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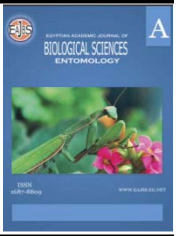

Biodiversity of Ground Spiders (Araneae) Occurred in Tomato and Tomato Yield Fertilized with Different Organic Manures in Fayoum Governorate

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ABSTRACT

A spilt plot design field experiment with three replicates was conducted at Ibshway, Fayoum governorate, Egypt 2014/2015 winter season to study the interaction effect applying different organic manures (compost, chicken manure and farmyard manure) and three potassium levels (K_0, K_1, K_2 liquid potassium 38%) on ground spiders (Araneae) associated with tomato hybrid (010) in addition to tomato yield. Spiders were sampled using pitfall traps. Community composition of the organic, standard fertility of collected spiders was determined throughout the period of study using the Shannon-Wiener and Simpson Indices of diversity. A total of 63, 55, 113, 54 individuals included 14, 15, 13, 14 species in compost, chicken manure, farm yard manure and standard fertilization respectively. According to Simpson, it was found that farm yard manure included the highest number of dominant species. Most species caught belonged to family Lycosidae (92 individuals + one egg sac). Sørensen Quotient of Similarity between compost, chicken manure, farm yard manure compared with standard fertilization concluded that 79%, 89% and 74% of similarity. Statistical analysis proved that no significant differences were observed between means of both manures and potassium treatments while a significant difference occurred between farm yard manure K_1 and other manure treatments. The results of tomato yield revealed that there is a significant increase caused by chicken manure application and the highest increase in tomato yield was obtained with chicken manure (12.55 ton/fed), potassium had no significant effect. The interaction effect between organic manures and potassium levels on tomato yield had no significant differences although the highest yield was obtained by chicken manure with K_1 potassium level (12.71 ton/fed.).

INTRODUCTION

Tomato is one of the most important vegetables grown in Egypt. The production of vegetables avoiding environmental pollution requires minimizing the use of chemicals during the production process (El-Tohamy *et al.*, 2009).

The application of organic manure in fertilizing tomato plants provide the nutritional requirement of plants and also suppress plant pests populations. Many workers have been studied the effect of organic fertilizers on tomato yield quality (Durdane *et al.,* 2011, Olaniyi and Ajibola 2008, Mohammad *et al.,* 2013 and Ibrahim and Fandi 2013). Spiders constitute one of the major groups of generalist predators due to their high abundance and predominantly insectivorous feeding habits. They play an important predatory role in agro-ecosystems, woodlands, and other terrestrial ecosystems (Nyffeler and Benz, 1987; Symondson *et al*., 2002) and changing patterns of cropping (Gibbons *et al.,* 1993) cause reduction in diversity and abundance of spiders in agricultural fields. Agricultural management has a considerable effect on the activity of spiders (Cole *et al*., 2005 and Fuller *et al.,* 2005) found more spider activity in organic wheat than conventional. In organic management, where agro-chemical application is prohibited, diversity of spiders is economically important (Östman *et al*., 2003). Organic practice may add diversity to the soil structure and increase the abundance of prey and in turn the abundance of spiders (Öberg, 2007). Morever Eyre *et al.,* (2007) found that fertility rather than crop protection management had considerably more influence on the activity of beneficial spiders. The spider community may play an important role in the regulation of insect populations in both vegetable and field crops (Young and Edwards, 1990).

This work aimed to evaluate the interaction effect of applying different organic manures and different liquid potassium levels on the activity density and diversity of ground spiders in addition to tomato yield.

MATERIALS AND METHODS

Experimental design:

The present investigation was conducted at Ibshway, Fayoum governorate during the winter season, 2014-2015. Seeds of tomato (*Solanum lycopersicum* L.; Solanaceae) (hybrid 010) produced by Sengenta company was sown in seedling trays in a greenhouse on August 10-13, in 2014. A spilt plots design with three replicates was used. Organic fertilizers were applied in the main plots and potassium levels were applied in the sub plots. During soil preparation, calcium supper phosphate (15.5% P2O5) at the rate of 46.5 kg/fed was broadcasted. Three organic manures [compost, chicken manure and farm yard manure (Fym)] were separately mixed with the soil surface in a rate of 2.5 ton/fed. for each replicate and standard fertilization (control). Tomato seedlings were transplanted in the experimental field after 20 days in rows of 1.0 m wide and 3.0 m long with intra row spacing of 50 cm. The organic nitrogen unit 120 kg/fed were applied after 15, 30 and 50 days from transplanting in each plot. Three liquid potassium 38% with levels of K0 (0 L/fed), K1 (8.5 L/fed), K2 (17 L/fed) were sprayed after 21 days from transplanting. Spiders were sampled by using pitfall traps method as described by Southwood (1978) and Slingsby & Cook (1986). Three pitfall traps were placed in each fertilizer treatment every ten days. Samples were sorted in the laboratory; collected spiders were kept in glass vials containing 70% ethyl alcohol and some droplets of glycerine, counted and identified to species as much as possible.

Frequency and abundance values

The frequency values of the most abundant species were classified into three classes according to the system adopted by Weis Fogh (1948); “Constant species” more than 50% of the samples, "accessory species" 25-50 % of the samples and "accidental species" less than 25%. On the other hand, the classification of dominance values were done according to Weigmann (1973) system in which the species were divided into five groups based on the values of dominance in the sample; Eudominant species (>30% individuals), dominant species (>10-30% individuals), subdominant (5-10% individuals), recedent species (1-5% individuals) and subrecedent species (<1% individuals).

Species diversity

The biodiversity collected of ground fauna was estimated by using equilibrium. Diversity of collected arthropods was determined for samples pooled over one summer season by two different patterns of fertilization. It was measured by diversity index that reflected the number of species (richness) in the samples. Two common indices were computed, Shannon-Wiener index "H" and Simpson index "S". They were calculated as described by Ludwig and Reynolds (1988). $H' = -\Sigma (ni/n) \ln (ni/n)$ and $S = \Sigma (ni/n)2$ where ni is the number of individuals belonging to the i^{th} of "S" taxa in the sample and "n" is the total number of individuals in the sample. "H" is more sensitive to changes in number of species and diversity, while "S" is a dominance index gives more weight to common or dominant species (Ludwig & Reynolds, 1988); it highly suggests that the two individuals drawn at random from the population belong to the same species. If the result is high then the probability of both individuals belonging to the same species is high, and as a result the diversity of the community samples might be low.

Sørensen quotient of similarity

To allow a comparison of the two samplings between microhabitats of the two cultivation systems, Sørensen's quotient of similarity (Sørensen, 1948) was used to determine the similarities of spider species composition among the communities, it is: $QS = 2\ C/A + B$. Where A and B are the number of species in samples A and B, respectively, and C is the number of species shared by the two samples; QS is the quotient of similarity and ranges from 0-1. [A = Organic management, B = conventional management].

Statistical analysis:

Analysis of variance was conducted to determine the significance between means of males, females and juvenile structure in addition to tomato yield. All collected data were statistically analyzed according to technique of analysis of variance for split-plot design by "MSTAT-C" computer software package. The differences among treatment means were compared by LSD test at $P \leq 0.05$ (Gomez and Gomez 1983).

At ^{1st} harvest on 25/11 /2014 fruit from each plot were collected, weighed and recorded, the same is true for ^{2nd} and ^{3rd} harvesting on 2/12/2014 and 9/12/2014 respectively. At the end of experimental period data of the previous plots were collected and subjected to statistical analysis. Soil sample from experimental site was taken before transplanting and subjected to analysis, soil physical properties were determined according to klute (1986) Chemicals properties (Table 1) determined according to Page *et al.,* (1982) P was determined according to Chapman and Pratt (1961).

Table 1: Some initial physical and chemical soil properties of the studied soil (0-30)

Physical properties		**Chemical properties**	
$CaCo_3$ %	2	PH (1:2.5 soil: water susp)	7.9
		Ec., mmhos/cm	0.9
		Soluble cations (meq./L)	
Clay %	14.40	Ca^{++}	2.6
Salt %	6.60	Mg^{++}	3.2
Sand%	79.00	Na^{+}	16.8
Textural class	Sandy loam	Soluble anions meq/L	
		Hco_3	1
		Cl	2.5
		So_3	20.6
		Available nutrients ppm	
		N	50
		P	4.6
		K	420

RESULTS AND DISCUSSION

Spider collecting

Tables (2 and 3) showed that the collected spiders recorded were 285 individuals, represented by 7 families of 20 identified genera. The 7 families found in the present study represent 17.5% of the 40 families recorded in Egypt (El-Hennawy, 2006).

Table 2: Species richness of spiders inhabiting soil of different manures associated tomato plants

Families & taxa names	Compost manure			Chicken manure			Farm yard manure			Standard fertilization			Σ			Σ	Total	%
	♂	♀	j	♂	♀	j	♂	♀	j	♂	♀	j	♂	♀	j			
Lycosidae																		
Wadicosa fidelis	4	3	1	7	5	5	3	4	29	4			18	12	35	65	165+▲	57.89
Pardosa sp.	3		1		1		1	3	2	1	1		5	5	3	13		
Hogna ferox	4	7	6	3	1	1	3	8+▲	39	3	7	5	13	23+▲	51	87+▲		
Gnaphosidae		1				1		1	1					2	2	4		
Zelotes laetus	1	1		2	2	4	2			2	2		7	5	4	16	34	11.93
Micaria dives	3	2		1						6	2		10	4		14		
Salticidae	1	2	1		1					1			2	3	1	6		
Phlegra flavipes		1		1			1					1	2	1	1	4	11	3.86
Thyene imperialis							1						1			1		
Linyphidae	6	2		4	2		5		1	4	1		19	5	1	25		
Bathyphantes sp.	1	1											1	1		2	34	11.93
Prinerigone vagans				1						1			2			2		
Erigone sp.									1	1	3		1	3	1	5		
Theridiidae			4			2			1	1	1	1	1	1	8	10		
Enoplognatha gemina	3			3			3						9			9	25	8.77
Kochiura aulica	1	2		1			1					1	3	2	1	6		
Dictynidae		1		1	3	2	1	1	1		2	1	2	7	4	13	13	4.56
Philodromidae																	3	1.05
Thanatus albini						1				1		1	1		2	3		
Σ	27	23	13	24	15	16	21	17+▲	75	25	19	10	97	74+▲	114	285+▲		
Total		63			55			113			54			285+▲				

▲: Egg sac

Spiders inhabiting land of management

Compost manure

63 spiders were collected in compost manure treatment. They were identified to 6 families, 14 genera, and 14 species. Juvenile comprised 20.6% while adults averaged 79.4%. The sex ratio was 1.2 male: 1 female. Of the most abundant species, 3 species recorded the highest numbers, *Hogna ferox* (17 individuals), *Wadicosa fidelis*, Lycosidae (8), and Linyphid sp. (8).

Chicken manure

55 spiders were collected in chicken manure treatment. They were identified to

7 families, 15 genera, and 15 species. Juvenile comprised 29.1%, while adults averaged 70.9%. The sex ratio was 1.6 male: 1 female. Of the most abundant species, 5 species ranked the first, *Wadicosa fidelis*, Lycosidae (17 individuals), *Zelotes laetus*, Gnaphosidae (8), Linyphid sp. (6) Dictynid sp. (6), and *Hogna ferox*, Lycosidae (5).

Table 3: The dominance-frequency relationship of spider communities associated with tomato plants affected by different manures

Families &taxa names	Compost manure					Chicken manure					Animal manure					Standard fertilization				
	No.	sp.%	Dom.	F.%	Freq.	No.	sp.%	Dom.	F.%	Freq.	No.	sp.%	Dom.	F.%	Freq.	No.	sp.%	Dom.	F.%	Freq.
Lycosidae				45.9	ac				41.8	ac				81.4	C					
Wadicosa fidelis	8	12.7	D			17	30.9	E			36	31.9	E			4	7.4	sd		
Pardosa sp.	4	6.3	sd			1	1.8	R			6	5.3	sd			2	3.7	R	38.9	Ac
Hogna ferox	17	36.9	D			5	9.1	sd			50	44.2	E			15	27.8	D		
Gnaphosidae	1	10.6	R	12.7	A	1	1.8	R	18.1	A	2	1.8	R	3.6	A					
Zelotes laetus	2	3.2	R			8	14.5	D			2	1.8	R			4	7.4	sd	22.2	A
Micaria dives	5	7.9	sd			1	1.8	R								8	14.8	D		
Salticidae	4	6.3	sd	7.9	A	1	1.8	R	3.6	A				1.8	A	1	1.9	R		
Phlegra flavipes	1	1.3	R			1	1.8	R			1	0.9	sr			1	1.9	R	3.8	A
Thyene imperialis											1	0.9	sr							
Linyphidae	8	12.7	D	15.9	A	6	10.9	D	12.7	A	6	5.3	sd	6.2	A	5	9.3	sd		
Bathyphantes	2	3.2	R																18.6	A
Prinerigone vagans						1	1.8	R								1	1.9	R		
Erigone sp.											1	0.9	sr			4	7.4	sd		
Theridiidae	4	6.3	sd	15.9	A	2	3.6	R	10.9	A	1	0.9	sr	4.5	A	3	5.6	sd		
Enoplognatha gemina	3	4.8	R			3	5.5	sd			3	2.7	R						7.5	A
Kochiura aulica	3	4.8	R			1	1.8	R			1	0.9	sr			1	1.9	R		
Dictynidae	1	1.6	R	1.6	A	6	10.9	D	10.9	A	3	2.7	R	2.7	A	3	5.6	sd	5.6	A
Philodromidae									1.8	A									3.7	A
Thanatus albini						1	1.8	R								2	3.7	R		
Σ		63					55					113					54			

Frequency (abundance), by Weis Fog
> 50 % = Constant (C)
25 - 50 % = Accessory (ac)
> 25 % = Accidental (A)

Dominance, by Weigmann
> 30 % = Eudominant (E)
10 - 30 % = Dominant (D)
5 - 10 % = Subdominant (sd)
1 - 5 % Recedent (R)
> 1 % = Subrecedent (Sr)

Farm yard manure

A total of 113 individuals were collected in treatment of farm yard manure. These belong to 7 families of 13 genera, and 13 species. Juveniles comprised 66.4% while adults averaged 33.6%. The sex ratio was 1.2 male: 1 female. Of the most abundant species, 2 genera of family Lycosidae recorded highest numbers, *Hogna ferox* (50 individuals), and *Wadicosa fidelis* (36).

Standard fertilization

A total of 54 spiders were cached in treatment of Standard fertilization. They were identified in 7 families, 14 genera, and 14 species. Juvenile comprised 18.5% while adults averaged 81.5%. The sex ratio was 1.3 male: 1female. Of the most abundant species, 2 genera were recorded highest numbers, *Hogna ferox*, Laycosidae (15 individuals) and *Micaria dives*, Gnaphosidae (8).

Species richness

Among the 22 species of the collected spiders (table 2), 14 species of 6 families were recorded in compost manure system, 15 species of 7 families in chicken manure system, 13 species of 7 families in farm yard manure system and 14 species of 7 families in standard system. A total of 7 species had common occurrence in all treatment. Family Philodromidae was absent in soil treated with animal as organic system.

Family Laycosidae recorded the highest number of spiders of 165 individuals with one egg sac. In farm yard manure the highest number of spider belonging to family Lycosidae (92 individuals + one egg sac), compost manure (29), chicken manure (23) and standard received low numbers (21); it was the only dominant family, comprised 55.76%, 17.85%, 14% and 12.73% of the total catch in Farm yard manure, compost manure, chicken manure and standard fertilization respectively.

Eyre *et al.,* (2008) found that spider species activity in five crop types, with organic and conventional fertility. Also, significant differences in activity between crop types were noted with 16 species, 12 least active species in vegetable plots. Within crops there were 20 significant responses to fertility, with 16 more active in conventional plots. Crop protection management produced four significant models, with three preferences for organic management. Small linyphiid species showed a distinct preference for the densest vegetation on conventionally fertilised plots, whilst the larger lycosid species were more active on the more open organic plots. In general, there was more activity in conventionally managed crops. Weibull & Östman (2003) found differences in spider activity between cereal and grassland crops and more activity was noted in grass/clover plots for most species, with the least on the vegetable plots. Within crops there were 20 significant models with fertility, with more activity of 16 species in conventional plots. Hafiz and Abida (2009) recorded highest number of spiders, 4645 spiders belonging to 7 families, 16 genera and 21 species in organic manure.

Frequency and abundance values

Table (3) showed exhibits of spiders associated with tomato plants as affected by different organic fertilizers. Family Lycosidae was considered “Constant” in farm yard manure (Fym) according to Weis Fog system which occupied 55.76% of the collected spiders. While considered “accessory” in compost manure, chicken manure, standard fertilization. Members of this family: *Wadicosa fidelis* and *Hogna ferox*. ranges between “Eudominant” and “Dominant” according to Weigmann classification of dominance.

The present results agree with that of Hafiz and Abida (2009) who indicated that species and numbers of lycosids were numerically dominant. Also,the results are in accordance with Eyre *et al.,* (2008) as they stated that linyphiid species prefer plants in conventional cultivation and larger lycosid, philodromid, and gnaphosid species prefer the organic cultivation. Moreover, *Rizk et al.,* (2012) indicated that members of Lycosidae were common. and all their developmental structures were collected by pitfall traps below the four plants: Egyptian mint, Castor bean, Roselle (karkadi), and Red pepper. A wide range of species can occur in arable fields, of which money spiders (Linyphiidae) and wolf spiders (Lycosidae) are the most abundant ones (Alford, 2003).

Species diversity

Table (4) compares the biodiversity of spiders collected from tomato plants of the different treatments, i.e. compost manure, chicken manure, farm yard manure, standard fertilizer, using Shannon-Wiener "H" and Simpson "S" Indices of diversity. The vegetations of different treatment varied in their spider richness.

Table 4: Estimation of Shannon-Wiener and Simpson Indices of spider diversity in tomato plants as affect with different manures.

Type of index	Compost manure	Chicken manure	Farm yard manure (Fym)	Standard fertilization
Shannon-Wiener Index	1.47	1.6	0.76	1.48
Simpson Index	0.24	0.25	0.67	0.25

The spiders collected from tomato plants treated with farm yard manure recorded the highest population (113 individuals), while standard recorded the least species richness (54 individuals).

According to Shannon-Wiener "H" Index, the chicken manure recorded the highest value, 1.6 of 15 species and 7 families, while farm yard manure recorded the smallest value, 0.76 of 13 species and 6 families, therefore, it could be concluded that enhanced that chicken manure had a higher diversity index and farm yard manure had a lower diversity index. Similarly, the values calculated for other manure described the different species diversity index for each group.

According to Simpson Index, which reflected the measure of dominance, it was found that the farm yard manure included the highest number of dominant species of values 0.67, Lycosid members recorded (92 individuals and one egg sac). The present results are in agreement with Öberg (2007) who stated that organic practice may add diversity to the soil structure and increase the abundance of prey and in turn the abundance of spiders. The same results are recorded by (Feber *et al.,* 1998; Yardim and Edwards, 1998; Schmidt *et al.,* 2005) as they found that abundance of spiders in organic fields was more than conventionally.

Similarity of species

Community of spiders collected from standard system (54 indv.) was lower than those collected from compost manure system (63 indv.), chicken manure system (55) and farm yard manure system (113 indv.), while the number of spider species was greater in chicken manure (15 sp.) than that of other treatments which recorded 14, 14, 15 and 13 species respectively. To estimate spider composition of that different microhabitat, Sørensen's quotient of similarity was applied by comparing the number of species and individuals of control apparently with catch one of those treatments. It is concluded that the similarity to standard compared by other treatments recorded 79%, 89% and 74% for compost manure, chicken manure, farm yard manure respectively that is to say that community of chicken manure nearly resembled community of standard by 89%.

Statistical analysis

Statistical analysis proved that no significant differences were observed between means of manure treatments and no significant differences between potassium treatments, while a high significant difference occurred between farm yard manure K_1 and other treatments (Table 5).

Tomato yield:

Data in Table (5) revealed that the application of organic manure alone indicated that chicken manure enhanced a significant increase in tomato yield (12.55 Ton/fed.) followed by compost treatment (10.07 Ton/fed.). Whereas, liquid potassium fertilizer had no significant effect on tomato yield. These results of potassium effect on tomato yield may be due to that the tested soil was rich in potassium content (Table 1).

These results agree with that of Olaniyi and Ajibola (2008), as they pointed out that the application of poultry manure and inorganic nitrogen fertilizer 60 kg/ha. increased significantly tomato yield. With regard to the interaction effect of organic manure and liquid potassium fertilizer on tomato yield, it is clear from table (5), there is no significant effect on the yield although the application of chicken manure with K_1 (8.5 L/fed. liquid Potassium 38%) gave the highest tomato yield followed by chicken manure with K_2 (17 L/fed. liquid Potassium 38%).

Table 5: Effect of different organic manures applied on number of spiders and tomato yield

Treatment	Characters	
	Spiders No. (10 rep)	Yield (kg/m^2) (3 rep)
Organic manure		
Compost (M1)	2.10	10.07b
Chicken (M2)	1.83	12.55a
Farmyard (M3)	3.77	9.78b
Standard (M4)	1.80	9.32c
LSD (5%)	**NS**	**0.31**
Pottassium (K)		
K_0	1.90	10.38
K_1	3.28	10.47
K_2	1.95	10.44
LSD (5%)	**NS**	**NS**
Interaction		
M1×K0	2.10b	10.00
M1×K1	1.60b	10.11
M1×K2	2.60b	10.11
M2×K0	2.60b	12.45
M2×K1	1.40b	12.71
M2×K2	1.50b	12.49
M3×K0	1.40b	9.74
M3×K1	7.90a	9.74
M3×K2	2.00b	9.85
M4×K0	1.50b	9.31
M4×K1	2.20b	9.33
M4×K2	1.70b	9.32
LSD (5%)	**3.56**	**NS**

The results of organic manures effect on tomato yield are in agreement with that obtained by Mohammad *et al.*, (2013) and Ibrahim and Fandi (2013).

Finally chicken manure effect on tomato yield have been supported with the results of spider biodiversity that is to say chicken manure recorded the highest biodiversity of spider (15 species).

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ARABIC SUMMERY

التنوع الحيوي للعناكب الأرضية في نباتات الطماطم ومحصول الطماطم المعامل باسمدة عضوية مختلفة في محافظة الفيوم

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2- مركز البحوث الزراعية – معهد بحوث البساتين .
3- مركز البحوث الزراعية – معهد بحوث الاراضي والمياه والبيئة.
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أجريت التجربة في مركز ابشواى، محافظة الفيوم 2015/2014 موسم الشتاء لدراسة تأثير تطبيق إستخدام أسمدة عضوية مختلفة وهي كمبوست، سماد الدجاج والسماد البلدى (FYM) وثلاثة مستويات من البوتاسيوم (K0 ، K1، K2 بوتاسيوم سائل 38٪) على التنوع الحيوي للعناكب الأرضية المرتبطة بمحصول الطماطم الهجين (010). وقد أخذت عينات العناكب بواسطة مصائد الحفر كل عشرة أيام.

أسفر البحث عن وجود عشرون نوعا وينتمون جميعاً لسبع عائلات وكانت العائلة Lycosidae هي السائدة. أظهرت النتائج المتحصل عليها وجود إختلافاً في تنوع العناكب تحت تأثير الاسمد المختلفة، حيث سجلت اعداد العناكب في الكمبوست، تسميد الدواجن، التسميد الحيواني والتسميد الازوتي: 63، 55، 113 و54 علي الترتيب.

كذلك من دراسة التكوين البيئي للتنوع بإستخدام مؤشر شانون - فينر فقد وجد أن تسميد الدواجن (1.6) أعطي أعلى قيمة للتنوع الحيوي للعناكب. وباستخدام مؤشر سامبسون وجد أن التسميد الحيواني يحتوي على العناكب الأكثرشيوعاً حيث أنه أعطى قيمة (0.67). وكان تأثير تسميد الدواجن معنوي حيث أعطي أعلي محصول طماطم بنسبة (12.55 كجم/م^2). وكان تأثير تسميد البوتاسيوم وتأثير التفاعل بين الاسمد العضوية وتسميد البوتاسيوم غير معنوي بالرغم من ان تسميد الدواجن (K1) أعطي (12.71 كجم/م^2).