد الفرمونية لرصد الآفة وتحديد الكثافة العددية لها ومستوى الإصابة في ثلاث مناطق بولاية الخرطوم (شمبات، الفكي هاشم و سوبا) وكذلك في ولاية سنار وحلفا الجديدة وذلك عن طريق فحص المصائد إسبوعيا طوال فترة التجربة . أظهرت نتائج التحليل الإحصائي أن أعلى كثافة عددية لهذه الآفة الحشرية قد تم تسجيلها خلال أشهر الخريف (أغسطس وسبتمبر) ومن ثم بداية الشتاء (نوفمبر وديسمبر)، بعد ذلك بدأت أعداد الآفة في التناقص خلال شهري يناير وفبراير إلى أن وصلت مستويات تكاد تكون منعدمة في أشهر الصيف من مارس إلى يونيو. في سنار ووادي حلفا أيضاً قد وضح أن الكثافة العددية للحشرة ومستوى الضرر والإصابة له علاقة بمعدل الأمطار حيث أن أعلى كثافة عددية وإصابة قد تم تسجيلها في أشهر الخريف(يوليو وحتى سبتمبر). بشكل عام أن أعلى معدلات للإصابة قد تم تسجيلها في المحاصيل المزروعة في الخريف (أغسطس وسبتمبر) تلتها التي تم زراعتها في بداية الشتاء (نوفمبر وديسمبر) وأقل إصابة سجلت في تلك التي زرعت في نهاية الشتاء (يناير وفبراير) وتكاد تكون الإصابة منعدمة في أشهر الصيف (مارس إلى يونيو). من خلال هذه الدراسة نخلص إلى أن دودة الحشد الخريفية (FAW) هي آفة خطيرة ومدمرة خاصة خلال أشهر الخريف وبداية الشتاء وتتأثر معدلات الإصابة بمواعيد الزراعة والظروف المناخية.