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Effect of Different Fertilization Treatments on the Biodiversity of Mites Associated with Tomato Plants and its Yield in Fayoum Governorate, Egypt

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ABSTRACT

A field experiment was conducted on tomato plants, hybrid (010) at Ibshway, Fayoum governorate, Egypt in winter season (2014-2015). Three replicates were used to study the interaction effects of different organic manures [compost, chicken manure and farmyard manure, and three potassium levels (K_0, K_1, K_2 liquid potassium 38%)] on the biodiversity of mites and the yield of tomato. Random samples of debris, litters and soil are collected every ten days intervals from November 2014 to January 2015. The results revealed 33 species of 27 genera in 21 families from Astigmata, Prostigmata, Mesostigmata and Cryptostigmata. Famiy Scutacaridae ranked the first in populations followed by Family Haplozetidae. The effect of three levels of organic fertilizers was recorded. The interaction effects between organic manures and potassium levels on tomato yield also were discussed.

Key words: Mites; Biodiversity; Organic fertilizers; Tomato.

INTRODUCTION

Tomato (*Solanum lycopersicum* L.; Solanaceae) is considered one of the most important vegetable crop grown in Egypt for its local consumption and exportation. Tomato can be grown on a small scale in the kitchen garden, and also in a commercial scale as a cash crop. One of the basic methods to improve tomato yield and fruit quality is the cultivar production and evaluation. Yearly, there are many recommendations for new cultivars and hybrids. Several studies proved that nitrogen has a marked effect on vegetative characteristics of tomato plants. The application of organic manure in fertilization system in tomato plantations provide the nutritional requirements of plants and also suppress the plant pest's populations. Many researchers and practicing farmers observed that fertility practices replenish and maintain high soil organic matter and enhance diversity of soil macro and microbiota and provide an environment that through various processes enhances plant health (McGuiness, 1993).

Oribatid mites (Acari: Oribatida) are widely distributed around the world, playing a biological role of great importance in both natural and agricultural ecosystems. They form the main part of soil microarthropods and play an important role in several soil processes, such as organic matter decomposition, material and energy cycles and soil formation. They also act as vectors of numerous parasites; as a dominant component of soil organisms, and are obviously suitable bioindicators (Peterson and Luxton, 1982; Lee and Pankhurst, 1992 and Haq, 1994).

Soil mites are abundant organisms and sensitive to soil perturbations in agricultural practices and their numbers and diversity often get reduced affecting their ecosystem services (Minor and Cianciolo, 2007). Several soil mite genera are considered good bio-indicators of habitat and soil conditions (Behan-Pelletier, 1999). The soil biota complements each other in commutation of litter, mineralization of essential plant nutrients and conservation of those nutrients within the soil system (Marshall, 2000).

The objective of this paper is to evaluate the interaction effects between different organic manures treatments and liquid potassium levels on the biodiversity of mites inhabiting tomato plants as well as the tomato yield in Fayoum governorate, Egypt.

MATERIALS AND METHODS

a. 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 used (fed. = Feddan = 4200 square meter). 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. In each experimental unit, plants of the two outer rows were assigned to measure their effects on mite biodiversity.

b. Samples collection:

Observations were performed in different fertilization treatments. In each treatment, random samples of debris, litters and soil were collected periodically at ten days intervals from November 2014 to January 2015. These samples weighing approximately 0.25 kg, were kept immediately in polyethylene bags, and brought to the laboratory for extraction by Berlese funnel (Krantz and Walter, 2009). The extracted mites were mounted in Hoyer's medium. After a cover slide had been placed, the slides were placed on a hot plate for two weeks. Name of region, host plant, collecting date were written on labels and stuck on the slides. Specimens of phytophagous, predacious and other mites of miscellaneous feeding habits were identified to species level using a microscope and referring to the key of taxonomic references cited by Zaher (1986), Smiley (1992), Krantz and Walter (2009), Abo-Shnaf *et al.* (2013) and Abo-Shnaf & Moraes (2014).

c. Species diversity:

The biodiversity of collected soil mites were estimated by using equilibrium. Diversity of collected mites was determined for samples pooled over one summer season by two different patterns of fertilization. It was measured by diversity index that reflected to 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).

$$H' = -\Sigma (ni/n) \ln (ni/n) \text{ and } S = \Sigma (ni/n)^2,$$

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 and 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 maybe high, as a result the diversity of the community samples might be low.

d. Statistical analysis:

Analysis of variance was conducted to determine the significance between means of males, females and immatures structure in addition to tomato yield. All collected data were statistically analyzed according to the 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).

The first, second and third harvesting were respectively on November 11, 25 and December 2, 2014, fruits from each plot were collected, weighed and recorded. At the end of experimental period, data of the previous plots were collected and subjected to statistical analysis.

RESULTS AND DISCUSSION

Mite species richness:

Table (1) showed that the mite species inhabiting debris, litters and soil underneath tomato plants at Fayoum governorate included 33 species of 27 genera belonging to 21 families in different mite suborders. The families are: Acaridae (Astigmata); Bdellidae, Caligonellidae, Cunaxidae, Eupodidae, Rhagidiidae, Scutacaridae, Siteroptidae, Tetranychidae and Tydeidae (Actinedida); Ameroseiidae, Laelapidae, Macrochelidae, Ologamasidae, Pachylaelapidae, Parasitidae, Phytoseiidae and Uropodidae (Gamasida); in addition to Haplozetidae and Oppiidae (Oribatida). The mite species are classified into three groups according to their habitat:

a- Mite collected from debris:

This group occurs on leaves, debris and those are included two species: *Tetranychus urticae* Koch and *Petrobia* spp. (Tetranychidae).

b- Mite collected from litters:

This group occurs only in debris underneath tomato plants and included 27 species such as: *Neoseiulus barkeri* Hughes (Phytoseiidae); *Tydeus kochi* Oudemans (Tydeidae); *Androlaelaps aegypticus* Hafez, El-Badry & Nasr; *A. casalis* (Berlese); *Hypoaspis koseii* Hafez, El-Badry & Nasr; *H. orientalis* Hafez, El-Badry & Nasr; *H. petrovae* Shereef & Afifi; *Laelaspis astronomicus* (Koch) (Laelapidae); *Parasitus zaheri* Hafez & Nasr; *Vulgarogamasus* spp. (Parasitidae); *Coleoscrius tuberculatus* Den Heyer; *Cunaxa capreolus* (Berlese);*Cunaxa* spp.; *Neocunaxoides andrei* (Baker & Hoffmann) (Cunaxidae); *Eupodes temperatus* Shiba, (Eupodidae); *Spinibdella bifurcata* Atyeo, (Bdellidae); *Ameroseius wahabi* (Ibrahim & Abdel-Samed); *A. zaheri* (El-Badry, Nasr & Hafez) (Ameroseiidae); *Macrocheles merdarius* (Berlese) (Macrochelidae); *Caligonella humilis* (Koch) (Caligonellidae); *Trichouropoda* spp. (Uropodidae); *Siteroptes* spp. (Siteroptidae); *Heterodispus chanti* (Scutacaridae); *Pachylaelaps aegypticus* Hafez

Table 1: Richness of mite species inhabiting tomato plants under effects of different manure treatments from September 2014 to January 2015.

Family	Species	Compost manure			Chicken manure			Animal manure			Standard			Total
		K0	K1	K2	K0	K1	K2	K0	K1	K2	K0	K1	K2	
Acaridae	*Tyrophagus putrescentiae*	0	16	12	2	38	7	15	16	6	1	25	25	163
Haplozetidae	*Xylobates souchnaiensis*	88	127	94	40	84	60	98	75	71	79	49	30	895
Oppiidae	*Oppia concolor*	34	59	23	6	126	20	20	17	24	10	23	14	376
	O. sticta	28	30	37	9	17	20	22	15	68	10	22	11	289
Ameroseiidae	*Ameroseius wahabi*	0	0	0	0	0	0	0	0	0	0	0	1	1
	Ameroseius zaheri	6	1	6	4	14	23	20	12	2	2	2	5	97
Laelapidae	*Androlaelaps aegypticus*	16	20	13	14	22	21	39	22	13	11	17	7	215
	Androlaelaps casalis	0	0	0	0	0	1	0	0	0	0	0	0	1
	Hypoaspis koseii	0	0	0	0	0	0	0	0	0	1	0	0	1
	Hypoaspis orientalis	0	0	0	0	0	0	0	0	0	4	0	0	4
	Hypoaspis petrovae	0	0	0	0	0	0	0	0	0	0	0	1	1
	Laelaspis astronomicus	3	0	2	0	0	0	1	0	0	1	0	0	7
Macrochelidae	*Macrocheles merdarius*	0	0	3	0	9	1	1	1	0	0	0	0	15
Ologamasidae	*Gamasiphis pulchellus*	17	22	12	11	19	10	12	18	19	24	27	8	199
Pachylaelapidae	*Pachylaelaps aegypticus*	5	3	8	6	17	5	3	16	12	12	11	10	108
Parasitidae	*Parasitus zaheri*	1	0	2	0	0	0	0	0	0	2	0	0	5
	Vulgarogamasus spp.	1	0	2	0	5	1	0	0	0	0	3	0	12
Phytoseiidae	*Neoseiulus barkeri*	4	2	0	0	13	4	1	0	0	0	1	1	26
Rhodacaridae	*Multidentorhodacarus aegypticus*	35	11	0	17	2	4	1	8	7	12	0	4	101
Uropodidae	*Trichouropoda* spp.	0	0	0	0	0	0	0	0	3	4	0	0	7
Bdellidae	*Spinibdella bifurcate*	0	2	1	0	5	6	0	3	2	0	0	2	21
Caligonellidae	*Caligonella humilis*	0	2	1	0	0	1	0	0	0	0	0	0	4
Cunaxidae	*Coleoscrius tuberculatus*	3	3	1	2	2	2	6	3	9	3	8	6	48
	Cunaxa capreolus	0	0	1	0	1	1	0	0	3	2	3	1	12
	Cunaxa spp.	0	0	0	0	0	0	4	0	0	2	0	0	6
	Neocunaxoides andrei	0	0	0	0	0	0	0	0	1	0	0	0	1
Eupodidae	*Eupodes temperatus*	2	0	0	0	0	1	0	1	0	1	1	0	6
Rhagidiidae	*Shibaia shereefi*	0	0	0	0	0	0	0	0	1	0	0	0	1
Scutacaridae	*Heterodispus chanti*	124	594	315	153	661	390	723	1698	668	539	1178	122	7165
Siteroptidae	*Siteroptes* spp.	0	0	0	0	2	2	0	0	0	1	0	10	15
Tetranychidae	*Petrobia* spp.	0	0	0	0	0	0	1	0	0	0	0	0	1
	Tetranychus urticae	1	1	2	2	1	0	1	1	1	1	0	0	11
Tydeidae	*Tydeus kochi*	0	5	31	0	0	11	3	4	0	1	10	2	67
Total		368	898	566	266	1038	591	971	1910	910	723	1380	260	9881
			1832			1895			3791			2363		

K0 = no Potassium K1 = 1% liquide Potasium (38%) K2 = 2%liquide Potasium (38%)

& Nasr (Pachylaelapidae); *Shibaia shereefi* Abou-Awad (Rhagidiidae); *Gamasiphis pulchellus* (Berlease) (Ologamasidae); and *Multidentorhodacarus aegypticus* Abo-Shnaf, Castilho & Moraes (Rhodacaridae).

c- Mite collected from soil:

This group occurs only in soil included four species, *Tyrophagus putrescentiae* (Schrank) (Acaridae); *Xylobates souchnaiensis* Abd El-Hamid (Haplozetidae); *Oppia concolor* Koch and *O. sticta* Popp (Oppiidae).

Rank abundance of mite families:

The collected mites were presented by 21 families (Table 1). There are ten families constitute the majority of the total collected mite species i.e: Acaridae, Oppiidae, Haplozetidae, Ologamasidae, Scutacaridae, Ameroseiidae, Phytoseiidae, Rhodacaridae, Laelapidae and Pacheylaelapidae.

The greatest number of collected individuals presented by the Family Scutacaridae (7165 individuals) and ranked the first (72.51%), followed by the Family Haplozetidae (895 individuals) which ranked the second (9.58%).

Effect of tested treatments on mite populations:
Compost manure:

Table (1) shows that a small dose of K_1 (1% potassium 38%) in plot treated with compost manure increased the abundance of mites to 898 individuals; while those of higher doses of K_2 (2% of potassium 38%) have only (566 individuals). The families Uropodidae, Rhagidiidae and Siteroptidae were not distinguished in all of those plots treated with compost manure.

Chicken manure:

Similar results were obtained in the plot treated with chicken manure, where a small dose of K_1 (1% potassium 38%) increased the abundance of mites to 1038 individuals; while higher doses of K_2 (2% of potassium 38%) significantly decreased this population to 591 individuals; in relation to the plot treated with chicken manure with K_0 (without potassium treated), only 266 individuals were recorded. The families Uropodidae and Rhagidiidae were not distinguished in all of those plots treated with chicken manure.

Farmyard (Fym):

Also, the same results were obtained in the plots treated with farmyard (Fym), where a small dose of K_1 (1% potassium 38%) increased the abundance of mites to1910 individuals; while higher doses of K_2 (2% of potassium 38%) significantly decreased this population to 910 individuals; in relation to plot treated with farmyard with K_o (Fym), only (971 individuals) were recorded. Families Parasitidae, Caligonellidae and Siteroptidae not distinguished in all those plots treated with farmyard (Fym).

Standard manure:

In standard manure, a small dose of K_1 (1% potassium 38%) increased the abundance of mites to 1380 individuals, while higher doses of K_2 (2% of potassium 38%) decreased this population to 260 individuals. Standard manure with K_o, also decreased this population to 723 individuals. Families Macrochelidae, Caligonellidae and Rhagidiidae were not distinguished in all of those plots.

These results are in agreement with those obtained by Graczyk *et al.* (2008) who mentioned that a small dose of fertilizer increased the abundance of mites, but higher doses decreased them comparing to the control plots. Also, they are in parallel with that of Moore (1994) who recommended that agricultural practices alert the abundance and dynamics of different organisms and nutrients in soils, and affect the structure and dynamics of whole food webs.

Types of fertilizations affected the mite abundance:

Family Scutacaridae is the main family found in all plots with higher numbers than other mite families followed by the Family Haplozidae. The obtained results lead to that plots treated with farmyard (Fym) had more mites (3791 individuals) than plots treated with standard manure (2363 individuals) followed by those treated with chicken manure (1895 individuals), while the lowest number of mites was found in plots treated with compost (1832 individuals). These results agree with those of Amitai (1992) who mentioned that predatory mites played an important role in suppressing pest population occupying different habitats and used in biological control programs. Members of Phytoseiidae, Laelapidae, Macrochelidae and Stigmaeid are very essential as biological control agents of plant and soil-inhabiting pest mites, e.g., tetranychids, tenuipalpids and eriophyids (Santos & Laing, 1985 and Kheradmand *et al.*, 2007).

Table (2) compares the biodiversity of collected mite species underneath tomato plants in different treatments (compost manure, chicken manure, farmyard and standard fertilization) using Shannon-Wiener "H" and Simpson "S" Indices of diversity. The vegetations of tomato varied in mites richness. The collected mite species in tomato plantations treated with farmyard was the highest (3791 individuals); while those treated with compost manure was the lowest (1832 individuals). According to Shannon-Wiener "H" Index, the compost manure (21 species, 18 families) and chicken manure (19 species, 19 families) recorded the highest value (1.51 and 1.51 respectively); while farmyard recorded the lowest value (0.88 of 21 species and 18 families). This indicate that compost manure and chicken manure had a higher diversity index; while farmyard had a lower one. 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, the plots treated with

Table ((2): Estimation of Shannon-Wiener and Simpson Indices of mite diversity in tomato plants under effects of different manure treatments.

Type of index	Compost manure	Chicken manure	Farmyard (Fym)	Standard fertilization
Shannon-Wiener	1.51	1.51	0.87	1.04
Simpson	0.36	0.45	2.87	1.02

Table 3: Effect of different organic manure treatments on number of mites and tomato yield.

Treatment	Characters	
	Mites No. (10 rep)	Yield (kg/m²) (3 rep)
Organic manures		
Compost (M1)	67.52	10.07b
Chicken (M2)	69.93	12.55a
Farmyard (M3)	140.04	9.78b
Standard (M4)	86.44	9.32c
LSD (5%)	**NS**	**0.31**
Potassium (K)		
K_0	64.03b	10.38
K_1	145.00A	10.47
K_2	63.92b	10.44
LSD (5%)	**58.46**	**NS**
Interaction		
M1×K0	40.44	10
M1×K1	99.78	10.11
M1×K2	62.33	10.11
M2×K0	29.56	12.45
M2×K1	115	12.71
M2×K2	65.22	12.49
M3×K0	107.22	9.74
M3×K1	212.22	9.74
M3×K2	100.67	9.85
M4×K0	78.89	9.31
M4×K1	153	9.33
M4×K2	27.44	9.32
LSD (5%)	**NS**	**NS**

farmyard maintained the highest number of dominant species of value of 2.87 and recorded (3791 individuals) of scutacarid mites.

Statistical analysis:

Statistical analysis proved that no significant differences were observed not only between means of different manure treatments, but also in interaction effects between organic manures and potassium treatments; while a high significant differences were observed between means of potassium treatments (Table 3). Application of organic manure alone indicated that chicken manure caused a significant increase of tomato yield (12.55 Ton/fed.) followed by compost (10.07 Ton/fed.) (Table 3). These results agree with the results of Olaniyi and Ajibola (2008) who pointed out the application of poultry manure and inorganic nitrogen fertilizer (60 kg/ha) significantly increased tomato yield. Potassium had no significant effect. The interaction effects 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.).

Finally, chicken manure effects on tomato yield have been supported by the results of mite biodiversity which indicated that chicken manure recorded the highest biodiversity of soil mites (19 species and 19 families).

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