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Biological Aspects of the Fall Armyworm *Spodoptera frugiperda* (J.E. Smith) on different Host Plants

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ABSTRACT

The fall armyworm *Spodoptera frugiperda* (J.E. Smith) has become one of the factors threatening the productivity of agricultural crops worldwide. In the Egyptian fields, it became one of the most dangerous pests that attack maize at the country level. In northern Egypt, the larvae were found feeding on plant species such as corn, okra, mallow, amaranth, also the larvae were found feeding on the fruits of tomato and pepper plants and table beets. Therefore, it was bred in a laboratory on these plants and fruits, which showed the ability to survive in all these plant families with rates 90 ,80,76.7, 83.3 ,70,63.3 and 10%. The eggs incubation period was similar in all plants with ranged 2.5-3.0 days. Larval duration recorded 13.0±1.0,15.0±1.0,16.0 ±0.5 ,13.0 ±1.0,19.0±1.0, 19.5±0.0 and 18 ±0.0 days. pupal duration found to be similar in all host plant with range 6.0±0.6 to 6.3±0.6 days. Adults longevity exhibited a significant difference between maize, okra, amaranth, mallow with 10.5±0.13 day and that on tomato, pepper and table beet with 8.0±1.0, 6.0±1.0 and 4.0±05 days, respectively. The female preoviposition period lasted 2.0±0.5 day in all plant species ,also Oviposition period lasted 5.0±0.5 day ,and post oviposition period lasted 2.00±0.0 days .In egg laying choice test females laid eggs on maize and amaranth plants, meanwhile in no-choice test, females laid eggs on all plants .

Keywords: Fall Armyworm, Biology, longevity

INTRODUCTION

The fall armyworm (FAW), *Spodoptera frugiperda* (J.E. Smith) is one of the crop pests and socioeconomic environmental transboundary factors which causing very high economic yield losses ranged 20 to 40 percent in the world (CABI 2017, CABI 2018, FAO, 2018). In China, FAW recorded by the end of 2018 and became the top serious pest in 2021 (Wang *et al.* 2020, Wu Li-hong *et al.*2021, Zhou *et al.*2021). In Africa, FAW is recorded in 2016 and by one year is occurred in 47 countries (Goergen *et al*., 2016; Etienne Tendeng *et al.*, 2019). Without control methods, FAW has the ability to cause maize damage in 12 African countries with range of 20-53% of losses (Day *et al*., 2017; De Groote *et al*., 2020). In Egypt, FAW recorded in upper Egypt in 2019 attacking maize and sorghum (Mohamed *et al*. 2021; Hend et al., 2022). Maize and grasses are the main hosts for FAW, it can exceed maize with high infestation that reached to100% (Cruz *et al*., 1999; Hardke *et al.*, 2015; Moreblessing *et al*., 2019). Also FAW was recorded on 353 plant species (Montezano *et al.*, 2018; Wan *et al.*, 2020). In the absent of maize, FAW can infest and damages other vegetable crops such as Okra (*Abelmoschus esculentus* L.), mallow (*Corchorus olitorius*) , table beet (*Beta vulgaris*) many solanaceous crops, and damage the fruits such as bell pepper (*Capsicum annuum*) and tomato (*Solanum lycopersicum* Mill), and other weeds such as (*Amaranthus* spp.) (Abrahams *et al.*, 2017, Day *et al*., 2017; Montezano *et al.*, 2018), the fruit damage of tomato ranged 10 to 33.5% (El Sheikh, 2021). As a lepidopteran pest (Lepidoptera: Noctuidae), FAW have two strains, one infesting maize (*Zea mays* L.) and the other infested rice and grasses (Juárez *et al*., 2012). FAW were affected by cold temperature for long period and have no diapause (Rodney *et al*., 2015, Geogern *et al*., 2016). The larval length influenced by temperature before developing to adults (Aguilon *et al.*, 2015). The suitable temperature of develop and survival rate of larvae found in the range 25 to30 degree (Mohamed *et al*. 2021). The host plant species affected on the duration and survival rate of larvae (Salem *et al*., 2021). With the end of the season of maize by converting it to silage in the area under study, armyworm may have an economic impact, especially during the autumn to the new crops. Therefore, the suitability of host plants on development and survival rate was studied to estimate the damage could be happened in the same aria.

MATERIALS AND METHODS

Host plant studies:

Armyworm classification confirmed with the beginning of the appearance at the end of September 2020 on maize and amaranth which were planted in Qutour Center, Gharbia Governorate. The onset of infection on different plants in the same location were investigated, till September 2022 and were recorded monthly. Direct counts of the larvae and bite eggs were used.

Biological studies:

The laboratory study of the fall Armyworm was carried out in the Vegetable Pest Research Laboratory at the Plant Protection Research Institute, Dokki Giza. The study was carried out at a temperature of 28±2 ºC, a humidity of 60% and a light period of 12:12 hours. Fall armyworm larvae were collected from the corn plants on which they are located in the field and transferred to the laboratory. These larvae were bred until they turned into pupae and full insects on the

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corn plants. Corn, okra, mallow and amaranth plants were bred in small pots up to 40 days old, and green young fruits were obtained for tomato and pepper plants to be used in the breeding process, also amaranths plats were transplanted from the field to laboratory. The incubation period of egg stage was recorded on various plants. In respect to the larval stage, the first instar larvae were divided and reared in a plastic container containing parts of plant leaves of maize, okra, mallow, amaranth, table beet, pepper and tomato. For each plant species, 10 larvae were reared in each container and the experiment was repeated three times with total 30 larvae/plant species. The development and survival rate of the larval stage were monitored. Once larvae completed their development to pupae, all pupal were collected and counted on each plant to record their development and survival rates. After adult exclusion, adults were reared on two kind of cages: A cage was made in small greenhouse, covered with nets, with an area of 2 × 4 meters and a height of 1.5 meters and planted with the seven plant species with 40 day-olds to study the host preferences and choice test of egg laying. The second cage was equipped in the laboratory, with an area of 40 × 40 cm and a height of 60 cm, covered with net, also contain a planted cups with different species, also in both cages a 5% sugar solution was presented in a plastic box containing a piece of cotton to feed the moth and each plant species to investigate, the adult longevity ,preoviposition period, oviposition period, post oviposition period, female fecundity and the selection of plants to lay eggs with or without maize.

The developmental times and survival rate were analyzed using an ANOVA at 0.05 probability level. In case of significant, means were separated using Duncan's multiple test.

RESULTS AND DISCUSSION

Results

Data in Table (1) indicate that the mean numbers (±SE) of immature stage durations of *S. frugiperda* rereading on different plants. The incubation period was similar in all plants and recorded 2.5±0.5day. The larvae duration receded the lowest duration on maize and amaranth with13.0±1.0 day, meanwhile the longest larval duration was recorded on pepper by19.5±0.5. A significant differentiation found on the total period between host plants, the total duration from eggs to adults recorded the longest period on tomato and pepper, meanwhile the lowest period recorded on maize, okra and amaranth.

Table 1. Effect of different host plants on durations (± SE) of the immature stages of *S. frugiperda*.

Host plants		Maize	Okra	Mallow	Amaranth	Tomato	Pepper	Table beet
Parameters		Means ±SE	Means ±SE	Means ±SE	Means ±SE	Means ±SE	Means ±SE	Means ±SE
Incubation period		2.5±0.5a	2.5±0.5a	2.5±0.5a	2.5±0.5a	2.5±0.5a	2.5±0.5a	2.5±0.5a
larval stage	1st instar	1.5±0.3b	2.0±0.5a	2.0±0.5a	1.5±0.3b	3.5±0.5c	3.0±0.0d	3.0±0.0d
	2nd instar	1.5±0.3b	2.0±0.5a	2.0±0.5a	1.5±0.3b	3.0±0.5c	3.5±0.0c	3.0±0.5b
	3rd instar	2.0±0.5a	2.0±0.5a	2.0±0.5a	2.0±0.5a	2.5±0.5c	3.0±0.0b	2.0±0.0a
	4th instar	2.0±0.5b	2.0±0.5b	3.0±0.5c	2.0±0.5b	3.0±0.5c	3.5±0.5c	3.5±0.0c
	5th instar	3.0±0.0c	3.0±0.0c	3.0±0.0c	3.0±0.0c	3.5±0.0c	3.0±0.5c	3.5±0.0c
	6th instar	3.5±0.5c	4.0±0.0c	4.0±0.0c	3.5±0.5c	3.5±0.5c	3.5±0.5c	3.0±0.0c
Total larval stage		13.0±1.0a	15.0±1.0b	16.0±0.5b	13.0±1.0a	19.0±1.0c	19.5±1.0c	18±0.0c
pre pupal		1.0±0.0	1.0±0.0	1.0±0.0	1.0±0.0	1.0±0.5	1.0±0.5	1.0±0.5
Pupal stage		5.0±0.6a	5.0±0.6a	5.3±0.6a	5.0±0.6a	6.0±0.6a	6.3±0.6a	6.3±0.6a
Total Immature (Egg-Adult)		23.5±0.2a	25.5±0.3b	26.5±0.4b	23.5±0.2a	29.1±0.5c	29.7±0.6c	28.0±0.5c

Values in the same row followed by different letters are significantly different by ANOVA test (P<0.05).

Data in table (2) show the survival rate of the immature stages of *S. frugiperda* on different host plants. On larval stage the rate of survival recorded 100%, but about 50% only survived on table beet, the total survival of larval stage showed no differences between maize, okra, amaranth, meanwhile in mallow, pepper and tomato the survival rate were significant with the first group. On table beet recorded the lowest survival rate with 10%.

Table 2. Survival rates of the fall armyworm *S. frugiperda* on various host plants

Host plants		Maize	Okra	Mallow	Amaranth	Tomato	Pepper	Table beet
Parameters		%	%	%	%	%	%	%
Incubation period		100	100	100	100	100	100	100
larval stage	1st instar	100.0a	100.0a	100.0a	100.0a	100.0a	100.0a	50.0b
	2nd instar	100.0a	100.0a	100.0a	100.0a	100.0a	100.0a	66.0b
	3rd instar	100.0a	100.0a	100.0a	100.0a	100.0a	100.0a	66.7b
	4th instar	100.0a	90.0a	90.0a	100.0a	100.0a	83.3a	100.0a
	5th instar	100.0a	92.6a	96.3a	100.0a	86.7a	96.0a	80.0b
	6th instar	100.0	100.0	88.5	86.7	92.3	95.8	100.0
Total larval stage		96.7a	83.3a	76.7b	86.7a	76.7b	66.7b	16.7c
Pupal stage		96.6a	83.3a	75.3a	82.0a	95.8	82.6	62.5
Total Immature (Egg-Adult)		96.4	80.0	70.7	96.2	70.0	63.3	10.0

Values in the same row followed by different letters are significantly different by Anova test (P<0.05).

Data in Table (3) show the preoviposition, ovipositional, post oviposition, adult's longevity and female fecundity of the fall armyworm *S. frugiperda* on different host plants. It can be indicated that no differences found in preoviposition period in all host plants.in oviposition period showed also no differences in all host plants Except for females produced from table beets, it didn't produce eggs. Adult longevity found to be significant differences between tomato and the female Fecundity showed the highest egg production on maize, okra, mallow and amaranths, this plant group produce around 1600 to 1700egg/female. A significant difference on egg production found between tomato and pepper from one side and the others from the other side.

Table 3. Adult longevity and female fecundity (± SE) of the fall armyworm *S. frugiperda* on various host plants

Host plant parameters	Maize	Okra	Mallow	Amaranth	Tomato	Pepper	Table beet
pre-oviposition	2.0±0.0a	2.0±0.0a	2.0±0.0a	2.0±0.0a	2.0±0.0a	2.0±0.0a	4.0±0.5c
Oviposition	5.0±0.5a	5.0±0.5a	5.0±0.5a	5.0±0.5a	5.0±0.5a	2.5±0.10b	0.0±0.0c
post-oviposition	2.0±0.0a	2.0±0.0a	2.5±0.5b	2.0±0.5b	2.5±0.5b	2.0±0.10a	00.0±0.0c
Female longevity	10.5±1.3a	11.5±1.3a	10.5±1.3a	10.5±1.3a	8.0±1.0b	6.0±1.0b	4.0±0.5c
Male longevity	9.1±1.0a	11.5±1.1a	8.5±1.3a	9.5±1.3a	8.0±1.0b	6.0±1.0b	0.0±0.5c
Fecundity	1700±100a	1500±100a	1500±100a	1600±100a	1100±50b	1100±50b	00±00c

Values in the same row followed by different letters are significantly different by Anova test (P<0.05).

Data in Figure (1) show the female egg laying under choice and no-choice host plant tests of the fall armyworm *S. frugiperda.* Data showed that female armyworms preferred laying eggs on corn and amaranth plants, in the presence of other plant hosts. While when placing the females with each plant host without the presence of the optional, the results showed that the eggs were not laid on the beet, pepper and tomato plants, but when placing the green fruits of tomatoes and peppers, it laid eggs on them. It was also noted that the females placed eggs on the wall of the cages, in the presence or absence of their favorite host plant.

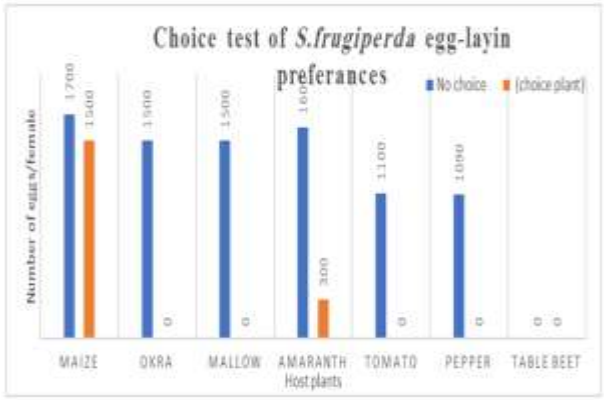

Fig. 1. Choice test of the fall armyworm *S. frugiperda* egg -laying preferences on different host plants.

Discussion

On duration times, the incubation period of FAW founded to be ranged from 2.5 to 3 days which were agreed with Murúa *et al.* (2008), Garcia *et al.* (2018) and Mohamed *et al*. (2021). The larval stage duration differed based on the host plant in which it ranged from 14 to 19.5 days and this in consistent with those of Igyuve *et al.* (2018), Lamsal *et al.* (2020), ELSheikh *et al.*,(2021) and Mohamed *et al* (2021). Further, the host plant type affected on the larval duration and changed in each specie which could be the reasons of crop damage as mentioned by Agboyi *et al.* (2019). On tomato and pepper fruits, the duration of larvae found to be longer than other host plants which are in consistent with that found by Makgoba *et al.* (2021) and Wu Li-hong *et al.* (2021). The pupal duration did not differ on all host plants with duration less than 8 days which was closed to that reported by Nandita and Sonali (2020) but not closed to that reported by Sharanabasappa *et al.* (2018). The female of FAW lived longer than male which is in consistent with Vina *et al.* (2003). The total life cycle of FAW ranged from 23 to 28 days which are agreed with that of Nandita and Sonali (2020) and . The survival rate is affected by the host plant type that is ranged on maize and okra from 70 to 96% which are in consistent with those of Besmer *et al*., (2022) and in consistent with the same author in tomato that recorded with him 20%. The preoviposition period, oviposition and post oviposition did not differ between all host plants except table beet which is agreed with Wu Li-hong *et al.* (2021). Female egg productivity found with rang of eggs affected by the plant feed type and temperature

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الجوانب البيولوجية لدودة الحشد الخريفية مع اختلاف العوائل النباتية

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معهد بحوث وقاية النبات -مركز البحوث الزراعية - الدقى - جيزة

الملخص

أصبحت دودة الحشد الخريفية أحد العوامل التي تهدد إنتاجية المحاصيل الزراعية في جميع أنحاء العالم. في الحقول المصرية ، أصبحت من أخطر الآفات التي تصيب الذرة على مستوى الدولة. في شمال مصر وجدت اليرقات تتغذى على أنواع نباتية مثل الذرة ,البامية ,الملوخية ,القطيفة , ثمار نباتات الطماطم والفلفل وبنجر المائدة. تم تربيتها معمليا على هذه النباتات فأظهرت قدرتها على البقاء في كل هذه الفصائل النباتية بنسب 90 و 80 و 76.7 و 83.3 و 70 و 63.3 و 10٪. فترة حضانة البيض متشابهة في جميع النباتات حيث سجلت 2.5 - 3.0 يوم. سجلت مدة اليرقات 13.0 ± 1.0 ، 15.0 ± 1.0 ، 16.0 ± 0.5 ، 13.0 ± 1.0 ، 19.0 ± 1.0 ، 19.5 ± 0.0 و 18 ± 0.0 يوم. سجل طور العذراء تشابة في جميع النباتات المضيفة مع 6.0 ± 0.6 إلى 6.3 ± 0.6 يوم. يسجل طول العمر البالغ فرقًا معنويًا بين الذرة والبامية والقطيفة والملوخية بمعدل 10.5 ± 0.13 يوم وتلك في الطماطم والفلفل وبنجر المائدة مع 8.0 ± 1.0.6.0 و 1.0 ± 4.0 05 يومًا على التوالي. كانت فترة وضع البيض متشابهة أيضًا 5.0 ± 0.5 يوم ، وسجلت فترة ما بعد البيض 2.00 ± 0.0 يوم بدون معنوية ، تضع الإناث بيضًا على نباتات الذرة والقطيفة في حالة الاختيار بين العوائل بينما فى حالة عدم الاختيار تضع البيض على جميع النباتات المضيفة و على ثمار الطماطم والفلفل الأخضر .