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RESEARCH ARTICLE

Influence of Organic Soil Fertilization on the Population of two Insect Pests and the Productivity of Tomato Plants in a Plastic Greenhouse

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ABSTRACT

Organic fertilizers are key ingredient of organic farming systems for safer environment, healthier, safer food production and suppression of some insect pests. In this work, the effect of four organic soil fertilizers (vermicompost, compost, cattle manure and chicken manure) on the population of two major tomato pests (*Tuta* (*T.*) *absoluta* and *Bemisia* (*B.*) *tabaci*) and tomato productivity in Egypt was investigated. The experiments took place in a plastic greenhouse in the Nubaria region (30.76658, 30.29312). The greenhouse comprises of 10 rows with a length of 10 m and apart of 1 m. Two rows each was defined for one type of fertilizer (treatment) and divided into five repetitions (approx. 30 plants each). Insect populations were expressed as numbers of eggs and larvae of *T. absoluta* and eggs and nymphs of *B. tabaci*. Insect damage was expressed as the number of pores induced in tomato fruit. The results showed a significant effect (Two-Way ANOVA) of all organic fertilizers, particularly cattle and chicken manure, causing the largest increase in tomato production and the largest population decline and damage from the two pests. Cattle manure is recommended for use in Egypt due to its lower cost and greater availability.

INTRODUCTION

Organic fertilization is an important input of organic farming that can improve the quality and quantity of crops. The organic matter also improves the physical properties of the soil, such as aggregation, increasing soil aeration, lower bulk density, persistent surface crust, increased water retention and supply of plant nutrients (Yafan and Barker, 2004). The higher cost of inorganic fertilizers and the problems associated with the use of these chemicals are receiving increasing attention worldwide because pests, diseases and weeds become resistant to chemical pesticides and environmental pollution and ecological imbalances can occur (Mahmoud et al., 2016). However, fertilization can affect pest populations in different ways depending on the type of fertilizer used, the crop and the pest (Abd-Alhamid et al., 2015, Abdel-Hakim et al., 2015). Organic fertilizers are important for the plant as they slowly release mineral nutrients into the soil and give plants the ability to store larger amounts of water needed by the crop (Berg et al., 2017). However, excess nutrient intake can also result in increased reproduction, longevity and general fitness of certain pests (John et al., 2004). Organic fertilizers may have the potential to reduce pest infestations. NPK fertilizers increase pest populations, but organic fertilizers decrease aphid populations on tomato plants (Yardim and Edwards, 2003). A reduction in aphid populations with organic fertilizer application has been reported by Godase and Patel (2001), Surekha and Rao (2001) and Miguel and Clara (2003). Yadav et al. (2004) working on okra plants fertilized with poultry manure observed increased plant height with relatively less pest infestation.

This work aimed to determine the effect of four types of organic soil fertilizers commonly used by Egyptian farmers on the population of *T. absoluta* and *B. tabaci* on tomato plants, as well as the effects of these fertilizers on two tomato crop productivity parameters throughout growing season of summer crop in a plastic greenhouse.

MATERIALS AND METHODS

Experiments of this work were performed in a plastic greenhouse on reclaimed land in Egypt's western desert, Nubaria region (30.76658, 30.29312). The tomato variety Logeen (a common variety in Egypt) was sown at the nursery and received normal agricultural practices up to the date of transplanting. All fertilization methods were distributed in fully randomized blocks and used at the recommended rates prior to transplantation. Tomato seedlings were transplanted from the nursery into the plastic greenhouse measuring 10 x 30 m. The greenhouse has 10 rows, 10 m long and 1 m apart. Two rows each was defined for one type of fertilizer (treatment) and divided into five repetitions (approx. 30 plants each). Fertilizers were applied at rates of 50 kg/treatment or (4 tons/ha). The organic fertilizer types under studied were: vermicompost, compost, cattle manure and chicken manure. The control plots were left without fertilization. Weekly samples of 35 tomato leaves (a tomato leaf contains 7-9 leaves) were randomly collected from each treatment throughout the growing season, which lasted from January 26 to April 6, and brought to the laboratory in paper bags. The sampled leaflets were collected randomly along the plants. The samples were examined in the laboratory under a stereomicroscope and the number of laid eggs, hatched larvae, live and dead larvae or nymphs of *T. absoluta* or *B. tabaci* per 35 leaflets was recorded. During the harvest season, infestation rates of *T. absoulta* on tomato crops were evaluated in conjunction with different types of fertilization. During the period from January 26 to April 6, samples from 30 fruits were randomly collected weekly and affected and healthy fruits in the collected samples were recorded. The number of pores induced by the insect larvae in the fruit was also recorded. Two productivity parameters (weight and number of fruits per 8 plants) related to fertilization treatments were studied. From each fertilization treatment, fruits were taken at random from 8 plants for 3 weeks during the harvest period and their number and weight were recorded and statistically compared. Data were processed and analyzed statistically by two-way ANOVA.

RESULTS

Effect of organic fertilizer types on populations of *T. absoluta* infesting tomato leaves

The weekly population of eggs and larvae of *T. absoluta* infesting tomato leaves from late January to April under different types of organic fertilization is shown in Table 1. Fig. 1 summarizes the collective population of eggs + larvae throughout the growing season. From late January to March 1st, the insect population associated with all types of fertilization was - as expected - low (below 30 insects/35 leaflets), mainly due to the relatively colder temperature during this period. During the period from March 1st to the third week of March, the egg population of *T. absoluta* began to increase and the differences between fertilization treatments began to show. Chicken manure recorded the lowest egg population, ranging between 5217.7 eggs/35 leaves, followed by cattle manure (12-28 eggs/35 leaves) and compost (12.7-24.7 eggs/35 leaves). Control plots had 13.5-45.5 eggs/35 leaflets. However, vermicompost had 17.5-50.2 eggs/35 leaves.

The larval population was relatively lower due to the usual farming practices that were followed, including insecticide spraying. This is evident from the total insect population numbers (eggs + larvae) which showed the same trend as the egg population. The collective insect population (eggs + larvae) showed the same trend as the egg population. All fertilizer types had lower insect populations than the control plots, except vermicompost, which had the highest population. Chicken manure recorded the lowest population with 5,526 insects/35 leaflets, followed by cattle manure (13.5-31 insects/35 leaflets) and compost (14.5-41.5 insects/35 leaflets). Vermicompost had 23.5-54.5 insects/35 leaves.

A comparison between the collective mean numbers of *T. absoluta* populations (eggs + larvae) associated with the different fertilizer types throughout the growing season is shown in Fig. 2. All fertilizer types had significantly lower insect populations than the control plots, with the exception of vermicompost, which had a statistically comparable population to the control plots. Chicken manure recorded the lowest insect population with 19.81 insects/35 leaflets, followed by cattle manure (21.2 insects/35 leaflets) and compost (28.63 insects/35 leaflets). Control plots had 45 insects/35 leaflets.

Effect of organic fertilization types on infestation of tomato fruits by *T. absoluta*

Infestation rates of tomato crops with *T. absoluta* larvae throughout the harvest period from March 26 to April 6 under different types of organic fertilization are shown in Fig. 3. Infestation rates in fruit resulting from all organic fertilization treatments were significantly lower than those resulting from the (non-fertilized) control plants. Treatment with cattle manure had the lowest infestation rate with the insect pest (13.61%), followed by vermicompost (27.22%), compost (28.61%) and chicken manure (36.38%). These results support the recommendation to use organic fertilization, particularly cattle manure, as a component of organic farming to suppress *T. absoluta* infestation on tomato crops.

The number of pores in tomato fruits induced by *T. absoluta* larvae – as a measure of the infestation intensity – is shown in Fig. 4. Fruits derived from all

Table 1: Population of eggs and larvae (individuals /35leaflets) of *Tuta absoluta* on tomato plants in a plastic green house with different types of organic fertilization along the tomato growing season 2020.

Sampling date	Stage	Vermi Compost	Compost	Cattle Manure	Chicken manure	Control
26.1	Eggs	11.25±2.02	8.25±2.90	26±1.22	24.25±0.85	11.75±0.48
	Larvae	2.25±0.85	1±0.41	3.25±0.48	1.25±0.25	0.75±0.25
	Sum	13.75±1.25	9.25±2.49	29.25±1.31	25.75±0.62	12.25±0.62
2.2	Eggs	27.75±2.25	21±4.64	20.75±1.93	15.75±0.85	16±0.71
	Larvae	4±1.78	2±0.71	8.75±0.63	13±2.86	7.75±2.32
	Sum	31.75±2.09	23±5.33	29.25±1.31	28.75±2.62	23.75±2.25
9.2	Eggs	21.75±3.99	12±1.22	5.75±1.65	11±1.78	28.25±2.29
	Larvae	6±2.55	5.5±1.32	7±3.34	1.75±0.25	6.5±1.94
	Sum	27.75±5.72	17.5±1.50	12.75±1.88	12.75±1.93	34.75±3.90
16.2	Eggs	5.5±2.02	5.5±4.52	4.25±1.93	6.25±4.33	3.25±0.85
	Larvae	8.5±3.10	6±2.74	3.75±1.38	7.25±3.17	9.25±0.85
	Sum	14±4.02	11.5±4.03	8±0.70	13.5±7.45	12.5±1.19
23.2	Eggs	14.5±2.63	4.5±1.26	2.75±1.49	3.75±2.17	11±2.48
	Larvae	2.25±0.85	4.75±2.95	3.25±1.89	4±1.68	4±1.22
	Sum	16.75±2.86	9.25±3.42	6±1.35	7.75±2.52	15±3.48
2.3	Eggs	17.5±5.87	12.75±5.19	12±2.68	5.25±2.50	13.5±4.57
	Larvae	6±2.35	1.75±1.18	1±0.41	0.25±0.25	9.75±3.84
	Sum	23.5±4.64	14.5±4.29	13±2.79	5.5±2.72	23.25±5.21
9.3	Eggs	32.5±6.44	20.75±3.82	18±3.16	13±3.24	29.75±2.43
	Larvae	5.25±1.60	9±4.04	2.75±0.63	1.25±0.75	7.25±2.66
	Sum	37.75±6.26	29.75±4.76	20.75±3.75	14.25±3.98	37±3.89
16.3	Eggs	42.25±7.98	24.25±5.27	21.5±2.99	14.25±3.42	36.75±1.75
	Larvae	4.75±1.55	9±4.08	3.5±0.87	2.5±0.65	4.25±1.31
	Sum	47±8.41	33.25±6.43	25±3.76	16.75±4.00	41±2.67
23.3	Eggs	50.25±8.12	24.75±7.05	28±4.55	17.75±4.96	45.5±1.55
	Larvae	4.25±1.31	16.75±9.23	3±1.29	1.75±1.18	5±1.47
	Sum	54.5±8.29	41.5±13.02	31±5.80	19.5±6.07	50.5±2.98
30.3	Eggs	118.5±12.52	47.25±6.49	24±3.92	26±1.68	91.75±3.17
	Larvae	6±1.78	9.25±4.75	2.75±0.85	2.5±0.96	5.25±0.48
	Sum	124.5±13.91	56.5±8.93	26.75±4.73	28.5±1.32	97±3.41
6.4	Eggs	195.5±16.83	66.75±7.84	28±1.78	41.5±6.76	143.75±3.68
	Larvae	4±0.41	2.25±0.85	1.5±0.65	3.5±1.32	4.25±1.11
	Sum	199.5±16.60	69±8.52	29.5±2.17	45±6.16	148±3.08

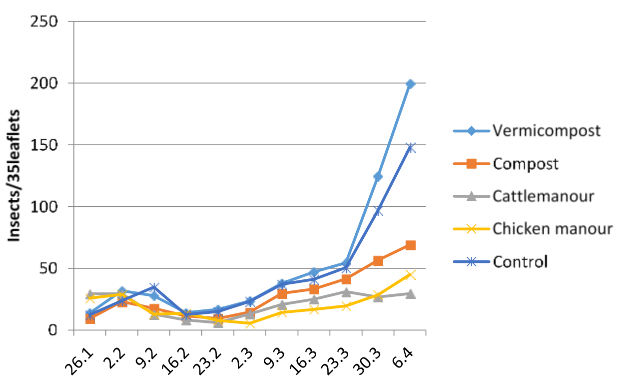

Fig. 1: Population (individuals /35leaflets) of *Tuta absoluta* on tomato plants in a plastic greenhouse under different types of organic fertilization.

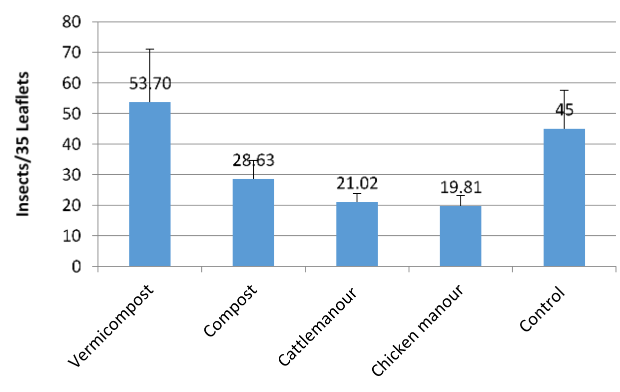

Fig. 2: Mean population of *Tuta absoluta* (insects/ 35 leaflets) on tomato plants in a plastic greenhouse under different types of organic fertilizers throughout the growing season of 2020 (LSD= 14.27).

types of organic fertilization had significantly fewer pores than control plots (no fertilization). The cattle manure gave the lowest void counts in tomato fruit (6.41 voids/30 fruit), followed by the compost, the chicken manure and the vermicompost (9.08, 12.58 and 13 voids/30 fruit). This finding confirms the recommendation to use cattle manure as a component of organic farming as a measure to suppress *T. absoluta* in tomato fields.

Table 2: Population eggs and nymphs (insects /35leaflets) of the white fly *Bemisia tabaci* on tomato plants in a plastic greenhouse under different types of organic fertilization.

Sampling date	Stage	Vermi compost	Compost	Cattle manure	Chicken manure	Control
26.1	Eggs	28.33 ±9.53	12.33±2.03	23.00±0.58	40.00±2.31	29.00±4.62
	Nymphs	3.25±1.97	1.5±0.96	15.5±4.35	12.5±5.20	4.75±1.80
	Sum	34.66±8.67	15.33±2.60	46±0.57	60±1.73	36±6.35
2.2	Eggs	39.00±4.04	15.00±0.58	35.33±2.60	38.33±1.45	28.33±2.03
	Nymph	9.5±2.60	8.75±1.80	8.5±1.55	15±1.47	10.75±2.39
	Sum	52.33±3.17	26±2.31	46.33±2.02	55.67±1.76	42.33±2.66
9.2	Eggs	78.33±2.03	27.33±6.64	23.00±2.31	45.00±7.51	17.00±1.15
	Nymph	25.25±11.00	8.5±3.52	10±3.24	26.75±7.74	20.75±4.27
	Sum	121. 67±6.35	39. 67±10.39	38±4.04	84. 33±4.33	44.33±2.0
16.2	Eggs	47.00±6.35	32.33±3.76	28.00±1.73	21.33±1.45	29.33±2.03
	Nymph	15.5±6.99	7±2.65	7.75±3.01	11.75±3.97	15.75±2.14
	Sum	73±1.73	43.33±5.48	40±4.04	39.67±0.66	48. 3±0.8
23.2	Eggs	27.33±0.88	12.00±1.15	14.33±1.45	11.33±1.45	21.33±2.03
	Nymph	6±3.49	5.25±2.02	7.5±2.90	8.75±2.98	20.5±4.66
	Sum	37.67±4.05	20±2.88	26.33±3.17	23.67±1.76	48.67±0.66
2.3	Eggs	29.00±1.73	16.33±0.88	15.33±1.45	19.00±4.04	29.00±1.73
	Nymph	16±3.11	9.5±3.12	11±2.61	7.25±1.11	21.25±3.09
	Sum	49±4.61	30.67±0.66	30.67±1.2	28±3.46	54.33±3.75
9.3	Eggs	25.00±2.31	10.33±1.45	17.33±3.18	13.00±1.73	33.00±3.46
	Nymph	9.75±2.59	9.25±1.65	7±1.29	7.5±2.40	16.25±3. 92
	Sum	39±1.15	21.67±2.33	26.33±3.75	24±0	56±4.04
16.3	Eggs	11.00±0.58	10.00±1.15	11.00±0.58	6.00±0.58	20.00±0.58
	Nymph	8.5±3.93	4.75±2.06	5±2.86	5±2.35	12.25±2.46
	Sum	26±0.57	17.33±0.33	20±1.73	14.33±0.88	36.33±0.33
23.3	Eggs	12.00±0.58	8.33±0.33	10.33±0.88	9.00±1.73	15.33±1.45
	Nymph	2.75±1.11	2.25±1.65	2.75±1. 89	1.5±1.19	3±1.78
	Sum	16.33±0.33	12.67±1.76	15.67±0.66	12±2.88	21.33±0.88

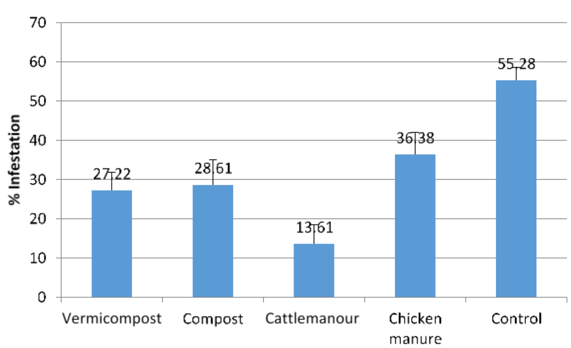

Fig. 3: Percentages of infestion by *Tuta absoluta* in tomato fruits associated with type of organic fertilization LSD=17.78

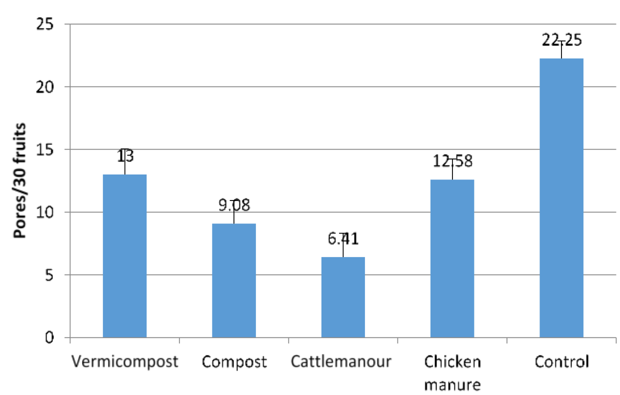

Fig 4: Numbers of pores induced by *Tuta absoluta* in tomato fruits associated with type of organic fertilization LSD=8.12.

Effect of organic fertilization types on population of *B. tabaci*

The egg and nymph populations of *B. tabaci* whitefly collected weekly during the growing season under different types of organic fertilizer are shown in Table 2, while the collective number of eggs + nymphs / 35 tomato leaves is shown in Fig. 5. From the beginning of the vegetation period, differences in *B. tabaci* infestation levels were observed due to different types of fertilization. Tomato plants in the control plots (no fertilization) had moderate populations of *B. tabaci* compared to organic fertilization treatments.

The insect population started at 36 insects/35 tomato leaflets on January 26 and remained below 56 insects/35 leaflets until March 9, then declined to a minimum of 21.3 insects/35 leaflets by the end of the growing season. Compost plots started at 15.33 insects/35 tomato leaves. It then varied between 48.33 insects/35 leaflets on February 9 and 12 insects/35 leaflets at the end of the growing season on March 23, while in cattle dung plots it started at a level of 46 insects/35 leaflets and then gradually decreased to around

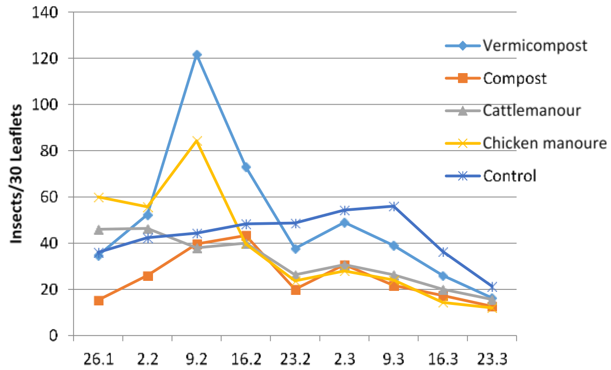

Fig 5: Population (individuals /35leaflets) of the white fly *Bemisia tabaci* on tomato plants in a plastic greenhouse under different types of organic fertilization.

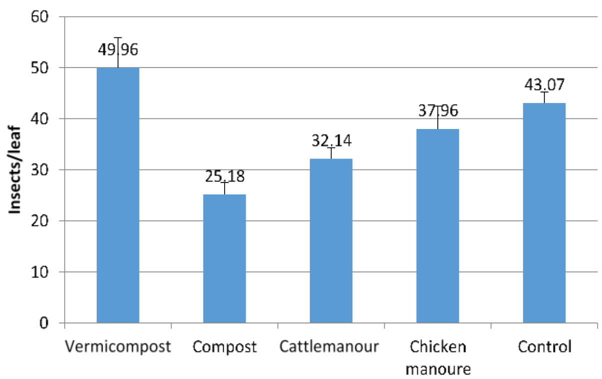

Fig 6: Mean population of *Bemesia tabaci* (insects/ 35leaflets) on tomato plants in a plastic greenhouse under different types of organic fertilizers throughout the growing season of 2020 (LSD = 7.88)

to reach their value minimum (12 insects/ 35 leaves) at the end of the growing season. In vermicompost plots, this population varied from 36 insects/35 leaflets at the beginning of the growing season to 120 insects/35 leaflets on February 9th and then declined sharply to 37.66 insects/35 leaflets on February 23rd and 12 insects/35 leaflets at the end of the growing season. In chicken manure plots, the *B. tabaci* population behaved similarly to the vermicompst fertilizer. It started at 60 insects/35 leaflets and increased to peak at 84.3 insects/35 leaflets on February 9th and then declined to its minimum at the end of the growing season.

A comparison between the overall means of whitefly individuals under different types of fertilization throughout the growing season is shown in Fig. 6 (35 leaflets) significantly (two-way ANOVA) less than the control plots (43.07 insects/35 leaflets). While the insect population in the vermicompost and chicken manure plots was statistically comparable to that in the control plots.

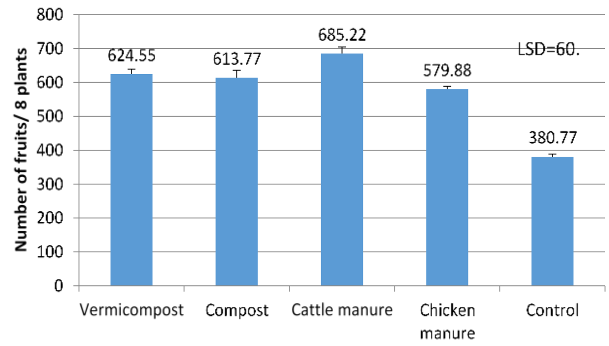

Fig. 7: Effect of organic fertilization on number of tomato fruits/ 8 plants (LSD= 60.51).

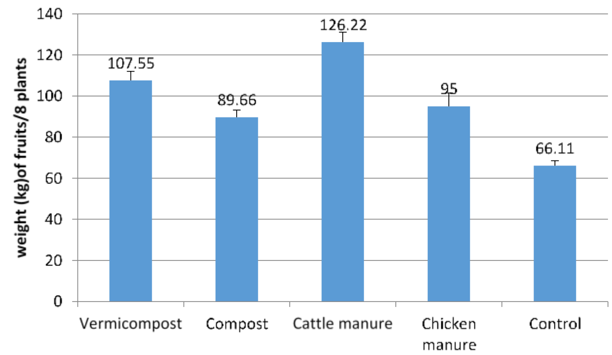

Fig 8: Effect t of organic fertilization on total weight of fruits produced by 8 tomato plants (LSD = 17.94).

Influence of organic fertilizers on tomato productivity

The effects of the studied types of organic soil fertilization on two parameters of tomato productivity (number and weight of fruits / 8 plants) are shown in Fig. 7. All types of organic fertilizers contributed significantly to the number of fruits produced compared to the control (no fertilization) plots. The cattle manure produced the highest number of fruits (685.22 fruits/8plants), followed by vermicompost, compost and chicken manure (624.55, 613.77 and 579.88 fruits/8plants, respectively). Also, all organic soil fertilizers produced significantly higher fruit weights than the control plots (Fig. 8). The cattle manure yielded the highest weight of tomato fruit/8 plants (126.22 kg). The vermicompost, which is in the second installment, yielded 107.55 kg, while the chicken manure and compost yielded 95 and 89.66 kg/8 plants, respectively.

DISCUSSION

Organic fertilization is a key ingredient of organic farming for healthier and safer food production as well as suppression of some insect pests. This work investigates the effects of four commonly used organic soil fertilizers in Egypt on the productivity and populations of two insect pests, *T. absoluta* and *B. tabaci*, on tomato plants in a plastic greenhouse. Organic soil fertilizers can increase plant resistance to pests and diseases than plants grown with synthetic inorganic fertilizers (Arancon et al., 2004). Our results showed significant effects on both crop productivity and populations of the two pests from all fertilizer types used. Cattle manure, the cheapest fertilizer, has had the most desirable effect on both productivity and population suppression of the two insect pests. Weekly population records of *T. absoluta* eggs and larvae showed that the population was below 25 insects/35 leaflets in January and February due to cold weather. In March, when the plants were susceptible to insect damage, the numbers were 25-50 insects/35 leaflets, during the harvest season in April, when the insect population is economically neglected, over 50 (EPPO, 2005). Pooled average population records throughout the season showed that all species were more organic Fertilization significantly suppressed the *T. absoulta* population on tomato leaves, with the exception of the vermicompost, which gave statistically similar results to the control plots. Our results also showed that cattle manure resulted in the lowest injury rate expressed as the number of pores in tomato fruit, followed by compost, chicken manure, and vermicompost. The *B. tabaci* population was also affected by the type of organic fertilizer used. The cattle manure and compost significantly reduced the insect population on tomato plants, while the vermicompost and chicken manure made no statistical difference in the insect population. Ahmad et al. (2002) mentioned that an insecticide resistance management strategy for *B. tabaci* is recommended that particularly emphasizes the rotation of still-effective insecticides from different chemical classes along with the use of novel chemicals and other tactics of integrated pest management in Pakistan. Our results were generally consistent with the conclusions of Yardim and Edwards (2003) and John et al. (2004) who reported that the organic fertilizers decreased the insect populations of tomato crop pests, while the NPK chemical fertilizers may increase the populations of some tomato pests. Chatterjee et al. (2013) reported that cattle manure and vermicompost reduced *B. tabaci* on tomato plants due to the humic acid present in these fertilizers, which provides plants with a balanced source of nutrients with some growth-promoting vitamins and enzymes not available in synthetic fertilizers, and these substances can increase plant resistance to pests or make the plant less favorable to the pest (Brown, 2010; Andrade et al., 2017). Firdaus et al. (2013) studied resistance of *Solanum galapagense* towards *B. tabaci* and concluded that whitefly resistance in *S. galapagense* seems to inherit relatively simple compared to whitefly resistance from other sources and this offers great prospects for resistance breeding as well as elucidating the underlying molecular mechanism(s) of the resistance. Wang et al. (2010) studied the relationship between biotype of *B. tabaci* and its resistance to imidaclopride and thiamethoxam insecticides and concluded that Abamectin is the most effective insecticide against adult *B. tabaci* from all populations. Also, Gouveia et al. (2018) stated that resistance of tomato plants to white fly *Bemisia argentifolii* is associated with the gynotype of the plant. Al Khaboori and Sabr (2015) mentioned that cattle manure decreased the number of tunnels caused by *T. absoluta* on tomato plants grown in a plastic greenhouse in Iraq. Fertilization of crops with synthetic N can make crops more susceptible to some pests by increasing free amino acid levels (Mattson, 1980; Koritas and Garsed, 1985). Islam et al. (2017) working on the effect of different N concentrations on tomato plants concluded that the high concentrations of synthetic N attracted more *B. tabaci* to the plants. Blazheviski et al. (2018) also mentioned that the high concentrations of N and K increase the population of *T. absoluta* on tomato plants. Guedes et al. (2019) and Neiva et al. (2019) described the resistance of the South American tomato pinworm, *T. absoluta* to many chemical classes of insecticides both in South America and in Europe. Also, Jafarbeigi et al. (2020) studied the tomato resistance against *B. tabaci* triggered by salicylic acid, β-Aminobutyric acid, and Trichoderma. The insect suppression caused by organic fertilizer can be explained because such organic fertilizers promote an increase in soil organic matter and microbial activity and a gradual release of plant food, which allows plants to receive more balanced nutrition. However, chemical fertilizers would create nutrient imbalances in plants (Patriquin et al., 1995). Our results showed that all organic fertilizers studied significantly increased both the number and weight of tomato fruit produced, particularly cattle and chicken manure. Yule et al. (2019) detected the losses of tomato and pepper productivity due to Tomato yellow leaf curl Thailand virus transmitted by *B. tabaci* in tomato and pepper. Organic fertilizer as described by John et al. (2004) contains essential nutrients associated with high photosynthetic activities that promote root and vegetative growth, resulting in increased fruit yield. Growth and yield of tomato plants responded well to poultry manure (Mehdizadah et al., 2013; Ali et al., 2014; Usman, 2015). Zeidan (2007) worked on the lentil plants and found that organic fertilizers improved soil structure and water holding capacity through the availability of micronutrients, leading to more root development and more activity of beneficial soil organisms, ultimately increasing both quantity and quality of yield. Farmyard manure significantly increased both the fresh and dry weight of tomato shoots and roots (Gad et al., 2007) and stimulated the activity of bacteria that promote released availability of N, P and other nutrients in the soil and improve nutrient uptake by tomato roots (Bertand and Cleyetmarel, 2008). As the cheapest and most available organic fertilizer, cattle manure is recommended for both increased production and reduced infestation of *T. absoluta* and *B. tabaci* on the crop.

Authors' Contribution

YA conceived the idea, designed the experiments and wrote the data, MM made statistical analysis and participate in the tabulated the data, IMA collected the specimens from the field and examined it in the laboratory, SS and AS collected the scientific materials, wrote and typing the manuscript

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