J. King Saud Univ. Vol. 5, Agric. Sci. (2), pp 253-262 (A.H. 1413/1993)

Insect Pollinators of Certain Crops in the Sudan and the Effect of Pollination on Seed Yield and Quality

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Abstract. The present study is an attempt to evaluate the effect of honeybee pollination on the yield of sunflower, lucerne and cotton. Sunflower plants are known of their self incompatibility and the production of abundant pollen and nectar during flowering. This gave sunflower the advantage of being more attractive to honeybees and other insect pollinators than either cotton or lucerne. As a result, seeds of good quality and high yield were produced. The present work shows the importance of honeybees as pollinators for these crops under Sudan conditions. Sunflower was most affected by honeybees followed by lucerne and cotton. The seed-set, seed weight and oil content obtained for these crops could respectively be arranged in a descending order. The lowest quality and lowest yields were produced by non-pollinated plants. Besides honeybees other hymenopterous insects may play a secondary role as pollinators.

Introduction

Honeybee pollination is one of the most important factors affecting seed production of sunflower, lucerne and cotton [1, pp. 184-198 and 2]. It increases crop yield and improves seed quality. Inadequate pollination, on the other hand, can result not only in the production of low and delayed yields, but also in the production of high percentages of inferior seeds [3]. Drake [4] mentioned that cross-pollination of lucerne is largely dependent on insects. Bees are considered a primary agent in this respect and should therefore be present in great numbers. According to Headings [5] honeybees are efficient pollinators because of their physical and behavioral characteristics. Other insect pollinators such as *Bombus* and *Megachilids* play an important role in the pollination of many crops.

The present work was carried out to evaluate the role of honeybees and other insect pollinators in seed production of three of the most important crops in Sudan; sunflower, lucerne and cotton. Both yield and quality were considered.

Materials and Methods

The present work was carried out in the apiary of the Faculty of Agriculture, University of Khartoum, Shambat, Sudan throughout the years 1985-1986, 1986-1987. Wild swarms of honeybees were collected from the neighboring regions in swarm boxes supplied with combs containing honey and pollen. Each colony was provided with sugar syrup (1:1 w/w) one week before being rehived in a Langstroth hive. Tests were made on the following three crops: Sunflower (*Helianthus annus* L.) variety Kenya black, lucerne (*Medicago sativa* L.) cultivar Higazi and cotton (*Gossypium hirsutum* L.) var. Barac-B-67.

Honeybees together with other insect species were collected during the flowering periods of the test crops using a hand sweeping net. Three sampling locations were randomly chosen for each crop at varying distances from the hives. Insects were collected once a week at 2-hour intervals starting from 6 a.m. to 6 p.m. They were then sorted, counted and identified. Ten flowers from each crop were tagged and observations on the number of visiting bees and their behavior were taken every two hours during the test period.

To evaluate the effect of honeybee pollination on the yield of the above mentioned crops, three treatments were adopted for two successive years (1985-1986 and 1986-1987). In the first treatment, plants were covered with wire screen cages 2 × 2 × 2.5 m. enclosing a nucleus colony with a mated laying queen, two brood and three more combs containing honey and covered with worker bees. Feeding of the nuclei began a few days before the blooming season and continued daily at 5 p.m. until the end of the season. In the second treatment, plants were covered with similar cages so that all insect visitors were prevented from entering. In the third treatment, plots were left for open pollination by honeybees and other insects in the vicinity of the apiary site. Each treatment was replicated four times.

For yield assessment, fifteen randomly selected sunflower plants were taken from each experimental plot, harvested, threshed and the number of normal and empty seeds per head counted. The weight of 100 normal seeds was also measured. All the plots were then harvested, threshed, their yield determined, and the total yield per feddan* estimated.

Seven cotton plants from each plot were also taken at random to determine the number of bolls/plant, the number of seeds/boll, weight of 100 normal seeds, weight of lint/boll, yield/plot and the yield/feddan.

* one feddan (F) = 4200 m2

Similarly, twenty lucerne plants were randomly selected from each experimental plot and records were taken of the number of pods/plant, number of seeds/pod, weight of 1000 normal seeds, yield/plot and yield/feddan.

The germination capacity of seeds was tested according to the method described by ISTA [6]. A sample of 50 seeds from each test crop was taken immediately after harvesting and incubated at 20-30°C for eight days. Normal, abnormal and dead seedlings were counted and the germination percentage calculated.

To determine the oil content of sunflower and cotton seeds, the same technique adopted by AOAC [7] was followed. Results were in most cases subject to stastistical analysis.

Results and Discussion

A list of insect visitors to the three crops during two successive years (1985-1986 / 1986-1987) is presented in Table 1. The data in this table show clearly that insects of eight orders were attracted to the crops during the blooming seasons. These can be arranged in a descending order as follows: Hymenoptera (56.6% of the total number of visitors), Hemiptera (21.4%), Odonata (5.1%), Lepidoptera (4.9%), Orthoptera (4.3%), Thysanoptera (3.2%), Diptera (3.0%) and Coleoptera (1.5%).

The Hymenoptera constituted the highest percentage of insects attracted to sunflower and lucerne; mean percentages of 73.4 and 72.3 were recorded for them on both crops respectively. On cotton, almost equal percentages of the Hemiptera (41.1%) and Hymenoptera (37.2%) were trapped.

Cotton and sunflower seem to be more attractive to honeybees. About 80% and 75.6% of the total Hymenopterous insect visitors to both crops respectively were honeybees. However, about 44% of the Hymenoptera trapped from lucerne were honeybees.

Hymenopterous insects visiting the three test crops and directly affecting crop yield were *Apis mellifera* (67.8%), *Bombus* spp (14.7%), *Nomia* spp (5.5%), *Vespa orientalis* (5.3%), *Megachile* spp (5.2%), *Halictus* spp (1.0%) and *Philianthus abdulgader* (0.6%).

Figure 1 indicates the abundance of honeybees on the three crops. Their active peaks were shown in the early morning (6.00 a.m.) and late afternoon (4.00 to 6.00 p.m.). This was true with the three tested crops.

Table 1. Average number of insect visitors collected from sunflower, cotton and lucerne during two successive years 1985-1986 / 1986-1987 (means of 8760 observation).

Order	Family	Scientific name	Average number of insects on		
			Sunflower	Cotton	Lucerne
Lepidoptera	Papilionidae	*Papilio domodocus* L.	92.5	166.5	80.5
	Noctuidae	*Earias vitella* F.	39	17	22.5
	Pyralidae	*Slypta deragota* F.	23	13	–
	Pieridae	*Eurema hecabe* L.	12.5	–	–
Diptera	Syrphidae	*Eristalis* spp. (2 spp.)	20.5	14.5	13.5
	Muscidae	*Musca* spp. (2 spp.)	58.5	136.5	39.5
Hymenoptera	Apidae	*Apis mellifera* L.	1675	1278.5	681.5
	Vespidae	*Vespa orientalis* L.	105.5	101.5	77
		Philianthus abdulgader L.	32	–	–
	Bombidae	*Bombus* spp (3 spp)	182.5	221	383.5
	Halictidae	*Halictus* sp.	18.5	–	34
		Nomia melanderi L.	–	–	163.5
		Nomia sp.	117.5	–	13.5
	Megachilidae	*Megachile rotundata* L.	71.5	–	164.5
		Megachile sp.	12.5	–	29.5
Coleoptera	Coccinellidae	*Henosepilachna elaterii* L.	16.5	35	15.5
		Coccinella sp.	15.5	–	–
	Galerucidae	*Epicauta aethiops* L.	23	12	25
Odonata	Libellulidae	*Unidentified*	178	176.5	120.5
Thysanoptera	Thripidae	*Thrips* sp.	148.5	133	20.5
Hemiptera	Aphidae	*Aphids gossypii* L.	–	1145	–
	Aleurodidae	*Bemisia tabaci* L.	–	626.5	256.5
Orthoptera	Acrididae	*Schistocerca gregaria* L.	30.5	146.5	–
		Unidentified	125	67	–
	Mantidae	*Mantis* sp.	18.5	19.5	–
Total			3016.5	4309.5	2141

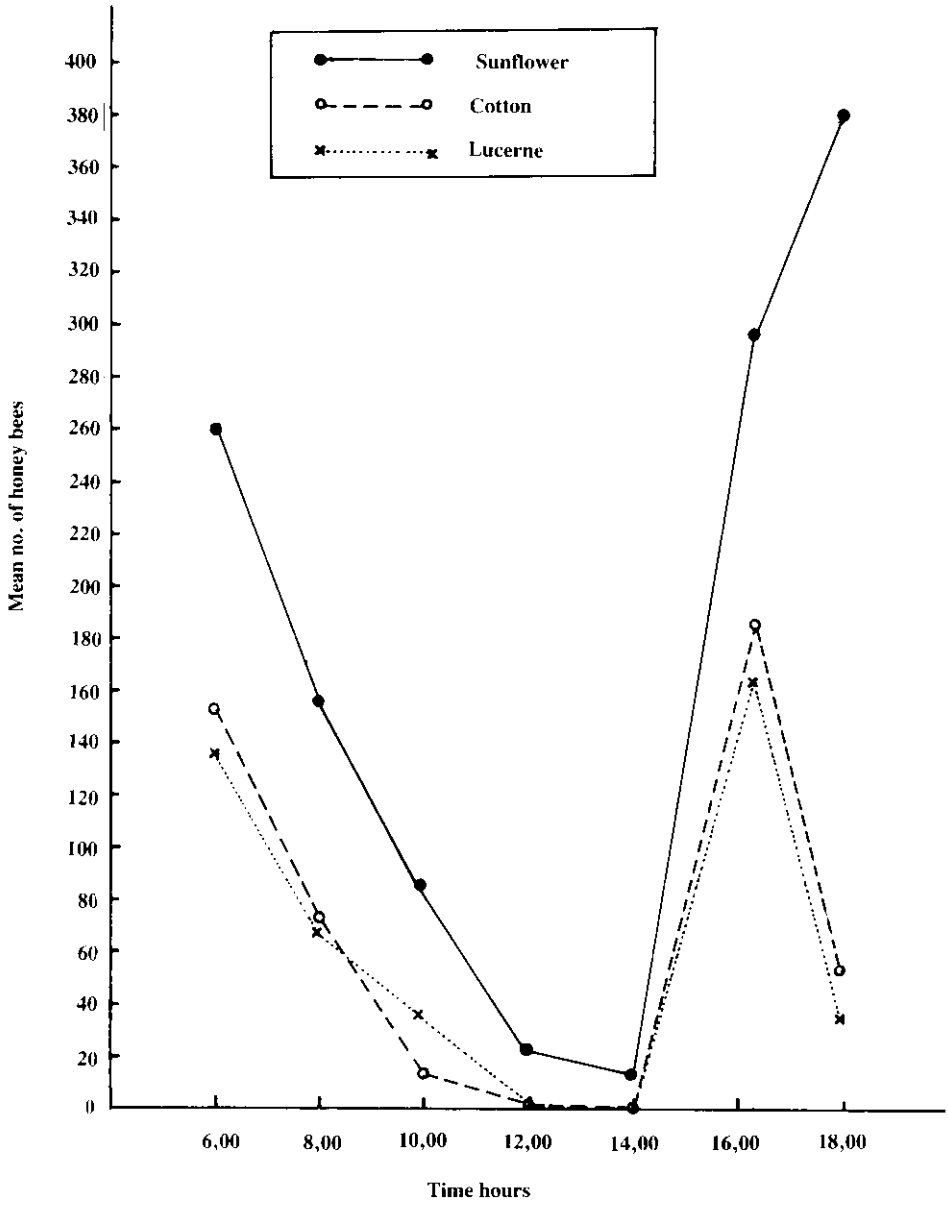

Fig. 1. Activity and abundance of honeybees (*Apis mellifera*) as indicated by numbers visiting sunflower, lucerne and cotton at daytime

Table 2 shows that sunflower pollinated by honeybees and other insect pollinators gave the highest yield (652.3 kg/F), followed by sunflower pollinated by honeybees alone (556.2 kg/F). Crops prevented from pollinators gave the least yield. The same trend was true for the remaining two crops (Tables 3 and 4). These findings are in close agreement with those of other workers. Free [8] and Free and Williams [9] stated that flowers of sunflower plants are characterized by being self-incompatible. In the mean time, they produce abundant pollen and nectar throughout the day during blooming. This may explain why sunflower was more attractive to honeybees and other insect pollinators.

Although cotton is a self-pollinated crop, more yield was produced and higher levels of seed germination and oil content were obtained in the presence of insect pollinators particularly honeybees (Table 4).

Honeybees visit cotton flowers primarily to collect nectar, and rarely to collect pollen. According to Glushkov [10], 88% of honeybee workers visiting cotton were observed collecting nectar only.

In the present study, 72.3% of the insect visitors of lucerne were Hymenopterous insects. Honeybees were the most abundant [44%) followed by *Bombus* spp (25%), *Megachile* spp. (12.5%) and *Nomia* spp (11.4%). These findings are supported by those of certain other workers [11-13].

The germination capacity of seeds of the three crops and the oil content of sunflower and cotton were obviously affected by pollination. As a general rule, the presence of insect pollinators resulted in higher percentage of germination and

Table 2. Effects of pollination of sunflower on the seed yield and seed quality (means of two seasons 1985-1986/ 1986-1987).

Parameters	Pollinators			L.S.D. 5%	L.S.D. 1%
	Honeybees	Without	Honeybees and other insects		
No. seeds / head	503.38 ± 38.20	81.31 ± 33.05	557.58 ± 29.28	69.08	103.14
No. empty seeds / head	84.53 ± 18.25	446.08 ± 126.38	70.68 ± 9.66	132.72	201.06
Wt. of 100 normal seeds (gm.)	6.74 ± 00.43	4.17 ± 00.82	8.10 ± 00.42	1.03	1.56
Yield (K/F)	556.17 ± 58.26	72.54 ± 33.41	652.31 ± 46.68	62.32	94.41
% Germination	81.50 ± 01.99	70.50 ± 01.83	88.50 ± 01.82	3.71	3.62
% Oil	42.20 ± 00.19	28.95 ± 00.52	44.28 ± 00.25	0.39	0.59

Table 3. Effects of pollination of lucerne on the seed yield and germination (means of two seasons 1985-1986/ 1986-1987).

Parameters	Pollinators			L.S.D. 5%	L.S.D. 1%
	Honeybees	Without	Honeybees and other insects		
No. pods / plant	58.97 ± 6.91	19.05 ± 4.27	64.06 ± 6.74	16.07	10.58
No. seeds / pod	5.31 ± 0.41	3.32 ± 0.39	5.69 ± 0.29	1.16	0.76
Wt 1000 normal seeds (gm.)	1.92 ± 0.16	1.27 ± 0.10	2.02 ± 0.11	0.32	0.20
Yield (kg/F.)	109.05 ± 14.24	33.32 ± 8.44	121.05 ± 14.07	31.68	21.09
% Germination	84.5 ± 01.29	67.50 ± 1.29	87.13 ± 1.50	2.47	1.25

Table 4. Effects of pollination of cotton on the seed yield and seed quality (means of two seasons 1985-1986/ 1986-1987).

Parameters	Pollinators			L.S.D. 5%	L.S.D. 1%
	Honeybees	Without	Honeybees and other insects		
No. bolls / plant	5.27 ± 0.46	4.93 ± 0.29	5.64 ± 0.58	0.89	1.35
No. seeds / boll	17.81 ± 0.58	15.47 ± 0.56	19.38 ± 0.76	1.36	2.06
Wt. 100 normal seeds (gm)	13.28 ± 0.30	10.47 ± 0.79	14.01 ± 0.44	1.05	1.59
Yield (kg/F.)	769.44 ± 68.83	585.81 ± 75.73	867.22 ± 86.43	161.39	244.50
Cotton lint/boll (gm.)	0.64 ± 0.01	0.52 ± 0.03	0.70 ± 0.01	0.03	0.04
% Germination	85.50 ± 02.00	73.00 ± 01.88	89.00 ± 01.41	3.33	5.05
% Oil	46.38 ± 00.28	41.45 ± 0.34	47.33 ± 00.41	0.71	1.08

higher oil content than no pollinators. Honeybees with other pollinators gave slightly better results than honeybees alone (Table 2,3 and 4).

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الملقحات الحشرية لبعض المحاصيل بالسودان وتأثير التلقيح على إنتاج ونوعية البذور

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ملخص البحث. أجري هذا البحث لحصر الملقحات الحشرية لثلاثة محاصيل حقلية، وهي عباد الشمس، والقطن، والبرسيم، بمنطقة شمبات بكلية الزراعة جامعة الخرطوم بالسودان، كذلك لدراسة تأثير تلقيح أزهار هذه المحاصيل بواسطة الحشرات على إنتاجية ونوعية البذور خلال موسمي ١٩٨٥/١٩٨٦م و ١٩٨٦/١٩٨٧م.

أظهرت النتائج أن الحشرات التي تقوم بزيارة وتلقيح أزهار هذه المحاصيل الثلاثة تنتمي إلى ثمانية رتب، يمكن ترتيبها تنازليًا كالتالي: رتبة غشائية الأجنحة (٥٦,٦٪ من مجموع الملقحات التي تم صيدها)، رتبة نصفية الأجنحة (٢١,٤٪)، الرعاشات (٥,١٪)، حرشفية الأجنحة (٤,٩٪)، مستقيمة الأجنحة (٤,٣٪)، هدبية الأجنحة (٣,٢٪)، ذات الجناحين (٣٪) وغمدية الأجنحة (١,٥٪).

بلغت نسبة الملقحات التابعة لرتبة غشائية الأجنحة ذروتها في محصولي عباد الشمس والبرسيم حيث سجلت متوسط ٧٣٪ في كل منهما بينما بلغ متوسطها ٣٧٪ في حقول القطن. من بين هذه الأعداد الهائلة بلغت نسبة نحل العسل نحو ٨٠٪ في حقول القطن، ٧٥,٦٪ في حقول عباد الشمس و ٤٤٪ في حقول البرسيم. أما تأثير باقي ملقحات هذه الرتبة فكانت على النحو التالي: النحل الطنان *Bombus spp.* (١٤,٧٪)، النحل الحافر *Nomia spp.* (٥,٥٪)، الدبور الشرقي *Vespa orientalis* (٥,٣٪)، النحل القاطع للأوراق *Megachile spp.*، النحل الحلو *Halictus* (١٪) وذئب النحل *Philianthus abdulgade* (٠,٦٪).

لدراسة تأثير التلقيح الزهري بواسطة الملقحات الحشرية على إنتاج ونوعية البذور تم إجراء عدة اختبارات، أظهرت نتائج هذه الأبحاث أن أعلى إنتاج لمحصول عباد الشمس كان نتيجة للتلقيح المكشوف

(نحل عسل + حشرات أخرى) حيث بلغت إنتاجية الفدان نحو (٦٥٢ كجم)، تلى ذلك التلقيح بواسطة نحل العسل فقط (٥٥٦ كجم/فدان). أما المحصول الذي لم يتعرض للتلقيح الخلطي فقد أنتج نحو ٧٢كجم/فدان فقط. كذلك كانت نسبة الإنبات ٨٨، ٨١٪ و ٧٠٪، كما بلغت نسبة الزيت المستخرج من البذور ٤٤، ٤٢٪ و ٢٩٪ على التوالي. أما محصول البرسيم والقطن فكانت نتائجهما بالنمط نفسه.