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INSECT POLLINATORS AND THEIR EFFECT ON THE YIELD OF LUPIN, *Lupinus termis*

Ebadah, I. M. A.*; A. M. Khater and H. M. Mansour****
*** National Research Center Dokki, Giza, Egypt**
**** Plant Protection Res. Institute, Agric. Res. Center Dokki, Giza, Egypt**

ABSTRACT

The present investigation aimed to identify insect visitors of the lupin (*Lupinus termis*) and their effect on the yield during flowering periods of 2005/2006 and 2006/2007 seasons at Shalakan district, Kalubia Governorate.

Obtained results indicated that 17 pollinator species belong to five orders; Hemiptera (2 species), Lepidoptera (2 species), Coleoptera (3 species), Diptera (6 species) and Hymenoptera (4 species). Honeybees, *Apis mellifera* L. proved to be the main numerous pollinator, constituting 14.66, 18.59% of the total collected insects in the two seasons, respectively. The highest occurrence of *A. mellifera* was detected around mid season and at 12-2 p.m. Prevailing air temperature and R.H. % affected moderately the occurrence of insect pollinators.

The presence of insect pollinators during flowering period of lupin significantly increased the main yield parameters such as number of pods/plant, number of seeds/pod, number of seeds/plant and weight of seeds/plant. On the contrary, insect exclusion caused the inverse. As a result, the seed yield/feddan attained 1631.95, 868.8 and 1366.87 kg for open pallination, insect exclusion and honeybee pollination, respectively.

Keywords: Pollinators, pollination, hymenoptera, Coleoptera, seed yield.

INTRODUCTION

In Egypt, lupin (*Lupinus termis*) is one of the most important leguminous crops, it used as a good source of protein and industrial drugs. insect pollinators are needed for the reproduction of 90% of flowering plants and one third of human food crops (Thapa, 2006). They play an essential role in increasing the productivity of field and horticultural crops, without displacing other necessary farm commodities. This role could be attributed to the efficiency of pollinating insects in increasing both self-fertilization (Pazy, 1984; Almeida and De Maltez, 1979) and cross pollination which promotes hybrid vigor (Langridge; Goodmann, 1985 and Yousif-Khalil *et al*, 1989).

In addition, pollinators are part of the intricate web that supports the biological diversity in natural ecosystems that helps sustain our quality of life (Thapa, 2006).

The present work was carried out to survey insect pollinators of the lupin along with their foraging behaviour. In addition, the effects of open pollination, insect exclusion and honeybee pollination on the yield parameters of the lupin were also taken in account during the two successive seasons of 2005/2006 and 2006/2007.

MATERIALS AND METHODS

The present study was carried out at Shalakan district, Kalubia Governorate. The experiments were performed during the two successive agricultural winter seasons of 2005/2006 and 2006/2007 to determine insect visitors of lupin (*Lupinus termis*) and the effect of insect pollination on the lupin yield.

1. Insect pollinators of lupin and their foraging behaviour.

Seeds of lupin (*Lupinus termis*) were planted in an area of half feddan at Shalakan district on the 12th and 9th of October, during season 2005 and 2006. The crop was grown in rows 60 cm wide and seeds were sown in hills, 30 cm apart. One plant was left in each hill. Normal agricultural practices were applied without any insecticidal application.

To measure dial swarming activity of the insect visitors, fifty double sweeps were made by using the sweeping net at two-hour intervals (starting from 8 a.m. until 4 p.m). Dial swarming activity of the insect visitors was estimated every week during the flowering period which started from January 17 to February 28, 2006 and from January 15 to February 26, 2007.

The collected insects were sorted and identified to genera and species when possible.

Weather factors including, ambient air temperature and relative humidity R.H. % were recorded at each interval. The correlation coefficient values between the number of collected insects and each of mean temperature and relative humidity calculated.

2. Effect of insect pollination on the yield of lupin:

2.1. Experimental fields;

To evaluate the effect of honeybee pollination on the yield of lupin, nine random plots (1.5 × 1.5 m) were cultivated with lupin and used as follows:

1. Three open plots were left for open pollination (as control) (A).
2. Three plots were covered with plastic screen cages 1.5 × 1.5 × 1.5 m to exclude all insect visitors (B).
3. Three plots as in (B) but each was provided with honeybee baby nucleus, honeybee pollination (C).

2.2.Plastic screen cages:

Wooden frame cage measuring 1.5 × 1.5 × 1.5 m was covered with plastic screen of 14 mesh/square inch and had a door to permit observation of plants and honeybees inside the cage, such cages were randomaly distributed on the cultivated area. The cages were placed on the field at the beginning of flowering period until its end.

2.3. Honeybee baby nucleus:

Three baby nuclei were used, each nucleus contained 2 combs, one of which contained sealed brood and the other contained stored honey, each nucleus was headed by sister mated queens (first cross Carniolan). Sugar syrup (1^{s}:1^{w}) was used for outdoor artificial feeding and inside the cages when necessary.

The following yield parameters were estimated during the two successive seasons:

- Total number of flowers per plant
- Total number of pods per plant
- Mean percentage of pod set = $\frac{\text{Total number of pods/plant}}{\text{Total number of flower/plant}} \times 100$
- Mean number of seeds per pod
- Mean number of seeds per plant
- Mean weight of seeds per plant (g)
- Mean weight of 100 seeds (g)
- Estimated seed yield/feddan .

Data obtained were statistically analysed according to Snedecor (1957).

RESULTS AND DISCUSSION

1. Survey of lupin insect visitors

During the course of the present study, 17 insect visitor species belonging to five orders, i.e. Hemiptera (2 species), Lepidoptera (2 species), Coleoptera (3 species), Diptera (6 species) and Hymenoptera (4 species) were recorded (Table 1).

Hemipterous insects, represented by *Oxycarenus hyalinipemnnis* and *Nezara viridula*, formed 4.02 and 6.20 % of the total visitors in the flowering periods of 2006 and 2007 seasons, respectively.

Lepidopterious insects, represented by *Syngrapha circumflexa* and *Polymatus baeticus* L. formed 4.24 and 4.93 % of the total insect count in the two season of study, respectively. The *Syngrapha* sp. and *Polymatus baeticus* L. being more abundant at 12 noon to 2 p.m. (Table 2).

Coleopterous insects represented 6.77 and 7.16 % of the total catch in the two seasons of study, respectively. This order was represented by 3 species *Coccinella undcimpunctata* L., *Sitona lividipes* and *Tropinota squalida*.

Insects belonging to order Diptera represented 59.69, 53.44 % of the total collected insects in the two seasons of study, respectively (Table 1). Daily peak activity of flies on lupin flowers was detected at 12 noon in both seasons (Table 2). *Melanagromyza phaseoli* was the most abundant species, followed by *Phytomyza atricontis* and *Musca domestia*. The respective percentages of occurrence of the three species were 15.63, 13.69 and 12.20 % in 2006 and 13.26, 11.42 and 12.20 % in 2007 flowering season.

The total numbers of hymenopterus insects were 340 and 292 insects, representing 25.30 and 28.28 % of the total insects collected in the two seasons of study, respectively (Table 1). The surveyed insects were 4 species i.e. honeybees, *Apis mellifera* L. (14.66 and 18.59 %); *Megachile submucida* Alfk. (3.57 and 3.97 %); *Anthophora* sp. (3.13 and 2.90 %) and *Polistes gollica* (3.94 and 2.81 %) of the total insect visitors in the two years of study, respectively. These results are similar to those of Wainwright (1978 a, b) Stoddared (1991) and Yousif-Khalil *et al*. (1992) taken in consideration the varied plant species.

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Data obtained clear that honey bees were the most abundant lupin visitor, being more active during the first half of February. The daily peak activity of honeybee on lupin blossoms was detected between 12.00 noon and 2 p.m. (Table 2).

Similar results were also reported by Voluzneva (1971); Stoddard (1991); and Wainwright (1978 a, b).

The correlation coefficient values between air temperature and number of collected insects recorded 0.12 and 0.53 in the two season, respectively. Correlation coefficient values (r) between R.H % and the number of insect visitors recorded –0.64 and –0.28 in the two seasons, respectively.

2. Effect of insect pollination on the yield of lupin

2.1. Mean number of flowers

As shown in Table (3), the mean number of flowers per plant in open pollinated, insect protected and honeybee supplied plots were 131.93, 132.72 and 127.29 flowers, in 2006; and 133.63, 124.03 and 129.48 flowers per plant, respectively without any significant differences, in both seasons.

2.2. Mean percentage of pod set

Data presented in Table (3), indicated that mean percentage of pod set recorded 33.02, 19.71 and 31.47 % in 2006, and 31.33, 22.88 and 29.93 % in 2007season for open pollination, insect exclusion and honeybee pollination in the two years, respectively. Insect protected plots showed the least significant percentage of pod set in the two years of study, while the differences between open pollination and honeybee pollination were insignificant in both seasons. Similar results were reported by Almeida and Maltez (1979), Kamler (1982), Yousif-Khalil *et al*., (1989) and Khater *et al*., (2003) taking into consideration the varied leguminous crop.

2.3. Mean number of pods/plant

Results in Table (3), indicated that open pollinated plots produced the highest significant mean number of pods/plant in both seasons (42.48, and 41.97 pods), whereas insect excluded plots yielded the least significant mean number of pods/ plant (26.26 and 25.92 pods). On the other hand, the differences between honeybee provided plots and open pollinated plots were insignificant in both seasons. Similar conclusion was also reached by Koltowski (1996 b) and Khater *et al*. (2003).

2.4. Mean number of seeds/pod

Obtained results indicated that the mean seeds/pod from open pollinated, insect excluded and honeybee poolinated plants recorded 3.19, 1.80 and 2.82 seeds/pod in 2006, and 3.17, 2.22 and 2.77 seeds/pod in 2007 season, respectively. Analysis of data clear that insect exclusion achieved the least significant mean number of seeds/pod in 2006 (Table 3). The results partially agree with Koltowski (1996 b) and Richards (1997).

2.5. Mean number of seeds/plant

As shown in Table (3), it is clear that open pollination yielded the highest significant mean number of seeds/plant, recording 84.60 and 87.60 seeds in the two seasons, respectively. Insect prevention induced the least significant one (40.77 and 38.17 seeds) in both seasons. These results are in

accordance with those of Somerville (1994), Koltowski (1996 a & b) and Khater *et al*., (2003).

2.6. Mean weight of seeds/plant

Results in Table (3) indicated that open pollination produced the highest significant mean weight of seeds/plant recording 33.33 and 37.49 g in both seasons, respectively. On the other hand, insect exclusion induced the least significant (16.07 and 18.85 g.) in the two years. These results agree with Mesquida *et al*. (1992) and Khater *et al*. (2003).

2.7. Mean weight of 100 seeds

The mean weight of 100 seeds resulted from open pollinated, insect excluded and honeybee pollinated plots recorded 37.35, 31.30 and 34.02g in 2006, and 36.15, 29.14 and 32.75 g in 2007 season, respectively. The differences between treatments were insiginificant (Tale 3). These results agree with Mesquide *et al*. (1992) and Khater *et al*. (2003).

Table (3): Yield data of the *Lupinus termis* as influenced by open-pollination (A), insect exclusion (B) and honeybee pollination (c) at Kalubia Governorate during 2006 and 2007 seasons.

Year	2006					2007				
Treatments	A	B	C	LSD		A	B	C	LSD	
				5 %	1%				5 %	1 %
Mean number of flowers/plant	131.93	132.72	127.29	-	-	133.63	124.03	129.48	-	-
Mean percentage of pod set	33.02	19.71	31.47	4.10	6.80	31.33	22.88	29.93	1.90	3.21
Mean number of pods/plant	42.48	26.26	39.77	3.12	5.18	41.97	25.93	38.72	3.50	5.81
Mean number of seeds/pod	3.19	1.80	2.82	0.70	1.20	3.17	2.22	2.77	0.67	1.11
Mean number of seeds/plant (g)	84.6	40.77	64.73	6.20	10.30	87.60	38.17	67.24	6.15	10.54
Mean weight of seeds/plant (g)	33.33	16.07	25.50	2.44	4.06	34.49	18.85	26.15	1.90	3.10
Mean weight of 100 seeds (g)	37.35	31.30	34.02	-	-	36.15	29.14	32.75	-	-
Estimated seed yield/feddan (kg)	1601.80	856.9	1360.03	230.58	383.11	1662.1	880.7	1373.7	108.00	179.40

2.8. Effect of insect pollinators on seed yield.

As shown in the Table (3), the estimated seed yield/feddan for open pollination, insect exclusion and honeybee pollination recorded 1601.8, 856.9 and 1360.03 kg in 2006; and 1662.1, 880.7 and 1375.7 kg in 2007 season, respectively. Open pollination induced the highest significant estimated seed yield/fed., meanwhile, insect exclusion was the least. The two years mean seed yield/fed., recorded 1631.95, 868.8 and 1366.87 kg. for the three treatments, respectively (Table, 4). Thus, the open pollination yielded 87.84% over the exclusion of the pollinators, while providing honeybee nucleus increased the seed yield by 57.33% over the exclusion of pollinators.

These results are in paralled with those of Langridge and Goodmann (1985); Williams (1987); Koltowski (1996 b) and Khater *et al*. (2003).

Table (4): Seed yield of *Lupinus termis* with and without pollinators.

Treatment	Yield (kg)	Increase %
Excluded pollinators	868.80	---
Open pollination	1631.95	87.84
With honeybee nucleus	1366.87	57.33

Generally, it could be concluded that insect pollination is very important for high yield production of crops and the presence of honeybee colonies is very necessary to ensure adequate pollination.

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الملقحات الحشرية وتأثيرها على إنتاجية محصول الترمس

إبراهيم محمد عبد المنعم عباده* ، على محمد خاطر و حمدى متولى منصور****

*** المركز القومي للبحوث – الدقي – جيزة – مصر**

**** مركز البحوث الزراعية – معهد بحوث وقاية النباتات – الدقي – جيزة – مصر**

تم إجراء هذه الدراسة بهدف تعريف الحشرات الزائرة لنباتات الترمس أثناء فترة التزهير خلال موسمي ٢٠٠٦/٢٠٠٥، ٢٠٠٧/٢٠٠٦ بناحية شلقان بمحافظة القلوبية.

أوضحت النتائج أن الحشرات الزائرة لأزهار الترمس تشمل ١٧ نوعاً حشرياً تتبع خمس رتب هي نصفية الأجنحة (نوعان)، حرشفية الأجنحة (نوعان)، غمديه الأجنحة (ثلاثة انواع) ، ثنائية الأجنحة (ستة أنواع) وغشائية الأجنحة (أربعة أنواع).

كان نحل العسل الأكثر تواجدا مقارنة بأنواع الملقحات الأخرى حيث بلغت نسبة تواجده ١٤,٦٦% ، ١٨,٥٩ % خلال موسمي الدراسة على الترتيب. وكان أعلى تواجد للنحل فى منتصف موسم التزهير وبين الساعة ١٢-٢ ظهرا خلال ساعات النهار.

ولقد اتضح أنه يوجد تأثير متوسط لدرجات الحرارة (موجبا) ونسبة الرطوبة (سالبا) على تعداد الحشرات الزائرة لأزهار نباتات الترمس.

وبدراسة تأثير التلقيح المفتوح والتلقيح بنحل العسل والعزل الحشري على محصول نبات الترمس في منطقة الدراسة اتضح أن التلقيح المفتوح كان الأعلى معنويا، بينما كان العزل الحشري الأقل معنويا في حين كان التلقيح منفرداً بنحل العسل وسطاً بين المعاملتين، حيث بلغ متوسط محصول الفدان من البذرة ١٦٣١,٩٥، ٨٦٨,٨، ١٣٦٦ كجم للمعاملات المتروكة للتلقيح المفتوح والمعزولة حشريا وتلك التي لقحت بنحل العسل على الترتيب.

Table (1): Number of each insect visitors/week collected from lupine field during the flowering seasons of 2006 and 2007 at Kalubia region.

Insect visitor species	Sampling date																		
	2006									2007									
	17 Jan.	24 Jan.	31 Jan.	7 Feb.	14 Feb.	21 Feb.	28 Feb.	Total	%	15 Jan.	22 Jan.	29 Jan.	5 Feb.	12 Feb.	19 Feb.	26 Feb.	Total	%
Order: Hemiptera																		
Oxycarenus hyalinipennis	-	3	7	6	1	1	-	18	1.34	2	4	6	5	-	2	2	21	2.03
Nezara viridula L.	3	4	1	5	9	7	7	36	2.68	3	5	7	4	8	10	6	43	4.16
Total	3	7	8	11	10	8	7	54	4.02	5	9	13	9	8	12	8	64	6.20
Order: Lepidoptera																		
Syngrapha circumflexa L.	-	2	2	5	4	3	1	17	1.26	-	1	4	3	5	2	-	15	1.45
Polymatus baeticus L.	4	3	7	10	6	8	2	40	2.98	-	5	9	8	12	2	-	36	3.48
Total	4	5	9	15	10	11	3	57	4.24	-	6	13	11	17	4	-	51	4.93
Order: Coleoptera																		
Coccinella undecimpunctata	3	7	11	4	6	6	10	47	3.50	-	4	9	7	8	3	2	33	3.19
Sitona lividipes	3	1	5	2	4	-	3	18	1.43	-	-	4	3	10	2	3	22	2.13
Tropinota squalida	6	6	4	5	2	3	-	26	1.93	-	-	4	5	3	7	-	19	1.84
Total	12	14	20	11	12	9	13	91	6.77	-	4	17	15	21	12	5	74	7.16
Order: Diptera																		
Syrphus corollae	4	4	5	9	13	7	6	48	3.57	-	2	7	6	11	3	10	39	3.78
Liriomyza congesta	13	18	15	12	19	20	22	119	8.85	12	11	10	7	6	17	15	78	7.55
Melanagromza phaseoli	32	23	46	44	28	23	14	210	15.63	12	18	24	19	21	16	17	137	13.26
Phytonyza atricontis	16	21	34	45	37	13	18	184	13.69	7	12	17	33	29	15	5	118	11.42
Musca domestica	14	26	15	21	44	20	24	164	12.20	15	21	29	12	19	8	22	126	12.20
Sarcophaga carnaria	13	19	7	16	10	8	4	77	5.73	10	3	5	13	7	11	5	54	5.23
Total	92	111	122	147	151	91	88	802	59.69	56	67	92	90	93	70	74	552	53.44
Order: Hymenoptera																		
Apis mellifera	4	22	35	58	39	17	22	197	14.66	21	17	28	36	47	19	24	192	18.59
Megachile submucida	6	2	4	10	14	5	7	48	3.57	-	5	7	11	7	9	2	41	3.97
***Anthophora* sp.**	3	4	5	8	13	7	2	42	3.13	-	4	5	13	6	2	-	30	2.90
Polistes gallicus	3	5	11	14	9	7	4	53	3.94	-	2	-	3	10	8	6	29	2.81
Total	16	33	55	90	75	36	35	340	25.30	21	28	40	63	70	38	32	292	28.27
General total	127	170	214	274	258	155	146	1344		82	114	175	188	209	146	119	1033	
Mean temp. (°C)	13.25	15.0	13.43	16.37	16.53	16.30	18.78	$r_1 = 0.12$		16.14	15.86	16.29	13.4	14.71	17.28	19.57	$r_1 = 0.53$	
Mean R.H. %	67.75	66.29	63.14	58.0	66.67	66.71	64.00	$r_2 = -0.64$		63.40	63.60	59.60	67.6	67.40	65.30	66.4	$r_2 = -0.28$	

Table (2): Dial swarming activity of insect pollinators at two-hour intervals at flowering period of Lupin during 2006 and 2007 seasons.

Insect visitor species	Av. No. of insects/ sample/two hours													
	2006							2007						
	8am	10am	12pm	2pm	4pm	Total	%	8am	10am	12pm	2pm	4pm	Total	%
Order: Hemiptera														
Oxycarenus hyalinipennis	-	3	8	5	2	18	1.34	-	2	6	12	1	21	2.03
***Nezara viridula* L.**	4	6	12	9	5	36	2.68	5	7	9	16	6	43	4.16
(Total)	4	9	20	14	7	54	4.02	5	9	15	28	7	64	6.20
Order: Lepidoptera														
Syngrapha circumflexa	-	2	7	5	3	17	1.26	-	-	4	9	2	15	1.45
Polymatus baeticus	1	4	17	11	7	40	2.98	-	6	13	16	1	36	3.48
(Total)	1	6	24	16	10	57	4.24	-	6	17	25	3	51	4.93
Order: Coleoptera														
Coccinella undecimpunctata	4	11	18	10	4	47	3.50	-	3	18	7	5	33	3.19
Sitona lividipes	2	3	4	6	3	18	1.34	-	5	3	8	6	22	2.13
Tropinota squalida	-	3	8	9	6	26	1.93	-	-	3	12	4	19	1.84
(Total)	6	17	30	25	13	91	6.77	-	8	14	27	15	74	7.16
Order: Diptera														
Syrphus corollae	3	7	13	17	8	48	3.57	-	5	10	13	11	39	3.78
Liriomyza congesta	8	19	37	38	17	119	8.85	4	20	23	22	9	78	7.55
Melanagromza phaseoli	14	33	69	65	29	210	15.63	7	18	61	34	17	137	13.26
Phytomyza atricontis	9	28	50	57	40	184	13.69	5	13	36	39	25	118	11.42
Musca domestica	18	36	52	42	16	164	12.20	13	26	41	32	14	126	12.20
Sarcophaga carnaria	5	10	38	11	13	77	5.73	-	8	20	16	10	54	5.23
(Total)	57	133	259	230	123	802	59.67	29	90	191	156	86	552	53.44
Order: Hymenoptera														
Apis mellifera	10	29	55	62	41	197	14.66	7	36	48	58	43	192	18.59
Megachile submucida	4	12	16	9	7	48	3.57	-	6	16	10	9	41	3.97
***Anthophora* sp.**	3	7	14	14	4	42	3.13	-	7	8	12	3	30	2.90
Polistes gallica	5	10	17	12	9	53	3.94	2	7	6	13	1	29	2.81
(Total)	22	58	102	97	61	340	25.30	9	56	78	93	56	292	28.27
General total						1344							1033	