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Establishment and parasitism efficiency of *Trichogramma principium* (Sugonyaev *et* Sorokina) on *Helicoverpa armigera* (Hb.) infesting cotton in Sudan

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ABSTRACT

This study was conducted at the Gezira Research Station (GRS) farm during 2010/11 season to verify establishment and parasitism efficiency of *Trichogramma principium* (Sugonyaev *et* Sorokina) (Hymenoptera: Trichogrammatidae) in eggs of *Helicoverpa armigera* (Hb.) (Lepidoptera: Noctuidae) infesting the Sudanese cotton cultivars "Barac 67B", "Hamid", "Burhan" and "Abdin". *Trichogramma* was acquired from the Rearing Unit, Agricultural Research Corporation (ARC), at preimaginal (prepupal) stage, in eggs of the rice moth *Corcyra cephalonica* (Stainton) (Lepidoptera: Pyralidae). Depending on numbers of *H. armigera* eggs / 100 plants, one release was done on each of Barac and Hamid and two on each of Abdin and Burhan. The release rate was 24,000 parasitoids /fed, at 7x7m distance between release points and 14-day intervals. Evaluation was done between treated plots with *Trichogramma versus* untreated. Observations consisted of the percentage of emerged parasitoids, percentage of parasitism and the numbers of the African bollworm larvae /100 plants. At the first release, the percentage of emerged parasitoids ranged between 71% in Barac and 86.4% in Hamid; the cultivars` average ranged between 60.5% and 94.8% and the overall average was 79.2%. The percentage of parasitized *H. armigera* eggs ranged between 22.2% and 60%. At the second release, the percentage of emerged adults ranged between 73.2% in Burhan and 82.1% in

Abdin; the cultivars average ranged between 46.6 and 96.7% and the overall average was 77.7%. The percentage of parasitized *H. armigera* eggs ranged between 22.2% and 77.7%. The high level of parasitoid emergence declared a good viability of the released material, tolerance of the parasitoid to the local weather conditions and acceptance of the crop. The levels of parasitism reported were quite acceptable for this introductory release and first occurrence of the parasitoid in this new cotton agroecosysytem. A positive signal of migration from treated to untreated plots was observed through parasitized *H. armigera* eggs detected in the latter plots. The numbers of *H. armigera* larvae were negligible in both treatments. Accordingly, for proving potential capacity of establishment and parasitism efficiency against *H. armigera*, *T. principium* is strongly recommended for use on Sudanese cotton cultivars.

INTRODUCTION

Cotton in the Sudan is attacked by four major insect pests: The African bollworm *Helicoverpa armigera* (Hb.) (Lepidoptera: Noctuidae), jassid *Jacobiasca lybica* De berg (Homoptera: Cicadellidae), aphids *Aphis gossypii* Glov. (Homoptera: Aphididae) and the whitefly *Bemisia tabaci* Genn. (Homoptera: Aleyrodidae). The bollworm is the disastrous one. In order to achieve effective control of *H. armigera*, often large quantities of insecticides are applied that drastically increase the cost of protection, enhance the development of insect resistance and constitute hazards to human, animal and the environment. Here, biological control stands as the most reliable tool for such a case, because it is safe, effective and compatible with other integrated pest management tactics. *Trichogramma* eggs parasitoid is one of the biological control agents, successfully reared worldwide and released for control of various insect pests attacking diverse agricultural crops and especially the African bollworm on cotton.

Trichogramma is characterized by being specific and by attacking and killing the pest eggs before hatching and damage the crops. According to Knipling and McGuire (1968), the goal of most *Trichogramma* release programs is to maintain a level of more than 80% parasitism on freshly laid host eggs. Hassan (1993) stated that *Trichogramma* was being used against lepidopterous pests in more than 50 countries on 32 million ha each year. Studying the parasitism potential of *T. australicum* and *T. chilotraeae* on eggs of *H. armigera*, Torreno and Cadapan (1984) reported that parasitization and subsequent emergence of both adult parasitoids were higher in newly laid (less than 12 hours) eggs than in the two and three-day-old eggs, i.e., as the host egg advances in embryonic development, it becomes less attractive for parasitization. Abdalla (2011) reported 88.8% parasitism on *C. cephalonica* fresh eggs with *T. principium*, *versus* 50.7% on 4-10 day-old-eggs, confirming that the newly laid host eggs are much preferred by females. Therefore, *Trichogramma* releases in fields should synchronize with the oviposition period. In this regard, Kanour and Burbutis (1984) stated that the best results were achieved when *Trichogramma* was released a few days before, rather than at the start of oviposition.

The timing, frequency, and rates of *Trichogramma* releases in the field are managed with different pest assessment aspects. Witz *et al*. (1985) suggested following the degree-days method. Bigler and Brunetti (1986) advised the use of light traps. Smith *et al*. (1990) recommended the pheromone traps. Prasad *et al*. (2009) proposed 4-6 releases /season at 50,000-100,000 parasitoids /ha, and 10 day intervals. Gusev and Lebedev (1988) recommended 5-7 day intervals and Smith (1996) indicated that the rate of release might vary considerably even for the same pest, crop, and country.

In the Sudan, *Trichogramma* has a wide potential scope of use (Abdalla, 2010). Some twenty years ago, *T. pretiosum* was once brought from USA *via* the Netherlands, as a ready bio-agent, and

directly released on some cotton fields. Indigenous attempts to produce *Trichogramma* was started in 1995 first in eggs of the grain moth *Sitotroga cerealella* (Lepidoptera: Gelechiidae) (Abdalla, 1996), then in 2000 in eggs of *Ephestia cautella* (Lepidoptera: Pyralidae) (Abdalla, 2003), but both efforts did not succeed. In 2009, the rice moth *C. cephalonica* was used and the rearing technique was successfully developed. The Russian species *T. principium* (Sugonyaev *et* Sorokina) was introduced from Syria and its rearing technique was successfully developed too (Abdalla, 2010). At present, some millions of *T. principium* are weekly produced during the release seasons, and released on different crops like cotton, sorghum, sesame, sunflower, sugar beat, tomato, eggplant and okra.

The objectives of this study were to verify the establishment and parasitism efficiency of *T. principium* in eggs of *H. armigera* infesting four Sudanese cotton cultivars.

MATERIALS AND METHODS

This field study was conducted at the GRS farm during 2010/11 season. The cotton cultivars used were "Barac 67B", "Hamid", "Burhan" and "Abdin". A randomized complete block design for treated *versus* untreated cultivars, with three replicates was adopted. Sowing was effected on mid July 2010, on ridges of 80 x 50 for inter- and intra-row spacing, respectively, with three plants thinned per hole. The area under Hamid was 10 feddans (fed) and for each of the other cultivars was 5 fed. The parasitoids were acquired from the *Trichogramma* Rearing Unit, ARC, at preimaginal (prepupal) stage, on eggs of the rice moth, prepared in form of "Trichocards" after being subjected to cool storage at 10°C and complete darkness for not more than 4 weeks (Abdalla, 2010; 2011). *Trichogramma* was released on ¾ of the area /cultivar and the rest ¼ was left untreated. The rate of release was 24,000 parasitoids /fed (Parasad *et al*., 2009); the distance between release points was 7x7m and the interval between

releases was 14 days (Smith, 1996). In the filed, each Trichocard, with *ca* 3,000 parasitoids glued to it, was cut into 10 pieces using scissors, and each piece was hanged on a branch or a leaf petiole through the "7" shape cut made on, in the release point, with the parasitoid surface directed towards the main stem. Depending on numbers of *H. armigera* eggs / 100 plants one release was done on each of Barac and Hamid and two on each of Abdin and Burhan. A pre release count was done 24h before, and the post release counts were carried-out at weekly intervals. Observations consisted of the percentage of emerged parasitoids out of the released Trichocards, the percentage of *H. armigera* parasitized eggs and numbers of *H. armigera* larvae /100 plants. Parasitized eggs were easily identified in the fields as they turn black starting from the fourth day of parasitism. The percentage of emerged parasitoids was determined a week after the release, by collecting back 20 Trichocard pieces /treatment, then checking them under the microscope (45x) for total numbers of blackened eggs and eggs showing exit holes by the following formula:-

$$\text{Emerged parasitoids (\%)} = \frac{\text{Number of blackened eggs showing exit holes} \times 100}{\text{Total number of blackened eggs}}$$

No insecticides were applied in this study. All other cultural practices were performed according to the ARC standards.

RESULTS AND DISCUSSION

Percentage of emerged parasitoids

As shown in Table 1, after the first release, the highest percentage of emerged parasitoids out of the released Trichocards ranged between 88.2% in Burhan and 100% in Hamid and Abdin; the lowest values ranged between 50% in Barac and 72.3% in Hamid, and the average ranged between 71% in Barac and 86.4% in Hamid cultivar. The average of the cultivars` lowest values was

60.5%; the average of the highest values was 94.8% and the overall average was 79.2%. After the second release, the highest percentage of emerged adults ranged between 93.3% in Burhan and 100% in Abdin; the lowest values ranged 38.9% in Burhan and 54.2% in Abdin, and the average ranged between 73.2% in Burhan and 82.1% in Abdin cultivar. The average of the cultivars` lowest values was 46.6%; the average of the highest was 96.7% and the overall average was 77.7%.

Emergence of *Trichogramma* parasitoids in fields is considered one of the characters that define "good quality parasitoid". According to Smith (1996), these characters are: Emergence, high fecundity, sex ratio (percentage of female offspring), longevity, host preference, host-searching activity and tolerance to local weather conditions. Weather, as stated by Andow and Prokrym (1990), is probably the most pervasive, in that it is a complex of meteorological variables that affect the development, emergence, survival, activity, and fecundity of *Trichogramma.* Yu and Byers (1994) stated that the most influential components of the weather are temperature and humidity; in the extreme, both these components have been linked to poor field results. Smith (1996) related parasitoid development and emergence directly to temperature, by stating that extremes in fields disrupt emergence, survival and performance of *Trichogramma*. In regard to the effects of other weather components, few field studies suggest that *Trichogramma* avoid dew and winds greater than 1.1 km/h (Keller *et al*., 1985), areas of bright light intensity and heavy rain (Wajnberg, 1995).

The recorded levels of emergence in this study were sufficiently high and declared three main points: (1) Success of the rearing, cool storage and release processes executed at both, the laboratory and the field levels that ultimately secured highly viable material. (2) Acceptance of *T. principium* to the host and the crop (3) Good harmony of the released *T. principium* with the prevailing weather

elements, i.e., the parasitoid had shown tolerance to the local weather conditions..

Table 1. Emergence of adult parasitoids out of the released Trichocards.

Cultivar	Percentage of emergence			SD
	Average	The highest	The lowest	
		First release.		
Barac 67B	71.0	90.9	50.0	12.3
Hamid	86.4	100.0	72.3	8.5
Abdin	79.1	100.0	55.6	11.5
Burhan	80.4	88.2	64.0	7.0
Overall average	79.2	94.8	60.5	
		Second release		
Abdin	82.1	100.0	54.2	11.1
Burhan	73.2	93.3	38.9	20.0
Overall average	77.7	96.7	46.6	

Percentage of parasitism on *H. armigera* eggs

The percentage of parasitized *H. armigera* eggs ranged between 22.2% in Burhan and 60% in Hamid cultivar after the first release and between 22.2% and 77.7% in Abdin cultivar after the second release, i.e., varied considerably (Table 2). However, a similar range between 18.2% and 82.8% was reported by Pascua and Pascua (1995) of *H. armigera* eggs on cotton parasitized with *T. chilonis*. In countries with advanced practices of *Trichogramma* uses, high levels of parasitism are consistently achieved. In China, Switzerland, Canada, and the former USSR *Trichogramma* releases have all shown consistent levels of 60-80% parasitism on Lepidopterous attacking cotton, sugarcane and corn (Li, 1994).

Suphangkasen (1979) recorded 80% egg loss of *H. armigera* attacking cotton due to parasitization by *T. chilonis*.

The wide range of parasitism recorded in this study, might be attributed to many causatives such as: (i) the release was introductory, i.e., it was the first time for this parasitoid to show up in this new agroecosystem, where all biotic and a-biotic factors are novel for it. Scholz *et al.* (2002) stated that inundative releases usually do not have high immediate impact on target pests. (ii) Low numbers of *H. armigera* eggs reported in the fields. Basso and Morey (1990) stated that *Trichogramma* parasitism tends to be higher in areas with high numbers of hosts, and contrarily in areas with low numbers of hosts. (iii) Low rate of release. The rate of release used in this study (24,000 parasitoids /fed. ≈ 57,000 /ha) did not come up in results of indigenous studies; it was extracted from the scientific literature (Prasad *et al.*, 2009) and is undergoing at present field verification. Diverse rates and wide ranges of *Trichogramma* release were reported by different authors. The latter author recommended a range of 50,000-100,000 parasitoids /ha. Smith (1996) recommended a rage of 46–956 thousand wasps/ha for *T. pretiosum* against *Helicoverpa* on cotton. Gross *et al.* (1981) stated that the rates of *Trichogramma* release in agricultural crops, such as corn, cotton and tomato, range from 500 to more than one million wasps /ha, with averages of 200,000 to 600,000 wasps /ha. These wide ranges as stated by Wang (1988) are probably related to the range in dimensional volume of the crop; China often reports lower rates than other countries, possibly because of the frequent use of large host eggs. Thus, the rate of release used in this study was probably low and needs to be increased in the future in order to get higher levels of parasitism.

T. principium had also shown good capacity of movement between fields where parasitized *H. armigera* eggs were observed in the neighboring untreated cotton fields. This was evident by the 33.3% parasitized eggs recorded in the untreated plot of Barac and

36% in Hamid after the first release and the 11.1% parasitized eggs in the untreated plot of Abdin after the second release (Table 2).

The numbers of *H. armigera* larvae, reported in both treated and untreated plots, were negligible and hence, are not reported in this article.

Table 2. Percentage of parasitized *H. armigera* eggs with *T. Principium*.

Treatment	Counts				
	1st	2nd	3rd	4th	5th
		First release			
Barac 67B (T)	NE	31.6	53.6	NE	33.3
Barac 67B (UT)	0.0	0.0	0.0	33.3	0.0
Hamid, T	60.0	57.8	25.0	NE	33.3
Hamid, UT	0.0	36.0	0.0	0.0	0.0
Abdin, T	NE	26.2			
Abdin, UT	0.0	0.0			
Burhan, T	22.2	27.5			
Burhan, UT	0.0	0.0			
		Second release			
Abdin, T	77.7	22.2	66.7		
Abdin, UT	11.1	0.0	0.0		
Burhan, T	66.7	33.3	33.3		
Burhan, UT	0.0	0.0	0.0		

T = treated with *Trichogramma*. UT = untreated. NE = no eggs. More than 50% of the initial data/count scored "zero" and hence, the data was not analyzed.

CONCLUSION

The eggs parasitoid *T. principium* proved to have a good potential as an effective biological control agent against the African bollworm *H. armigera*, and to establish in the cotton agroecosystem in Sudan.

RECOMMENDATION

The eggs parasitoid *T. principium* is strongly recommended for use on Sudanese cotton cultivars for control of the African bollworm *H. armigera*.

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Establishment and parasitism efficiency of Trichogramma principium (Sugonyaev et Sorokina) on Helicoverpa armigera (Hb.) infesting cotton in Sudan

المقدرة على الاستيطان والكفاءة التطفلية ل *Trichogramma principium* (Sugonyaev *et* Sorokina) ضد *Helicoverpa armigera* (Hb.) على القطن في السودان

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الخلاصة

أجريت هذه الدراسة بمزرعة محطة بحوث الجزيرة في موسم 2010-2011 للتثبت من المقدرة على الاستيطان و الكفاءة التطفلية ل *Trichogramma principium* (Sugonyaev *et* Sorokina) (Hymenoptera: Trichogrammatidae) على بيض دودة اللوز الأفريقية *Helicoverpa armigera* (Hb.) (Lepidoptera: Noctuidae) على أصناف الأقطان السودانية "باراك B 67"، "حامد"، "برهان"، و"عابدين". تم الحصول على طفيل التريخوجراما من وحدة الإكثار بهيئة البحوث الزراعية في طور ماقبل التشرنق بداخل بيض فراشة الأرز *Corcyra cephalonica* (Lepidoptera: Pyralidae) . اعتمادا على عدد بيض دودة اللوز / 100 نبات، فلقد أجريت إطلاقه واحدة على كل من الصنفين باراك و حامد و اطلاقتان على كل من الصنفين عابدين و برهان بمعدل 24000 طفيل للفدان و على مسافات 7x7م بين نقاط الإطلاق و بفاصل 14 يوما بين الإطلاقات. تمت المقارنة بين الحقل المعامل بالتريخوجراما و الغير معامل. اشتمل التقييم على تحديد النسبة المئوية لبزوغ الأطوار المكتملة من الطفيل، النسبة المئوية للتطفل و عدد اليرقات في ال 100 نبات. عند الإطلاقة الأولى، تراوحت النسبة المئوية لبزوغ الأطوار المكتملة بين 71% كما في باراك و 86.4% كما في حامد، و المتوسط للأصناف بين 60.5% و 94.8% و المتوسط العام لهم 79.2 % و تراوحت النسبة المئوية للتطفل بين 60% و 22.2%. عند الإطلاقة الثانية، تراوحت النسبة المئوية لبزوغ الأطوار المكتملة بين 73.2%% كما في برهان و 82.1% كما في عابدين، و المتوسط للأصناف بين 46.6% و 96.7% و المتوسط العام لهم 77.7% ، و تراوحت النسبة المئوية للتطفل بين 77.7% و 22.2%. يدل هذا المستوى العالي من بزوغ الأطوار المكتملة على الحيوية الجيدة للطفيل المطلق، تحمله للظروف الجويه وتقبله للمحصول العائل. تعتبر المستويات المتحصل عليها من التطفل مناسبة لهذا الإطلاق الإستهلالى و تواجد الطفيل لأول مرة على هذا الوسط البيئي الزراعي الجديد للقطن بالسودان. هنالك مؤشرات لبداية هجرة الطفيل من المساحات المعامله لغير المعاملة تمثل في تواجد بيض متطفل علية في الأخيرة. كان عدد يرقات ديدان اللوز قليلا في المعاملتين. و عليه، و لقابليته على الاستيطان و كفاءته التطفلية المقبولة على ديدان اللوز الأفريقية فان ال *T. Principium* موصى باستعماله بشدة على أصناف الأقطان السودانية.