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ORIGINAL ARTICLE

Investigations on the Biology and Ecology of *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) at New Halfa Scheme, Eastern Sudan

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Abstract

The African bollworm (*Helicoverpa armigera*) is known as a major pest of cotton and other crops in Sudan. The current study aimed to investigate some biological and ecological aspects of this pest, during 2007- 2010, including; surveys of host plants, as well as laboratory and field experiments on lifecycle, seasonal incidence and host preference. The mean durations of pre-imaginal stages, as followed on tomato (cv. Peto 86) fruits under laboratory conditions (mean, 26.2°C and 34% R.H.), were; 2.70±0.15, 16.50±0.18 and 10.80±0.20 days, for egg incubation, larval and pupal stages, respectively. The average period from egg to adult emergence was 30.00±0.53 days. Adult lifespan was 11.00±0.56 days for female and 9.90±0.53 days for male. Fecundity was 620.60±35.70 eggs as an average per female, during an oviposition period of 6.90±0.23 days. Survey results revealed eight plant species as major hosts for the pest, with pigeon pea and lablab bean displaying the highest incidence of infestation, whereas the wild plant "Tabar" *Ipomoea cordofana* sustained the lowest. Moreover, comparative studies among three tomato cultivars showed insignificant relatively high preference of the pest to Castle rock and Peto 86 compared to Strain B, as with respect to insect count and damaged fruits. It is concluded that *H. armigera* is an all seasons' pest in New Halfa, with high fecundity and multiplication levels on different host plants. Such hosts which are grown at variable times of the year help to enhance early buildup of the pest on cultivated crops especially in winter.

Keywords: African bollworm, *Lycopersicon esculentum*, lifecycle duration, host plants, seasonality.

Introduction

New Halfa Scheme in Kassala State is the second largest irrigated scheme in Sudan. It lies in the semi-arid zone of the country with maximum temperature of 38.1C° and minimum of 21.7°C. The rainy season is from June to September, with annual rainfall ranging between 250 – 500mm (New Halfa Meteorological Station 2004). The scheme occupies an area of 411,600 feddans (1 feddan= 0.42ha), from which 387,600 feddans is allocated for growing economic field crops like cotton (*Gossypium* spp.), groundnut (*Arachis hypogaea* L.), wheat

(*Triticum aestivum* L.) and sorghum (*Sorghum bicolor* (L.) Moench), whereas the rest is a free hold land (ca 24,000 feddans) used for forage and horticultural crops [e.g., tomato (*Lycopersicon esculentum* Mill), pigeon pea (*Cajanus cajan* (L.) Huth), other legumes and some fruits]. However, New Halfa is the main tomato growing region in Kassala State, where the crop is produced all the year round especially in autumn; with three cultivars (Castle rock, Peto 86 and Strain B) being the most popular. Besides its nutritional value, tomato fruit is considered as the main source of income earnings for the farmers.

Tomatoes as well as leguminous crops are attacked by a number of insect pests at different stages, with *Helicoverpa armigera* (Hubner) being the predominant species in different countries worldwide (Muthukumaran and Selavnarayanan, 2009). In Sudan, the major insect pests recorded for tomato and other leguminous crops included; *Liriomyza* spp., *Bemisia tabaci* (Gen.), *H. armigera*, *Phthorimaea operculella* (Zeller) and *Tuta absoluta* (Meyrick), with the latter species being newly introduced to the country (Ali, 2003; Mohamed *et al*., 2011, and Satti, 2011), but not yet established in New Halfa.

Larvae of *H. armigera* cause considerable damage to fruits of tomato and other hosts, so facilitate soft rot disease infection. Several biological characters including; high polyphagy, wide geographical range, mobility, migratory potential, facultative diapause, high fecundity and ability to develop resistance against insecticides, all have enabled *H. armigera* to attain key pest status for different crops (Zalucki *et al*., 1986; Fitt, 1989, and Torres-Vila *et al*., 2002). Among the major cultivated hosts for the pest are; cotton, maize (*Zea mays* L.), sorghum, sunflower (*Helianthus annuus L*.), chickpea (*Cicer arietinum L*.), pigeon pea and tomato. Also, there are some wild hosts which play significant role in the carryover of this pest during the dry season, and this is also potentially governed via biological and physiological characteristics of the pest.

Thus, knowledge of biology and ecology is important for understanding population dynamics of *H. armigera* in the field. Though, several biological studies have been done in Sudan (Schmutterer, 1969; Ali, 1983, and Balla, 1986), essential biological features, host range and preference of *H. armigera* especially in connection with tomato crop in New Halfa area are incomplete, given that the area is characterized by diversified farming systems and natural flora.

This study aimed to fill some gaps in important bio-ecological aspects of *H. armigera* at New Halfa area, emphasizing mainly; lifecycle, seasonal incidence, host range and preference to some tomato cultivars.

Materials and Methods

1. Laboratory rearing and lifecycle a study of *H. armigera*

Lifecycle duration of *H. armigera* was studied during January 2009, at the Faculty of Agriculture and Natural Resources, University of Kassala. The experiment was conducted under ambient laboratory conditions, where temperature and relative humidity were recorded during the study period using a thermo-hygrometer.

Forty fully grown larvae of *H. armigera* were collected from a tomato (untreated) field, and reared individually in a Petri dish, 9.0 cm in diameter. Each larva was supplied with pieces of fresh tomato (cv. Peto 86) fruits, renewed daily and frass discarded until it ceased feeding, then sawdust was provided as substrate for pupation.

Emerging moths after pupal stage were examined and paired and introduced on the same day into oviposition cages. Such cages consisted of kerosene lamp glasses with the top ends covered with muslin cloth and the lower fitted on an ordinary clean jam-jar filled with water. The jar was covered with a polyethylene sheet to protect moths from drowning. A small tube with 10% sugar solution, plugged with cotton wick, was

inverted and suspended inside the cage by a thread to serve for nourishing adults. A suitable fresh tomato branch with young leaves and flower buds was provided inside the cage as an oviposition site; it was dipped in water to keep it turgid. These branches were renewed daily to attract the moths for egg laying. Eggs were transferred by means of a moist fine camel hair brush into Petri-dishes lined with moist filter papers, using ten replicates. The date of egg laying and the number of eggs transferred into each Petri-dish were recorded and examined on a daily basis until hatching.

The newly hatched larvae were transferred to new Petri-dishes (10 larvae/dish), with ten replicates. The dishes, lined with moist filter papers, were daily provided with tender leaves of tomato plants (cv. Peto 86) for feeding. At the third instar stage the larvae were placed separately into new Petri-dishes to prevent cannibalism, each reared on a tomato fruit of the same previous cultivar. The development of larval stages was followed until pupation. Molting was recognized by detection of head capsule. The newly emerging adults were sexed and caged separately (i.e., in pairs). Eggs laid by each mated female were recorded; meanwhile, pre-oviposition, oviposition and post-oviposition periods and adult longevity were determined.

2. Field surveys of host range and incidence of the pest

Surveys of plants which serve as hosts for the African bollworm were carried out in New Halfa area during autumn - winter seasons (from July to January) in two consecutive years (2007/08 and 2008/09). Plants investigated included; "Taber" (*Ipomoea cordofana*), maize (*Zea mays* (L.)), sunflower (*Helianthus annus*), sorghum (*Sorghum bicolor*), lablab bean (*Lablab purpureus* (L.)) and pigeon pea (*Cajanus cajan*). The plants were inspected weekly at flowering and fruiting stages for larval count. For each host, 100 plants were sampled randomly each time, and the level of pest was recorded.

3. Incidence and preference of *H. armigera* among tomato cultivars

Host preference of *H. armigera* was assessed among three tomato cultivars (i.e., Strain B, Peto 86 and Castle rock) commonly grown in New Halfa. The experiments were conducted at the Demonstration Farm of the Faculty of Agriculture and Natural Resources, University of Kassala, New Halfa, during (2007-2010) autumn and winter seasons (i.e., two experiments in each year). Infestation levels (count of eggs and larvae) and fruit damage were taken as the main parameters of the study. The cultivars were grown in plots (6×7m) with five replicates, assigned in a Randomized Complete Block (RCB) design. Spacing was 1.5m and 0.3m between beds and plant holes, respectively. Seeds were sown (5 seeds/hole) in July (autumn season) and November (winter) through direct seeding, and then thinned thereafter to one plant per hole. Cultural practices recommended by the Agricultural Research Corporation, including irrigation, weeding and fertilizer application, were followed. To avoid leaf curl virus disease, *B. tabaci* was controlled during early vegetative growth using the insecticides Danitol 20% EC and Confidor 200SL., at recommended doses of 0.4L and 0.2L/fed., respectively. Temperature and rainfall data were obtained from New Halfa meteorological station.

Plots were inspected weekly for checking *H. armigera* infestation throughout the season. The upper part of the plant was chosen for examination because it is the preferred oviposition site by *H. armigera* (Torres-Vila *et al*., 2003). Ten random plants were examined per each plot, where numbers of eggs, larvae and damaged fruits were recorded. At maturity, all fruits of each variety were carefully inspected twice a week and the mean percentages of infested fruits were recorded. ANOVA was done for the collected data based on the RCB design and LSD Test.

Results and Discussion

1. Lifecycle duration of *H. armigera*

Results were achieved on developmental stages of *H. armigera* reared on tomato (cv. Peto 86) under laboratory conditions (mean, 26.2°C and 34% R.H.), during January 2009 at New Halfa. Results concerning durations of different immature stages and adults life span were presented in table 1. Eggs were laid (singly or in small groups) at night on lower and upper surfaces of leaves and branches of tomato in the cage. The average incubation period was 2.70±0.20days (the range: 2 – 3 days), with an average hatchability of 83.3±2.3%. Such results are within the range (2 – 6 days) previously reported for the species (Jallow and Matsumura, 2001, and Abdalla and Elkhidir, 2004).

The development period of each larval instar as well as the total larval period (16.50±0.18days) and larval mortality (37.00±3.70%) are shown in table 1. The 6th instar larva took the longest duration (4.20±0.22days), followed by the 1st stage (3.10±0.10), whereas each of the rest instars' duration was lowest. Nearly similar larval duration (16.20 days) on tomato was recorded by Jallow *et al*. (2001). Jallow and Matsumura (2001) also noted larval duration of 16.10 days on tomato fruits. It was observed from the current results that the newly formed pupae were pale-green in colour, and then changed to mahogany brown thereafter. Pupae took 10.80±0.20days, on the average, to give adults, with high emergence level (91.10±7.70%). No diapauses pupae were observed. However, comparable results on the pupal duration were obtained by Jallow and Matsumura (2001).

The total development period from egg to adult emergence was 30.00±0.53 days, on the average. Adults emerged at night. The forewings were greenish in the male and brownish in the female. The female lived relatively longer than the male; their mean life span recorded were 11.00±0.56 and 9.90±0.53 days, respectively. These results supported the findings obtained by Bhatt and Patel (2001) on the same aspect. Akashe *et al*. (1997) also reported that females lived 2-3 days longer than males.

Table 1. Life cycle durations of *Helicoverpa armigera* reared on tomato (cv. Peto 86) fruits under laboratory conditions (mean, 26.2ºC and 34% R.H.) at New Halfa (Jan. 2009).

Stage	Replicates	No. observed	% hatchability	duration (days)	
				Range	Mean (±S.E.)
Egg incubation	10	300	83.30 ± 2.30	02 – 03	02.70 ± 0.15
			% developed		
1st instar larva	10	10	-	03 – 04	03.10 ± 0.10
2nd instar larva	10	10	-	02 – 03	02.20 ± 0.13
3rd instar larva	10	10	-	02 – 03	02.20 ± 0.13
4th instar larva	10	10	-	02 – 03	02.20 ± 0.15
5th instar larva	10	10	-	02 – 03	02.70 ± 0.17
6th instar larva	10	10	-	03 – 05	04.20 ± 0.22
Total larval instars	**10**	**100**	**63.00 ± 3.70**	**13 – 18**	**16.50 ± 0.18**
			% emergence		
Pupa	10	63	91.10 ± 7.70	10 – 12	10.80 ± 0.20
			% developed		
Egg to adult stage	10	463	79.13 ± 4.57	25 – 33	30.00 ± 0.53
Female life span	10	10	-	07 – 15	11.00 ± 0.56
Male life span	10	10	-	06 – 13	09.90 ± 0.53

As shown in table 2, the mean pre-oviposition, oviposition and post-oviposition periods recorded were; 2.80±0.20, 6.90±0.40 and 1.20±0.20 days, respectively. This indicated that the female *H. armigera* spends almost all its life span in reproduction, and died within few hours after that. The fecundity of female was 620.60±35.70 eggs on the average (Table 2). Similar findings were reported by Bhatt and Patel (2001) on certain biological aspects of this moth. On the other hand, Liu *et al*. (2004) reported 559 eggs on tomato, while Mojeni (2008) in his oviposition preference studies recorded 338.2 eggs on tomato, 789.6 on cotton and 829.8 on chickpea. Such discrepancy in results could be attributed to differences in experimental conditions between the two studies, such as the variety of tomato used and other environmental conditions.

Table 2. Fecundity of *Helicoverpa armigera* reared on tomato (cv. Peto 86) fruits under laboratory conditions (mean, 26.2ºC and 34% R.H.) at New Halfa (Jan. 2009).

Serial No. of paired moths	Date when adult emerged	Start of egg laying	Pre-oviposition Period (Days)	Date when the last egg was laid	Oviposition Period (days)	Total No. of eggs laid	Date of adult death	Post-ovipostion Period (days)
1	10th Jan.	14th Jan.	4	21st Jan.	8	745	23rd Jan	1
2	11th "	13th "	2	18th "	6	255	20th "	1
3	11th "	14th "	3	20th "	7	601	21st "	0
4	12th "	15th "	3	19th "	5	456	20th "	0
5	13th "	16th "	3	24th "	9	806	26th "	1
6	13th "	15th "	2	20th "	6	571	22nd "	1
7	13th "	16th "	3	19th "	4	490	23rd "	3
8	14th "	17th "	3	23rd "	7	624	25th "	1
9	15th "	17th "	2	24th "	8	607	27th "	2
10	15th "	19th "	4	27th "	9	660	30th "	2
11	15th "	17th "	2	22nd "	6	623	25th "	2
12	15th "	18th "	3	26th "	9	778	28th "	1
13	16th "	20th "	4	25th "	6	648	28th "	2
14	16th "	18th "	2	25th "	8	613	26th "	0
15	16th "	18th "	2	21st "	4	603	23rd "	1
16	16th "	19th "	3	27th "	9	850	30th "	2
Total			45		111	9930		20
Range			**2 – 4**		**4 – 9**	**255 – 850**		**0 – 3**
Mean±S.E			**2.80± 0.20**		**6.90± 0.40**	**620.60±35.70**		**1.20± 0.20**

2. Detected hosts and incidence of *H. armigera*

The major host plants and population density of *H. armigera* in New Halfa area were determined through field surveys conducted during autumn and winter seasons of the years 2007/2008 and 2008/2009 (Table 3). Table 3 showed that five cultivated crops and a wild plant species acted as major hosts for the pest in the area. Moreover, other cultivated host plants included tomato and cotton crops; the former was dealt with in a separate experiment but cotton was excluded from the previous list and counts because it was subjected to intensive spraying with broad spectrum insecticides. Hence, a total of eight plants were recognized as main hosts for the pest in the studied area.

However, early grown weeds and some crops helped to harbor and multiply the pest before the establishment of tomato during mid autumn. For example, the results showed that during both years of the survey the pest appeared first on "Tabar" *Ipomoea cordofana* in July, and then moved to sorghum (*S. bicolor*), maize and sunflower in August and September. These findings are in line with Balla (1981) and Suliman *et al.* (2004) who reported that the weed *I. cordofana* is the first site for infestation

Table 3. Relative density of *Helicoverpa armigera* larvae on different host plants‡ as surveyed during two consecutive years (2007/08 and 2008/09), at New Halfa area.

Survey period/ Month	Mean* No. of larvae/ 100 plants					
	"Taber"	Sorghum	Maize	Sunflower	Lablab bean	Pigeon pea
First year survey (2007/08):						
July, 2007	10.8	-	-	-	-	-
August	-	-	25.0	-	-	-
September	-	-	20.0	45.5	-	-
October	-	-	-	39.5	-	-
November	-	-	-	-	53.8	-
December	-	-	-	-	56.6	76.3
Jan. 2008	-	-	-	-	-	56.0
Seasonal mean	**10.8**	**-**	**22.5**	**42.5**	**55.2**	**66.2**
Second year survey (2008/09):						
July, 2008	11.3	-	-	-	-	-
August	-	22.5	-	-	-	-
September	-	10.0	18.0	38.0	-	-
October	-	-	-	27.6	-	-
November	-	-	-	-	67.3	-
December	-	-	-	-	49.1	62.4
Jan. 2009	-	-	-	-	-	64.3
Seasonal mean	**11.3**	**16.3**	**18.0**	**32.8**	**58.2**	**63.4**
Overall mean	**11.1**	**16.3**	**20.3**	**37.7**	**56.7**	**64.8**

‡ = Tomato and cotton were also reported as hosts, but not included here in counts; * = Average of four counts done at weekly intervals for each month; (-) = No plant was found.

build-up of *H. armigera* before any attack on field crops. However, insect count reflected that leguminous crops (i.e., *C. cajan* and *L. purpureus*) sustained the highest infestation levels during both years (average 56.7 – 64.8 larvae/100 plants) as they started to show infestation from mid November and onwards until the end of winter. On the other hand, the wild plant *I. cordofana* showed the lowest infestation (11.1 larvae), while sunflower and cereal crops displayed intermediate infestations. It is clear that all these hosts are grown in autumn, except legumes are grown in winter; a condition which might sustain and amplify the problem of *H. armigera* on some economic crops targeted by the farmers in both seasons, particularly the tomato and cotton. As in other published studies (Ramnath *et al.* 1992; Hou and Sheng, 2001, and Ravi *et al*., 2005), differences in the population of larvae on various hosts were seen in this study, possibly reflecting adult oviposition preferences due to some reasons.

3. Incidence and preference of *H. armigera* among tomato cultivars

The tomato experiments, conducted during autumn (started in July) and winter (started in November) seasons of three consecutive years (2007/08, 2008/09 and 2009/10), were successfully performed. Hence, seasonal incidences and preference of *H. armigera* were compared among the three cultivars (Strain B, Peto 86 and Castle rock). Mean numbers of eggs, larvae and fruit damaged at flowering and fruiting stages are shown in tables 4 and 5 for autumn and winter experiments, respectively.

According to this study, larval damage of *H. armigera* was observed on tomato fruits and leaves, but flowers were never attacked. This corroborates the findings of Damel *et al*. (2005) who found that tomato flower tissue contains high levels of proteinase inhibitors when compared with leaves and fruits, a factor which inhibit growth and development of *Helicoverpa* larvae. Moreover, among

Table 4. Mean number of *Helicoverpa armigera* eggs, larvae and number of fruit damaged per 10 tomato plants during autumn seasons (2007, 2008 and 2010).

Cultivars	Count/10 plants at the 2nd week after fruiting			Count/10 plants at the 4th week after fruiting		
	Eggs	Larvae	Fruit damaged	Eggs	Larvae	Fruit damaged
V_1	9.7	8.8	9.4	9.4	9.5	10.9
	(4.5)	(2.8)	(4)	(4)^{b}	(4.2)	(6.2)
V_2	9.9	9	9.5	10.2	9.9	11.3
	(5.4)	(3.5)	(4.3)	(6)^{ab}	(5.3)	(6.8)
V_3	10.4	8.9	10.2	11	10.5	11.2
	(6)	(4.3)	(5.5)	(7.3)^{a}	(6)	(7.7)
Sig.	n.s.	n.s.	n.s.	*	n.s.	n.s.
SE±	0.7	0.6	0.73	0.5	0.9	0.94
CV%	15.40	15.90	17.00	11.90	20.70	19.60
LSD				1.2		

V1 = Strain B; V2 = Peto 86; V3 = Castle rock; n.s. = Non significant; * = Significant at 5% level.
Data transformed to $\sqrt{X+0.5}$; actual data in parenthesis.

Table 5. Mean number of *Helicoverpa armigera* eggs, larvae and number of fruit damaged per 10 tomato plants during winter seasons (2007/ 2008 and 2009/2010).

Cultivars	Count/10 plants at the 2nd week after fruiting			Count/10 plants at the 4th week after fruiting		
	Eggs	Larvae	Fruit damaged	Eggs	Larvae	Fruit damaged
V_1	9.6	8.6	9.4	10	9.8	11
	(4.5)	(2.8)	(4.3)	(6.5)^{b}	(5)^{b}	(9.3)
V_2	10	9.2	9.8	11.4	11	12
	(5.3)	(4)	(5.2)	(8.2)^{ab}	(6.7)^{b}	(10.3)
V_3	11	10	10.3	13	12	14
	(7)	(4.8)	(6)	(11)^{a}	(10.2)^{a}	(16)
Sig.	n.s.	n.s.	n.s.	*	**	n.s.
SE±	0.9	1.00	1.00	0.7	0.5	1.00
CV%	20.64	25.00	22.50	12.93	10.00	20.60
LSD				1.4	1.03	

V1 = Strain B; V2 = Peto 86; V3 = Castle rock; n.s. = Non significant; * = Significant at 5% level; **= Significant at 1% level.
Data transformed to $\sqrt{X+0.5}$; actual data in parenthesis.

prominent observations recorded was that, the first appearance of *H. armigera* (eggs and larvae) in all autumn experiments was in the second half of September, whereas their peak was almost reached during the first week of October. On the other hand, the winter experiments showed that the first appearance of the pest was in late January, and peaked in about mid February. Accordingly, the periods of the highest larval population coincided with the maximum damage on tomato fruits in almost all experiments, except in the second winter experiment (2008/2009) where tomato cultivars were highly infested by *B. tabaci*, and therefore no data was recorded. No local information is available to support, regarding the seasonality of *H. armigera* in New Halfa. Literature from abroad showed somewhat variable results due, plausibly, to different environmental conditions. For example, in Egypt Salem *et al.* (2008) indicated that the highest population density of *H. armigera* on tomato was found during August, which is a

little pit earlier than what is reported in the current research (September). In Tunisia, Boukhris *et al*. (2007) recorded the largest number of eggs and larvae of *H. armigera* so earlier in July, but in Pakistan the pest was reported in large numbers on tomato during the summer season (Hazara *et al*., 2000).

The results of both seasons' studies showed that the population incidence of *H. armigera* (eggs and larvae) and its damage on all tomato cultivars were always higher in winter than in autumn. This may be due to favorable environmental conditions (e.g., low temperature) in winter, in contrast to some factors (e.g., physical effect of rainfalls, wind storms and natural enemies) which negatively impact the pest in autumn. In line with the observed differential seasonality of the pest Tripathy *et al.* (1999) reported that high temperatures have negative effect on *H. armigera* populations. Also, Satti (2007) reported the highest activity of *H. armigera* on sorghum in Shambat area, Sudan, during winter season, while Rao *et al*. (2001), in India, showed the peak incidence of the pest on chickpea to be during January. Further, Tripahti and Sharma (1985) indicated that heavy rainfall and wind can force eggs off leaves and damaged pupae of *H. armigera* in the soil, preventing adult emergence. Maelzer and Zalucki (1999) and Kumar *et al*. (2009) also observed that heavy rains and strong winds were important factors responsible for reduced populations of *H. armigera* as they negatively affected eggs and larval stages.

Comparing preference of the pest, among the different tomato cultivars, the data (Tables 4 and 5) indicated that Castle rock manifested the highest infestation levels and fruit damaged in both seasons with significant differences in some counts, while Strain B revealed the lowest in both parameters. Therefore, Strain B can be considered, relatively, as the least preferred host by *H. armigera* when compared with the other two cultivars. The relatively higher preference to Castle rock and Peto 86 may be partially due to early flowering which could attract more females for egg laying. However, insect resistance is rarely found in cultivated tomato, but it may be more prevalent in wild accessions of *Lycopersicon esculentum*. Resistance screening by Talekar *et al*. (2006) demonstrated the presence of high levels of tomato fruit worm resistance in several wild tomato accessions. However, the authors reported that introducing such resistance into commercial tomato cultivars did not succeed.

Conclusion and Recommendations

The following points can be drawn from the findings of this study:

- *Helicoverpa armigera* proved to be an all seasons' pest with high fecundity in New Halfa, showing relatively higher abundance in winter than in other seasons.
- Pigeon pea, which seemed to be more attractive to the pest compared to the other hosts, should be studied as a trap crop. However, its field cultivation needs to be managed to prevent buildup of *H. armigera* as a source of infestation to other crops.
- The lowest incidence of *H. armigera* on autumn tomato (compared to winter) is a credit, as autumn represents the main season for tomato production in New Halfa. Factors contributing to such low density; probably rainfalls, wind and natural enemies, merits further investigations.

The cultivars Castle rock and Peto 86 were partially preferred by *H. armigera* compared with Strain B cultivar, hence, as the former two cultivars are mostly preferred in the area due to their early maturity and high yielding capacity, appropriate management protocol for the pest on these cultivars should be designed and evaluated for efficacy and economic and technical feasibilities.

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