SUST
Journal of Agricultural and Veterinary Sciences
Journal homepage:
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Influence of Seasonal Temperatures on Cowpea Aphid *Aphis craccivora* Koch, Infestation and its Reflection on Yield of some Faba Bean Varieties

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Article History: Received: 06/08/2016
Accepted: 22/12/2016

Abstract

This study was conducted for three consecutive seasons 2013/14, 2014/15 and 2015/16 at Elmasakin island, Northern State of Sudan. Four faba bean varieties were evaluated viz, Giza 843, Luz De Otono, loca variety (Turkey) and SM-L. The study proved that the outbreak of *Aphis cracccivora* infestation was occurring occasionally depending to the temperatures raising. The daily maximum temperatures around 30Cº and the average daily temperatures around 25Cº during December, January and February were predispose the aphid infestation to increase. The Luz De Otono, Giza 843 and local variety (Turkey) were mostly seems preferred to the insect than SM-L variety. Results revealed that the heavy infestation significantly reduced the number of pods per plant and density of plant population according to the varieties. Moreover, the potential grain yield reduced by 68.8%, 63.2%, 32.3% and 18.8% for Otono, Giza 843, local variety and SM-L respectively.

Keywords: Faba bean, Cowpea aphid, *Aphis craccivora*, Northern Sudan

Introduction

Faba bean *Vicia faba* L., is the legume crop grown widely under a range of climatic condition from temperate to subtropical regions (Stoddard *et al.*, 2010). This crop grows best under cool, moist conditions; however the optimum growing temperatures is 18°C - 27°C while hot dry weather is injurious to the crop (Focus, 2012). Ethiopia and Sudan are the mean producers of faba bean dry seeds in sub-Sahara of Africa. In 1999 to 2003 the annual production of Sudan estimated by 100,000 tons (Singh *et al.*, 2013). In Sudan the crop average areas is around 20,000 ha and reaches 35,000 ha in some season. The crop productivity is generally low and its average yields are around 1.8 t/ha, but annual fluctuation is considerable due to weather conditions and biological factors (Ahmed, 1995). The cut worm *Agrotis ipsilon*, leaf miner *Liriomyza trifollii*, aphid *Aphis*

craccivora and pod borer *Helicoverpa armigera* are the most important faba bean insect pests in Sudan (Mohamed *et al*, 1995). Generally, *A craccivora* is more dominant in hot dry climate. This species occurs infestation in 37% from total faba bean fields in Egypt and reached 71% from total fields in southern Morocco regions. The aphid cause plant damage by direct feeding it sucks quantities of soluble plant nutrients lead to slows the rate of stem elongation and decrease leaves and flowers production. The aphid feeding also causes substantial water loss with subsequent wilting and collapse of the plant. The pest also, secretes honeydew which encourages the sooty mold growth (Weigand *et al*., 1991). Furthermore, this insect is an important vector of Bean Yellow Mosic Virus (BYMV) and Bean Leaf Roll Virus (BLRV) (Hussein, 1995). The objectives of this study, was to evaluate the effects of temperature on faba bean aphid infestation and its reflect on productivities of some faba bean varieties.

Materials and Methods

The trial was conducted for three consecutive winter seasons 2013/14, 2014/15 and 2015/16 at Elmasakin island, Northern State of Sudan. Four faba bean varieties- viz, Giza 843, Luz De Otono, loca variety (Turkey) and SM-L were sown in the first week of November in 7 ridges per plot with 7m length, 60cm between ridges, 2 plants per hole and 20cm between holes. An experiment was arranged in Randomized Complete Block Design (RCBD) with 3 replicates. The percentage of aphid infestations was assessed in 3m at randomly selective row and frequented in 4rows in each plot. The number of the pest per plant was assessed in 20 plants. A count was frequented every 15 days in majority periods. The percentages of devastated plants by heavy infestation were assessed in 3m in each row per plot. In addition, the number of pods per plant, number of seeds per pod and grain yield/fed were estimated. Collected data were subjected to analysis of variance and mean separation was effected by Duncan's Multiple Range Test (DMRT) at 5% probability level. The metrological data were obtained from Dongola Airport Metrological Station.

Results and Discussion

In season 2013/14 it was observed that the means of maximum temperatures at mostly periods were recorded around 25ºC, except in the first week of December, mid and last weeks of January and February when the means of maximum temperatures were ranged between 30°C and 35.6°C (Table 1). In this season the highest temperatures were recorded at first week of December, however the maximum temperatures were sharply lowered afterwards and means of weekly maximum temperatures recorded from 23.7°C to 28.5°C in second week of December toward mid January. In this period no aphid infestation has been observed (Table 2, Figure 1). The aphid infestation was firstly recorded at the last week of January and the highest percentages of infestation 15.3%, 10.8%, 10.8% and

1.3% were recorded on Luz De Otono, Giza 843, local variety (Turkey) and SM-L respectively. At the last week of February when the mean of maximum temperatures recorded over 30°C and mean of daily temperature was 23°C (Table1).

Table 1: Mean daily and weekly temperature from December to February at Dongola Airport Metrological Station during 2013 - 2016

Week	2013/2014			2014/2015			2015/2016		
	Mean daily and weekly temperature (C^o)								
	Max	Mini	Mean	Max	Mini	Mean	Max	Mini	Mean
1-7 December	35.6	19.5	27.6	33.3	16.9	25.1	26.8	12.9	19.8
8-14 December	23.7	10.6	17.2	30.4	15.6	23	24.6	9.7	17.1
15-21 December	26.8	8.5	17.7	27.8	12.6	20.2	23.7	9	16.3
22-31 December	28.5	12.1	20.3	28.9	11.2	20.1	25.5	9.3	17.4
1-7 January	25.2	9.4	17.3	23.4	9.2	16.3	25.8	7.7	16.7
8-14 January	26.4	9.3	17.8	21.2	5.9	13.6	27.7	10.8	19.2
15-21 January	30.8	12.5	21.6	30.8	10.3	20.6	24.9	8.3	16.6
22-31 January	32.1	16.1	24.1	32.8	16.4	24.6	21.7	6.3	14
1-7 February	28.6	12.3	20.4	34.9	14.9	24.9	26.8	9.9	18.3
8-14 February	28	10.5	19.2	32.2	13	22.6	30.3	11.2	20.7
15-21 February	31.3	13.4	22.3	31.3	13.8	22.6	32.5	15.8	24.1
22-29 February	32.6	13.6	23.1	34.4	15.6	25	34.5	14.7	24.6
Mean	**29.1**	**12.3**	**20.7**	**30.1**	**12.9**	**21.6**	**27.1**	**10.5**	**18.7**

No the heavy infestation of pest was recorded in this season. Therefore the devastated plants in the varieties plots were unobserved (Table 2, Figure 1). In season 2015/16, the rates of temperatures during December, January and February relatively cooler than season 2013/14 (Table 1) and consequently the aphid infestation was lower than that in season 2013/14 (Table 3, Figure 2). In addition, the maximum temperatures from first week of December to first week of February were recorded around 25C^o and the mean of daily temperatures of this period recorded 18.7°C compared with 20.7°C during the same period in season 2013/14 (Table 1). In different varieties the highest percentages of the infestation were 1.3%, 1.2% and 1.2% recorded on Luz De Otono, Giza 843 and local variety (Turkey) respectively, at last week of February (Table 3, Figure 2). No pest infestation was recorded on SM-L variety as well as no devastated plants were recorded in these varieties plots (Table 3). This variety released in 1987 and aphid

tolerant its one of attributes (Salih *et al.*, 1995).

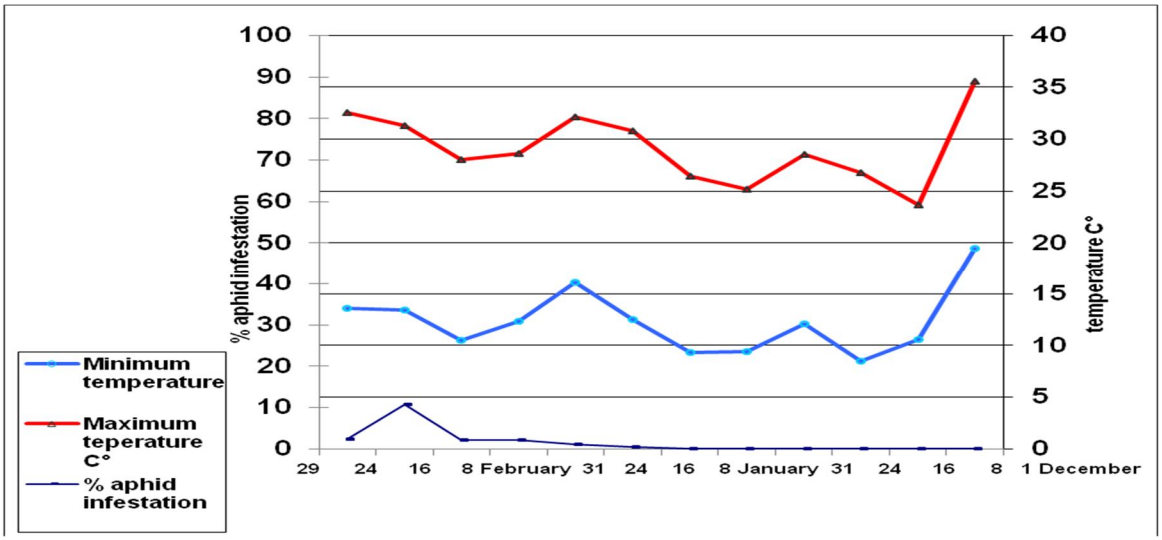

Figure1: Effect of temperatures on faba bean aphid infestation on local variety, season 2013/14

Table 2: Percentage of faba bean aphid infestation, its density per plant and percentage of devastated plants, Elmasakin island, season 2013/14

Variety	25/1/2014		10/2/2014		20/2/2014		2/3/2014	% devastated plants/3m
	% aphid Infestation	No. of aphids/plant	% aphid infestation	No. of aphids/plant	% aphid infestation	No. of aphids/plant	No. aphid/plant	
Local	(0.3)	(0.7)	(2.1)	(1.6)	(10.8)	(2.3)	(0.6)	0.0
variety	0.9[b]	1.1[b]	1.6[b]	1.4[b]	3.4[b]	1.6[c]	1.0[a]	
Luz De	(2.5)	(1.3)	(7.3)	(2.2)	(15.3)	(5.4)	(1.3)	0.0
Otono	1.6 [a]	1.3 [a]	2.7 [a]	1.6[a]	4.0[a]	2.4[a]	1.3[a]	
Giza	(0.4)	(0.7)	(1.1)	(1.2)	(10.8)	(3.2)	(0.7)	0.0
843	0.9[b]	1.1[b]	1.2[c]	1.3[c]	3.3[b]	1.9[b]	1.1[a]	
SM-L	(0.1)	(0.2)	(0.3)	(0.2)	(1.3)	(0.5)	(0.3)	0.0
	0.8[b]	0.8[c]	0.9[d]	0.8[d]	1.3[d]	1.0[d]	0.7[b]	
CV%	35.4	7.4	25.4	16.0	14.4	20.9	18.5	
SE±	0.2	0.1	0.2	0.1	0.2	0.2	0.1	

Data were transformed to √(X+0.5), the actual means in brackets. In each column, means with the same letter are not significantly different at P≤ 0.05 according to Duncan's Multiple Range test.

Table 3: Percentage of faba bean aphid infestation, its density per plant and percentage of devastated plants, Elmasakin island, season 2015/16

Variety	20/1/2016		5/2/2016		20/2/2016		% devastated plants/3m long
	% Infestation	No. of aphid/plant	% aphid infestation	No. of aphid/plant	% aphid infestation	No. of aphid/plant	
Local	(0.4)	(0.3)	(0.2)	(0.3)	(1.2)	(4.2)	0.0
variety	0.8[a]	0.8[b]	0.9[b]	0.9[c]	1.1[a]	2.0[a]	
Luz De	(0.3)	(1.2)	(1.2)	(4.5)	(1.3)	(4.3)	0.0
Otono	0.9[a]	1.6[a]	1.6[a]	2.7[a]	1.2[a]	2.1[a]	
Giza 843	(0.4)	(1.0)	(0.4)	(1.3)	(1.2)	(2.3)	0.0

	0.9[a]	1.5[a]	0.9[b]	1.7[b]	1.1[a]	1.5[b]	
SM-L	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	0.0
	0.7[c]	0.7[c]	0.7[c]	0.7[d]	0.7[b]	0.7[c]	
CV%	11.0	14.9	22.3	13.3	12.5	16.5	
SE±	0.1	0.1	0.1	0.1	0.2	0.2	

Data were transformed to √(X+0.5), the actual means in brackets. In each column, means with the same letter are not significantly different at P≤ 0.05 according to Duncan's Multiple Range test.

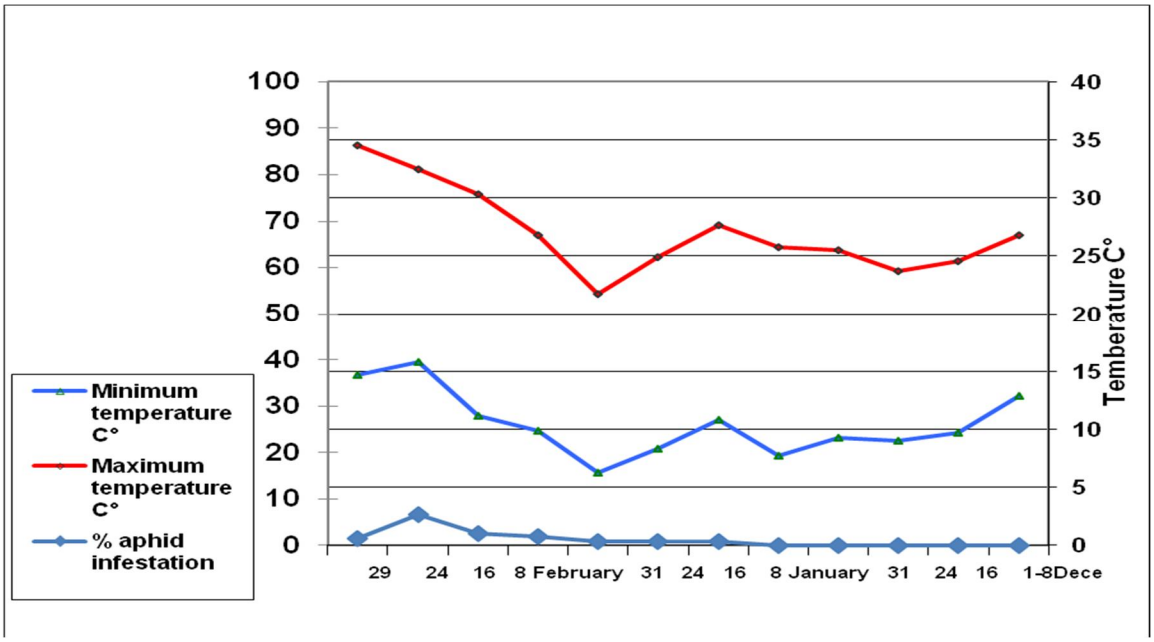

Figure 2: Effect of temperatures on faba bean aphid season 2015/16

The winter season of 2014/15 relatively was warmer than other two seasons. Except the period from mid December to mid January when the daily maximum temperatures were recorded between 30.4°C to 34.9°C and the mean daily temperatures were recorded between 22.6°C to 25.1°C (Table 1). The aphid infestations began early in December and aggravated in January and reached peak of infestation in the first week of February (Table 4, Figure 3). The completely infested plants (100%) was recorded on De Luz Otono and local variety while 89.4% infestation was recorded on Giza 843. The highest number of aphids per plant (1303) was recorded on Luz De Otono (Table 4). While percentages of devastated plants result to the heavey infestation were recorded 69.4%, 58.2% and 27.6% for Giza 843, Luz De Otono and local variety, respectivily (Table 4). According for these results, Gadalla, *et al* (2010) in Egypt, mentioned that, Giza 843 is lowest susceptible for *A craccivora* infestation. On the other hand this variety was confirmed tolerant for orobanche infection. The SM-L recorded the lowest percentage of the infestations with the lowest density of aphids per plant and no devastated plants were obsarved in the variety plots (Table 4). From above

mentioned results relatively, the prevailing daily maximum temperatures around 30Cº and average daily temperatures around 25º during December, January and February were the stimulus factor to the cowpea infestation increase. (Table 5) shows the effects of heavy aphid infestations on yield and yield components of the varieties. In season 2014/15 the numder of pods per plant was significantly affected by heavy aphid infestation.

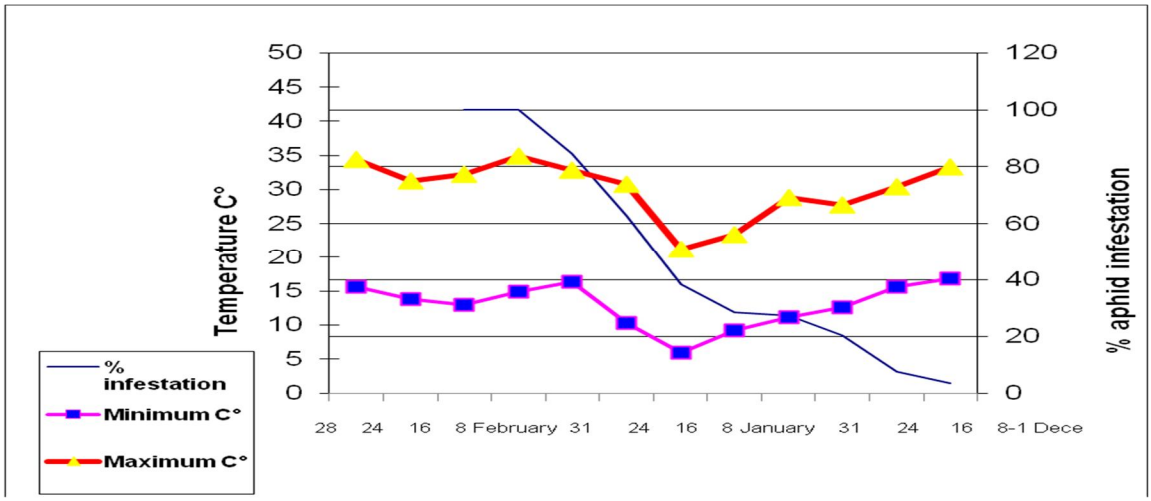

Figure 3: Effect of temperature on faba bean aphid infestation season 2014/15

Table 4: Percentage faba bean aphid infestation, it density per plant and percentage of devastated plants, Elmasakin island, season 2014/15

Variety	10/1/2015		25/1/2015		10/2/2015		% devastated plants/3m
	% Infestation	No. aphid/plant	% infestation	No. aphid/plant	% infestation	No. aphid/plant	
Local	(38.4)	(240.7)	(84.6)	(578.2)	(100)	(372.9)	27.6[b]
variety	6.2[b]	14.8[b]	9.1[a]	23.1[c]	10.0[a]	18.3[a]	
Luz De	(79.1)	(277.5)	(99.4)	(1303.0)	(100)	(567.5)	58.2[a]
Otono	8.9[a]	16.5[b]	9.9[a]	35.8[a]	10.0[a]	23.7[a]	
Giza 843	(50.7)	(494.9)	(82.6)	(983.3)	(89.4)	(415.5)	69.4[a]
	7.1[b]	21.7[a]	9.1[a]	30.7[b]	9.5[a]	20.3[a]	
SM-L	(1.8)	(0.1)	(3.3)	(0.1)	(3.0)	(0.2)	(0.0)
	1.6[c]	0.2[c]	1.9[c]	0.7[d]	1.9[b]	0.8[b]	0.7[c]
CV%	10.4	19.5	9.8	15.8	4.2	20.8	19.0
SE±	0.4	1.3	0.4	1.7	0.2	1.9	3.8

Data were transformed to √(X+0.5), the actual means in brackets. In each column, means with the same letter are not significantly different at P≤ 0.05 according to Duncan's Multiple Range test (DMRT).

The highest range of pods number per plant (28.0- 29.7) pods was achieved with Giza 843, whereas, the lowest range of pods number (16.0- 21.3) pods achieved with Luz De Otono in season 2013/14 and 2015/16 respectively. The lowest number of pods per plant for four varieties was recorded in season 2014/15 compared with the both other seasons (Table 5). This confirm the effect of aphid infestation on number of pods per plant.

The highest range of seeds per pods (4.3- 4.8) seeds was produced in Luz De Otono variety, whereas, the lowest range of seeds per pod (2.7- 3.2) seeds was produced in local variety (Table 5). Observed from data, the range (4- 5), (3- 4) (2- 3) and (2- 4) seeds per pod was produced in Luz De Otono, Giza 843, local variety and SM-L. Appeared from Table 5, the effect of *A crccivora*

infestation on number of seeds per pod in the four varieties was unclear.

The highest yield 1.7 tons/feddan gave by local variety while the lowest range of yield (1.1- 1.6) tons/feddan achieved with Luz De Otono variety in season 201/14 and 2015/16. Also Luz De Otono gave the lowest yield 0.5 tons/feddan in season 2014/15 compared with the yield of other varieties (Table 5). However, in experiments coundacted in Marra Mountain area this variety gave highest grain yield compared with the othe varieties. Colin (2012) mentioned Luz De Otono variety is produces long pods, good resistance for cold weather, sensitive to high temperatures and low tolerant or medium for aphid infestation. The grain yield of four varieties reduced in season 2014/15 compared with their grain yield in both the other seasons and percentages of loss recordrd 32.3% in local variety and in range (54.5 % - 68.8%), (53.3%- 63.2%) and (13.3%- 18.8%) Luz De Otono, Giza 843 and SM-L varieties respectively (Table 5).

Table 5: Faba bean varieties yields and yield components, Elmasakin island, seasons 2013/14, 2014/15 and 2015/16

Varieties	Number of pods/ plant			No. Seeds/ pod			Yield (tons/fed)			% loss in yield of season 2014/15 from two other seasons
	Season 2013/14	Season 2014/15	Season 2015/16	Season 2013/14	Season 2014/15	Season 2015/16	Season 2013/14	Season 2014/15	Season 2015/16	
Local variety	26.7^{a}	6.9^{b}	25.3^{a}	2.7^{b}	2.7^{b}	3.2^{b}	1.7^{a}	1.1^{a}	1.7^{a}	32.3
Luz De Otono	16.0^{b}	3.6^{c}	21.3^{b}	4.3^{a}	4.6^{a}	4.8^{a}	1.1^{b}	0.5^{b}	1.6^{a}	54.5 -68.8
Giza 843	29.7^{a}	7.4^{b}	28.0^{a}	3.3^{b}	3.3^{b}	3.4^{b}	1.5^{a}	0.7^{b}	1.9^{a}	53.3 -63.2
SM-L	24.9^{a}	16.3^{a}	26.0^{a}	3.3^{b}	3.0^{b}	3.4^{b}	1.5^{a}	1.3^{a}	1.6^{a}	13.3 -18.8
CV%	16.5	6.5	8.3	18.9	15.0	6.4	13.1	13.4	10.8	
SE±	2.3	0.3	1.2	0.4	0.3	0.2	0.1	0.1	0.1	

In each column, means with the same letter are not significantly different at P≤ 0.05 according to Duncan's Multiple Range test (DMRT).

Conclusion

This study revealed that the outbreak of cowpea aphid *Aphis cracccivora* Koch., was occasionally occurs in faba bean in Northern Sudan. The daily maximum temperatures around 30Cº with average daily temperatures around 25Cº during December, January and February predisposes the aphid infestation to increase. The Luz De Otono, Giza 843 and local variety (Turkey) seems to be preferred to the pest compared with SM-L variety.

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