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Response of Growth, Yield and Fruit Quality of Tomato (*Solanum lycopersicum* L.) to Different Organic Fertilizer Treatments under Two Pest Control Programs Against *Tuta absoluta* in New Valley-Egypt

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TWO field experiments were conducted at the Farm of Faculty of Agriculture, New Valley University during 2016/2017 and 2017/2018 seasons to study the impact of some organic fertilizers (poultry, cattle , sheep manures) and mineral fertilizers under, traditional pest control (TPC) and integrated pest management (IPM) on growth, yield and fruit quality of tomato cv. Rawan F1. The results indicated that mineral fertilization significantly surpassed organic manures in all vegetative growth characters and yield and its components. Whilst organic manure treatments significantly increased fruit contents of N, P, K, Ca, Mg, vitamin C, licobin, total soluble solids and total sugars compared to chemical fertilization in both seasons. TPC followed by IPM treatment exhibited best results for all studied characters compared to control, except number of fruits/plant, unmarketable yield and fruit content of carotenoid, total phenol, total flavonoid, water content and acidity. The differences between TPC and IPM programs were insignificant for yield and its components. Furthermore, the interaction between chemical fertilization and traditional program gave highest growth and yield parameters, while the interaction between poultry manure and traditional program gave fruits had higher chemical content compared to other interactions. Based on results, it could be recommended that fertilized tomato plants with mineral treatment (NPK) under IPM gave the best yield and the highest reduction percentage of infested leaflets with T. absoluta larvae and adult moths/trap/day, although TPC gave a slight insignificant increment in tomato yield, while soil application of composted poultry manure before tomato planting by 10.76 ton/fed. under TPC improved the quality of tomato fruits.

Keywords: Tomato, Fertilizers, Fruits, TPC, IPM, Yield, *Tuta absoluta*.

Introduction

Tomato (*Solanum lycopersicum* L.) is one of the most popular and widely grown vegetable crops in the world. Its fruits are cheap and rich sources of vitamins (vitamin C, A, B and K), minerals (potassium, calcium, sodium, magnesium, phosphorus, boron, manganese, zinc, copper, iron, etc.), and organic acids (citric, malic and acetic acids) which are known as health acids (Meena et al., 2014). Tomatoes are important source of lycopene; the most important antioxidant that has been linked with reduced risk of prostrate and various other forms of cancer as well as heart diseases (Barber and Barber, 2002). The fruits are consumed fresh as salad or utilized in processed products such as powder, soup, Ketchup and canned fruits. Tomato is grown all over the world. China, USA, Turkey, Italy, Egypt, India, Spain, Brazil, Iran and Mexico are the major producers (Mehmood et al., 2012). Tomato requires proper

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and sufficient nutrients for good fruiting and subsequent quality and being a heavy feeder of nitrogen, phosphorus and potassium, responds well to the application of manures and fertilizers (Gideon, 2012 and Singh et al., 2014).

Among the factors affecting tomato productivity is soil fertility; which is defined as the capacity of soil to provide physical, chemical and biological needs for the growth, productivity, reproduction and quality, related to plant and soil type, land use and climatic conditions (Abbott and Murphy, 2007). Decrease in soil fertility after few years of cropping is a major limitation in sustaining crop productivity and ensuring food security (Ewulo et al., 2016). To increase the soil fertility and yield, inorganic/chemical fertilizers are often used. Although chemical fertilizers have been considered as the most important contributor of increasing agricultural productivity in the world, the negative effects of chemical fertilizer on the soil and environment limits its usage in sustainable agricultural system (Adekiya and Agbede, 2017). Chemical fertilizers accumulate heavy metals in plant tissues which compromises fruit nutrition value and edible quality (Shimbo et al., 2001) and increase the concentration of nitrate in ground water, rivers, and lakes (Ajdary et al., 2007). Moreover, vegetables and fruits grown on chemically over fertilized soils are more prone to attacks by insects and diseases (Karungi et al., 2006) as well as about 50 percent of applied inorganic fertilizers are lost either through leaching or through volatization (Gosavi et al., 2010). The high cost of chemical fertilizers and their adverse effect on soil biological process and human health makes one to think for alternative sources of manures (Arahunashi, 2011).

In recent times, attention has been attracted towards organic manures as a valuable practice for sustainable agriculture to meet the nutrient requirements of crops (Gwari et al., 2014). This could be because of the rising cost of inorganic fertilizers coupled with their inability to give the soil a sound health (Oyedeji et al., 2014) and increasing consumer awareness of the relationship between foods and health (Riahi and Hdider, 2013).

Organic fertilizers are environmentally friendly and eco-friendly agricultural practices for sustainable food production (Islam et al., 2017). Using organic fertilizers such as animal manures, composts and by-product materials not only supplies plant nutrients, but increases tolerance and resistance to insects and diseases, helps in controlling weeds, retains soil moisture, and ensures produce quality (Barker and Bryson, 2006). Addition of organic manures improves soil structure and water holding capacity through availability of micronutrients, resulting in more extensive root development and enhanced activities of useful soil organism (Zeidan, 2007), which ultimately increases yield and improves food quality and safety of agricultural crops. Organic manures contain macro-nutrients, essential micro-nutrients, vitamins, growth-promoting indole acetic acid (IAA), gibberellic acid (GA) and beneficial microorganisms (Sreenivasa et al., 2009). Moreover, it was reported that organic farming increased microbial activities by 30-100 % and microbial biomass by 20-30 % (Elawad, 2004). Additionally, organic fertilizer application also benefits crop uptake, reduces NO_3^--N in the soil, alleviates soil NO_3^--N leaching, improves storability particularly tomato reduces nitrates and improves nitrate to vitamin C ratio of vegetables (Vogtmann et al., 1993). Organic manure plays direct role in plant growth as a source of all necessary macro and micronutrients in available forms during mineralization and improves physical and chemical properties of soils (Chaterjee et al., 2005). Addition of organic manures in particular to sandy soil, which was low in organic matter and had unfavorable physical, and biological properties and more N leaching, improved these unfavorable characters and increased crops productivity (Awosika et al., 2014).

Tomato crop is host for several pests. One of the most devastating pests and a serious threat is Tuta absoluta (Meyrick) which attacks leaves, flowers, stems and especially fruits at any developmental stage, from seedlings to mature plants (Desneux et al., 2011 and Urbaneja et al., 2012). It is originated from South America, rapidly invaded various European countries and spread very fast along the Mediterranean Basin including Egypt (Desneux et al., 2010). Although T. absoluta prefers tomato, it can also feed, develop and reproduce on other cultivated solanaceae such as eggplant, potato and sweet pepper (Adil et al., 2015). The severe infestation of this insect causes severe loss to the extent of 80-100% in tomato, both in protected and open field cultivation (Desneux et al., 2010). Chemical control has been the main method of control used against T. absoluta, but it increases the cost of production and reduces natural enemies of the pest (Desneux et al., 2010 and Gaffar et al., 2016). Additionally, chemical insecticides cause adverse environmental effects including water pollution, eradication of beneficial wildlife and human health problems (Abd El-Ghany et al., 2016). Reduction and elimination of the adverse effects of chemical pesticides is a vital goal of this study to maintain human health and the environment. So, it is very important to find new strategy of control which are effective in controlling this pest and less toxic to mammals and beneficial fauna in the environment to obtain a more sustainable tomato production as well as apply different strategies in an IPM program to manage T. absoluta outbreaks including culture control (crop protection, selective removal and destruction of infected plant material), physical control, biological control and used the correct pesticides (chemicals and biological control measures and the association of both (Chhetri, 2018, Larraín et al., 2014 and Gaffar et al., 2016).

Therefore, this experiment aims to study the effects of some types of organic manure in comparison to the recommended NPK fertilizer under two pest control programs on tomato growth, yield, and fruit quality, cv. Rawan F1 as well as T. absoluta management in a New Valley-Egypt.

Materials And Methods

Description of the study site

Two field experiments were carried out at Agricultural Research Farm of the Faculty of Agriculture, New Valley University that is located 10 km off the New Valley government road to Assiut (25“26‘31° N, 30“33‘36° E, altitude 283 m),characterized by favorable climatic condition to Tuta attacks.

The physical and chemical properties of the soil experiments

Samples were collected randomly from the experimental soil at 0.0 to 50.0 cm depth before planting to determine some of its physical and chemical properties in accordance to the methods of Black (1965) and Page et al. (1982), respectively. Data of soil analysis is presented in Table 1.

Experimental design and tested treatments

The experiments were conducted to investigate the effects of some different organic fertilizers under two pest control programs and their interactions on plant growth, yield and its components, fruit quality as well as some chemical constituents of tomato plants. The experimental design was split-plot system in a complete randomized block design with 3 replicates. The experiment included 12 treatments, which were 4 organic fertilizers (Recommended NPK as control, poultry, cattle and sheep manures) and 3 pest control programs (control, traditional and IPM programs). The different organic fertilizers were randomly occupied the main plots, which subsequently subdivided into sub-plots for pest control programs. The experimental unit area was 17.5 m2 and contained 5 ridges, each 3.5 m in length and 1 m in width. Seedlings of tomato (*Solanum lycopersicum* L.) cv. Rawan F1 were transplanted 30 days after sowing (10-12 October) during the two successive winter seasons of 2016/2017 and 2017/2018.

Time and method of treatments

Fertilizer treatments

Organic fertilizers were obtained from the Poultry and Livestock Research Station, Faculty of Agriculture, New Valley University, Egypt. They were analyzed for determination of their nutrient contents as shown in Table 2. The applied quantities/ dosage of poultry, cattle and sheep manures were 10.76, 17.85 and 20.05 ton/fed., respectively, calculated according to their nutrients content. These quantities were added to the soil during the soil preparation at 10 days before sowing.

Mineral fertilizer (control treatment) was added to the soil according to the instruction laid down by the Ministry of Agriculture, Egypt.

Pest control programs

The programs were applied when plants reached the age of 45 days after transplantation.

Traditional pest control program

Traditional program didn’t include any regular inspection/special feature, rather commonly used insecticides were sprayed as practiced traditionally. Chlorantraniliprole (Coragen® 20% SC, DuPont) and Indoxacarb (Avant® 15% EC, DuPont) insecticides were sprayed alternately to control larva of the target insects at the recommended rate (60 ml/200L/fed and 25 ml/200L/fed respectively) using a backpack sprayer (20 liters) with 7 days intervals between each spray. Chlorpyriphos (Dursban® ٪٤٨ EC, Dow Agro Science) and Lambada-Cyhalothrin (Axon® 5% EC, Cam for Agrochemicals) insecticides were sprayed alternately to control adult moth at the recommended rate (500 ml/200L/fed and 100 ml/200L/fed. respectively) using a knapsack sprayer (20 liters) with 10 days intervals between each spray.

TABLE 1. Some physical and chemical properties of the experimental soil

Soil properties	Value
Particle size distribution (%)	
Coarse sand	5.39
Fine sand	76.74
Silt	10.75
Clay	7.12
Texture class	Sandy
Chemical properties	
EC dsm^{-1} (1:5 ex.)	1.23
pH (1:2.5 w/v)	8.03
Organic matter (%)	0.47
$CaCO_3$ (%)	5.81
SP %	38.6
Water soluble ions meq/100g soil	
Ca^{+2}	1.29
Mg^{+2}	0.87
Na^{+}	3.79
K^{+}	0.35
CO_3^{-2}	0.00
HCO_3^{-}	1.41
Cl^{-}	3.49
SO_4^{-2}	1.40
Available nutrients (mg kg^{-1})	
N	44.5
P	5.09
K	125.6

*The values are the average of the two growing seasons.

TABLE 2. Chemical analysis of poultry, cattle and sheep manures as average of two seasons*

Sample	E.C 1:10	pH 1:5	O.M %	O.C %	T.N %	C/N	T.P %	T.K %	SP %
Poultry manure	3.78	6.18	33.22	19.3	1.36	14.2	0.55	0.61	183.7
Cattle manure	4.21	6.85	27.92	16.3	0.82	19.8	0.43	0.38	166.4
Sheep manure	4.09	6.41	20.47	11.9	0.73	16.3	0.37	0.46	152.5

*This analysis was carried out by the lab of Soil, Water and Environmental Research Institute, Agricultural Research Center, Mansoura, Egypt.

Integrated Pest Management (IPM)

Different IPM approaches were utilized depending upon the results of weekly visual inspection and the degree of infestation. Cultural control measures were applied weekly, by hand weeding and removal of wild solanaceous host plants were grown near to growing tomatoes. Mechanical control measures were applied in terms of installation of water trap in each plot at the above ground level. Water with soap was renewed in every 4 days. Collection and removal of infested tomato leaves in the sealed plastic bags were also carried out at twice per weekly. Chemical control measures were approached in terms of application of Achook® 0.15% EC (Azadirachtin) at the recommended rate (750 ml/200L/fed.) once in a week. Coragen® 20% SC, and Avant® 15% EC insecticides were applied alternately only on infested plants after results of inspection were obtained. Each insecticide was only applied when the number of mines by T. absoluta larvae reached 2-3 mines/leaflets (According to Agriculture Pesticides Committee Protocols, Egypt). Only edge lines for each experimental replicate were treated by Chlorpyriphos (Dursban® 48% EC) and Lambada-Cyhalothrin (Axon® 5% EC) insecticides alternately to control adult moth of the target insects. Control replicates were left without application of any program or chemical spray but rather only water sprays were followed.

Data recorded

Vegetative growth characters

Representative samples, five plants were randomly taken from each experimental unit at 65 days after transplanting to estimate plant height (cm), number of branches/plant, number of leaves/plant, fresh and dry weight/plant (g), and leaf area/plant (m^2) which was calculated according to the formula described by Koller (1972).

Chemical constitutes of leaves

At 65 days after transplanting, samples of plant leaves were taken, oven dried at 70 Co till constant weight. Dried samples of leaves were crushed separately and samples of 0.5 gm each were acid digested with a mixture of sulfuric acid and hydrogen peroxide and then brought to a final volume of 100 ml with distilled water, to determine N, P and K contents according to the methods described by Bremner & Mulvaney (1982), Olsen & Sommers (1982) and Jackson (1970), respectively and Ca and Mg contents were determined according to Jackson (1967). Chlorophyll a (mg/g F.W), b (mg/g F.W) and total chlorophyll (mg/g F.W) and carotene (mg/g F.W) were determined according to Lichenthaler and Wellburn (1983).

Yield and its components

At harvesting time (April in both seasons), all fruits in each plot were harvested and weighted and then converted to record average fruit fresh weight (g), fruit length (cm), fruit width (cm), fruit dry matter %, number of fruit per plant, average yield per plant (kg), marketable yield (ton/fed.), unmarketable yield (ton/fed.) and total yield (ton/fed.).

Chemical constituents of fruits

At breaker stage, ten ripe tomato fruits per experimental unit were picked and used for determination of carotenoid (mg/100g F.W), total sugars %, total phenol (mg/100g F.W), total flavonoid (mg/100g F.W) and licobin (mg/100g F.W) according to Lichenthaler and Wellburn (1983), Sadasivam and Manickam (1996), Malick and Singh (1980), Zhishen et al. (1999) and Ranganna (1977), respectively. Total soluble solids (TSS) % was measured by a digital refractometer (Atago N1, Japan), acidity % and vitamin C (mg/100g F.W) were determined according to A.O.A.C. (1975) and water content (WC) % in fruits was calculated as (FW – DW)/FW, where FW is fresh weight and DW is dry weight. N, P and K contents were determined according to Bremner & Mulvaney (1982), Olsen & Sommers (1982) and Jackson (1970), respectively and Ca and Mg contents were determined according to Jackson (1967).

Monitoring of T. absoluta

The intensity of larvae infestation was evaluated by examination of tomato plants. Samples of 30 leaves taken from 5 randomly selected plants (6 leaflets/plant). Two leaves each from top, middle and bottom of the plants per replication were collected. All active infestation leaflets were counted under a binocular microscope and umber of infested leaflets were separately recorded for each experimental treatment.

Tuta absoluta moth was monitored using water traps and placed at 30 cm above the ground level in the experiment sites. Traps consisted in plastic containers (10 cm deep and 21×27 cm size) containing approximately 3 L of soapy water to avoid adults to escape. The number of captured moths' individuals was recorded every 5 days and the means of captured adult/trap/day (ATD) were calculated.

The percentages of infestation reduction were calculated using the equation of Henderson and Tilton (1955) as follows:

$$\text{Reduction } \% = [\ 1 - (T_2/T_1 \times C_1/C_2)] \times 100$$

Where C1 & C2 are the means of infested leaflets numbers in pre-treatment and post-treatment, respectively in the control area. T1 & T2 are the means of infested leaflets numbers in pre-treatment and post-treatment respectively, in treatment areas.

Statistical analysis

All obtained data were subjected to statistical analysis of variance according to Snedecor and Cochran (1980) and means separation was carried out according to the least significant difference (LSD) and Duncan (1958) at 5 % levels of probability. The reduction percentages of larvae and catch moths, Tuta absoluta were subjected to transformation as described by Wadley (1967) where each value (x) was transformed to and then these transformed values were statistically analyzed because there were values of 0.00%.

Results and Discussion

Vegetative growth

Fertilizer treatments (organic and chemical fertilizers)

The response of tomato vegetative growth to different types of fertilizers was obtained in Table 3. Inorganic (NPK) treatment recorded the highest values of plant height (77.87 and 80.95 cm), number of branches/plant (10.60 and 10.93), number of leaves/plant (61.66 and 63.53), leaf area/plant (0.51and 0.55 m^2), fresh weight/plant (430.57 and 441.78 g) and dry weight/plant (98.15 and 101.32 g) compared to organic fertilizers in both seasons of the study. The differences between inorganic and organic fertilizers were significant in most of the recoded characters. As for organic fertilizers, poultry manure was the best treatment for tomato vegetative growth in comparison to other organic fertilizers (cattle and sheep manures).

Similar results were obtained by Mehdizadeh et al. (2013), Ali et al. (2014) and Usman (2015) on tomato, they reported that tomato plants responded well to poultry manure compared to other sources of organic manures. Moreover, Adekiya and Agbede (2009) revealed that poultry manure is a suitable nutrients source for tomato. In general, all studied treatments can be arranged in decreasing order as follows: NPK > poultry manure > cattle manure > sheep manure. The present findings are in good accordance with the results of Singh (2014) that the recommended NPK registered the highest vegetative growth of tomato plants followed by organic manures. Plants treated with inorganic (NPK) treatment showed better results than any other organic fertilizers and that could be attributed to the quick and readily availability of major nutrients like N, P and K to plants at earlier stages of plant growth while NPK of organic manure require more time for their utilization by plants because of slow releasing of NPK (Jagadeesha, 2008 and Meenakumari & Shekhar, 2012).

Addition of organic manure improves soil physical properties, including enhanced aggregation, increased soil aeration, lower bulk density, less surface crusting, increased water retention, enhances microbial biomass and activity and N supplies for plants (Hu and Barker, 2004 and Tu et al., 2006). The superiority of poultry manure on other organic manures (cattle and sheep manures) may be referring to that poultry manure was readily available and in the best form for easy absorption by the plant roots (Tiamiyu et al., 2012) and contains more amounts of organic matters, organic carbon and N, P, K (Table 2) which improve tomato growth. Moreover, poultry manure can readily supplies P to plants than other organic manure sources (Garg and Bahl, 2008).

Pest control programs

The results regarding the impact of traditional and IPM programs on tomato growth are presented in Table 3. Compared with the control, traditional and IPM programs significantly increased all studied vegetative characters (plant height, number of branches/plant, number of leaves/plant, leaf area/plant, fresh weight/plant and dry weight/plant) of tomato in both seasons of the study. The plants treated with traditional program gave the highest values of previous characters followed by IPM.

Interaction between fertilization treatments and pest control programs

The data in Table 3 show that the differences among different interactions were significant in all studied characters. It is also cleared that tomato plants fertilized with mineral application under traditional program recorded the highest values of vegetative growth characters, whereas untreated plants (control) fertilized with sheep manure came in the last rank in both seasons, respectively. Previous results indicated that traditional program was found effective in vegetative growth characters in both seasons and recorded the highest values of plant height (85.18 and 87.06 cm), number of branches/plant (11.80 and 12.00), number of leaves/plant (70.60 and 72.20), leaf area/plant (0.61 and 0.65 m^2), fresh weight/plant (470.99 and 482.07 g) and dry weight/plant (106.32 and 109.69 g) comparison by IPM, respectively. IPM program was least effective with infestation reductions of 8.2 %.

TABLE 3. Vegetative growth characters of tomato plants as affected by different organic fertilizer treatments under two pest control programs for Tuta absoluta and their interactions during 2016/2017 and 2017/2018 growing seasons

Treatments	2016/2017 season				2017/2018 season			
	Con.	TPC	IPM	Mean	Con.	TPC	IPM	Mean
				Plant height (cm)				
Mineral	66.72 ef	85.18 a	81.72 b	77.87 a	70.14 e	87.06 a	85.66 ab	80.95 a
Poultry	65.62 f	80.56 b	79.44 bc	75.20 b	69.38 e	83.24 b	80.12 c	77.58 b
Cattle	64.72 fg	77.04 c	73.64 d	71.80 c	65.16 f	79.94 c	77.76 cd	74.28 c
Sheep	62.74 g	72.88 d	68.38 e	68.00 d	63.48 f	74.84 d	71.58 e	69.96 d
Mean	64.95 c	78.91 a	75.79 b		67.04 c	81.27 a	78.78 b	
				Number of branches/plant				
Mineral	8.40 f	11.80 a	11.60 ab	10.60 a	9.00 fg	12.00 a	11.80 ab	10.93 a
Poultry	8.20 fg	11.20 ab	10.80 bc	10.06 a	8.80 gh	11.60 ab	11.20 bc	10.53 a
Cattle	7.40 gh	10.00 cd	9.60 de	9.00 b	8.20 hi	10.60 cd	10.20 de	9.66 b
Sheep	7.20 h	9.00 ef	8.80 ef	8.33 c	7.60 i	9.60 ef	9.40 fg	8.86 c
Mean	7.80 b	10.50 a	10.20 a		8.40 b	10.95 a	10.65 a	
				Number of leaves/plant				
Mineral	47.80 g	70.60 a	66.60 ab	61.66 a	48.80 h	72.20 a	69.60 ab	63.53 a
Poultry	45.80 gh	64.80 bc	61.60 cd	57.40 b	48.40 hi	67.60 bc	65.60 cd	60.53 b
Cattle	42.80 hi	59.80 d	58.40 de	53.66 c	45.20 hi	62.40 de	59.60 ef	55.73 c
Sheep	40.00 i	55.40 ef	53.00 f	49.46 d	44.80 i	55.80 fg	54.60 g	51.73 d
Mean	44.10 c	62.65 a	59.90 b		46.80 c	64.50 a	62.35 b	
				Leaf area/plant (m^2)				
Mineral	0.34 gh	0.61 a	0.57 b	0.51 a	0.37 g	0.65 a	0.61 ab	0.55 a
Poultry	0.33 hi	0.55 b	0.50 c	0.46 b	0.35 gh	0.58 bc	0.54 cd	0.49 b
Cattle	0.30 i	0.45 d	0.42 e	0.39 c	0.32 h	0.51 de	0.47 ef	0.43 c
Sheep	0.25 j	0.38 ef	0.37 fg	0.33 d	0.26 i	0.45 f	0.39 g	0.36 d
Mean	0.30 c	0.50 a	0.46 b		0.32 c	0.55 a	0.50 b	
				Fresh weight/plant (g)				
Mineral	363.11 g	470.99 a	457.62 b	430.57 a	371.30 g	482.07 a	471.98 b	441.78 a
Poultry	359.01 g	445.41 c	436.08 d	413.50 b	364.59 g	456.65 c	442.66 d	421.30 b
Cattle	347.69 h	407.33 e	401.04 e	385.35 c	354.14 h	418.39 e	411.25 e	394.59 c
Sheep	330.99 i	385.14 f	380.98 f	365.70 d	340.02 i	396.08 f	389.38 f	375.16 d
Mean	350.20 c	427.22 a	418.93 b		357.51 c	438.30 a	428.82 b	
				Dry weight/plant (g)				
Mineral	85.58 gh	106.32 a	102.54 b	98.15 a	87.45 g	109.69 a	106.81 a	101.32 a
Poultry	83.47 h	98.95 c	97.58 c	93.33 b	84.75 g	102.78 b	99.52 c	95.68 b
Cattle	79.51 i	94.07 d	92.10 de	88.56 c	81.64 h	96.20 d	94.09 de	90.64 c
Sheep	75.29 j	89.41 ef	87.80 fg	84.17 d	78.77 h	92.31 ef	90.61 f	87.23 d
Mean	80.96 c	97.19 a	95.00 b		83.15 c	100.24 a	97.76 b	

Values followed by the same letters within a column are not significantly differed at 5% according to Duncan's multiple range test.
Con. Control & TPC. Traditional pest control program & IPM. Integrated pest management program.

Chemical composition of leaves

Fertilizer treatments (organic and chemical fertilizers)

The results regarding the effect of fertilization treatments on leaves chemical content (chlorophyll a, b and total chlorophyll, carotene, N, P, K, Ca and Mg) are presented in Tables 4 and 5. As seen from the previous tables, all types of organic fertilizers surpassed mineral treatment in all studied parameters. The differences between organic and mineral fertilization were significant in 2016/2017 and 2017/2018 seasons. Among organic manure sources, poultry manure showed significant higher chemical content of leaves in the two seasons of the study compared to cattle and sheep manures, respectively. These results are in agreements with Adekiya and Agbede (2009) on tomato, they found that poultry manure significantly increased leaves content of N, Ca and Mg compared with NPK fertilizer. Moreover, Heeb et al. (2006) indicated that both N levels and N contents in the leaves of organic-treated plants were higher than inorganic treatment. The positive effect of organic fertilizers added to soil may be attributed to stimulating the activities of microorganisms which promotes release and availability of N (Tu et al., 2006) and other nutrients in the soil and consequently enhances nutrients absorption by tomato roots.

Pest control programs

In regards to the effect of traditional and IPM programs on leaves chemical content, it was found that both traditional and IPM programs significantly increased leaves content of chlorophyll a, b and total chlorophyll, carotene, N, P, K, Ca and Mg compared with untreated plants in both seasons of the study (Tables 4 and 5). Higher levels of these contents were seen in leaves of the plants under traditional program over IPM treatment.

Interaction between fertilizer treatments and pest control programs

Concerning the effect of interaction between fertilization and pest control programs on chemical contents in leaves, data in Tables 4 and 5 reveal that all interactions differed significantly in the examined characters in the two seasons of the experiment. Unlike the same trend in vegetative growth, tomato plants fertilized with organic application registered the highest chemical content of leaves when plants grown under traditional program. Generally, the highest content of chlorophyll a, b and total chlorophyll, carotene, N, P, K, Ca and Mg in tomato leaves were recorded in poultry manure treatment under traditional program while the lowest content were observed in control plants which fertilized with mineral treatment and without pest control.

Yield and its components

Fertilizer treatments (organic and chemical fertilizers)

The results on yield and its components, *i.e.,* average fruit fresh weight (g), fruit length (cm), fruit width (cm), fruit dry matter %, number of fruits/plant, yield/plant (kg), marketable yield (ton/fed.), unmarketable yield (ton/fed.) and total yield (ton/fed.) are presented in Tables 6 and 7. Except the number of fruits/plant and unmarketable yield (ton/fed.), application of inorganic fertilizer (mineral) exceeded organic manures (poultry, cattle and sheep) in average fruit fresh weight (73.96 and 76.98 g), fruit length (6.58 and 6.71 cm), fruit width (5.01 and 5.08 cm), fruit dry matter (3.18 and 3.15 %), yield/plant (2.32 and 2.39 kg), marketable yield (17.07 and 17.63 ton/fed.) and total yield (18.57 and 19.16 ton/fed.) in both seasons, respectively. In case of organic types, it was observed that the plants treated with poultry manure recorded the highest values of average fruit fresh weight (70.89 and 74.37 g), fruit length (6.27 and 6.39 cm), fruit width (4.80 and 4.90 cm), fruit dry matter (3.10 and 3.04 %), yield/plant (2.23 and 2.31 kg), marketable yield (16.18 and 16.84 ton/fed.) and total yield (17.84 and 18.52 ton/fed.) while sheep manure ranked first among the others in number of fruits/plant (33.51 and 32.80) and unmarketable yield (1.99 and 2.03 ton/fed.), respectively in the two studied seasons.

Similar results were obtained by Heeb et al. (2006), Kochakinezhad et al. (2012) and Singh (2014) they found that chemical fertilizer gave the highest tomato yield compared to organic manure. Also, Kochakinezhad et al. (2012) recommended that the selection of tomato cultivar-appropriate organic fertilizer can narrow that yield decrement to between 0.5 % to 4.7 %.

In addition, Tonfack et al. (2009) studied the response of two tomato cultivars to chemical and organic fertilizers. They reported that Rio Grande cultivar responded well to organic manure than chemical fertilizer while Rossol VFN cultivar recorded the highest yield with organic manure (poultry manure) application compared to chemical fertilization. The response of crop yield to organic manures varies depends on the types of manures, crop type and species, soil type and climate conditions.

TABLE 4. Chlorophyll a, b, total chlorophyll and carotene content of tomato leaves as affected by different organic fertilizer treatments under two pest control programs for Tuta absoluta and their interactions during 2016/2017 and 2017/2018 growing seasons

Treatments	2016/2017 season				2017/2018 season			
	Con.	TPC	IPM	Mean	Con.	TPC	IPM	Mean
				Chlorophyll a (mg/g F.W)				
Mineral	0.532 l	0.562 j	0.546 k	0.546 d	0.540 l	0.567 j	0.550 k	0.552 d
Poultry	0.599 g	0.690 a	0.641 d	0.643 a	0.603 g	0.696 a	0.646 d	0.648 a
Cattle	0.586 h	0.667 b	0.628 e	0.627 b	0.591 h	0.676 b	0.632 e	0.633 b
Sheep	0.572 i	0.656 c	0.610 f	0.613 c	0.579 i	0.660 c	0.615 f	0.618 c
Mean	0.572 c	0.644 a	0.606 b		0.578 c	0.650 a	0.611 b	
				Chlorophyll b (mg/g F.W)				
Mineral	0.366 l	0.393 j	0.380 k	0.379 d	0.375 l	0.402 j	0.390 k	0.389 d
Poultry	0.427 g	0.490 a	0.457 d	0.458 a	0.435 g	0.500 a	0.465 d	0.467 a
Cattle	0.413 h	0.483 b	0.447 e	0.448 b	0.422 h	0.491 b	0.456 e	0.456 b
Sheep	0.404 i	0.472 c	0.434 f	0.437 c	0.412 i	0.478 c	0.443 f	0.444 c
Mean	0.402 c	0.459 a	0.429 b		0.411 c	0.467 a	0.438 b	
				Total chlorophyll (mg/g F.W)				
Mineral	0.898 l	0.955 j	0.926 k	0.926 d	0.915 l	0.969 j	0.941 k	0.941 d
Poultry	1.026 g	1.180 a	1.099 d	1.101 a	1.038 g	1.196 a	1.111 d	1.115 a
Cattle	1.000 h	1.150 b	1.076 e	1.075 b	1.013 h	1.167 b	1.088 e	1.090 b
Sheep	0.977 i	1.129 c	1.044 f	1.050 c	0.992 i	1.138 c	1.059 f	1.063 c
Mean	0.975 c	1.103 a	1.036 b		0.989 c	1.117 a	1.050 b	
				Carotene (mg/g F.W)				
Mineral	0.715 l	0.738 j	0.724 k	0.726 d	0.720 l	0.747 j	0.732 k	0.733 d
Poultry	0.774 g	0.847 a	0.810 d	0.810 a	0.783 g	0.852 a	0.816 d	0.817 a
Cattle	0.760 h	0.832 b	0.799 e	0.797 b	0.767 h	0.841 b	0.806 e	0.804 b
Sheep	0.749 i	0.821 c	0.788 f	0.786 c	0.761 i	0.826 c	0.794 f	0.794 c
Mean	0.749 c	0.809 a	0.780 b		0.757 c	0.816 a	0.787 b	

Values followed by the same letters within a column are not significantly differed at 5% according to Duncan's multiple range test.
Con. Control & TPC. Traditional pest control program & IPM. Integrated pest management program.

TABLE 5. N, P, K, Ca and Mg content of tomato leaves as affected by different organic fertilizer treatments under two pest control programs for Tuta absoluta and their interactions during 2016/2017 and 2017/2018 growing seasons

Treatments	2016/2017 season				2017/2018 season			
	Con.	TPC	IPM	Mean	Con.	TPC	IPM	Mean
				N %				
Mineral	1.90 l	2.14 j	2.01 k	2.02 d	1.95 l	2.23 j	2.07 k	2.08 d
Poultry	2.49 g	3.17 a	2.84 d	2.83 a	2.54 g	3.21 a	2.91 d	2.88 a
Cattle	2.36 h	3.05 b	2.74 e	2.72 b	2.42 h	3.11 b	2.79 e	2.77 b
Sheep	2.28 i	2.94 c	2.59 f	2.60 c	2.29 i	3.04 c	2.65 f	2.66 c
Mean	2.26 c	2.82 a	2.54 b		2.30 c	2.90 a	2.60 b	
				P %				
Mineral	0.324 l	0.350 j	0.335 k	0.336 d	0.331 l	0.356 j	0.341 k	0.343 d
Poultry	0.386 g	0.450 a	0.420 d	0.418 a	0.392 g	0.460 a	0.423 d	0.425 a
Cattle	0.370 h	0.444 b	0.406 e	0.406 b	0.378 h	0.449 b	0.411 e	0.412 b
Sheep	0.359 i	0.428 c	0.395 f	0.394 c	0.365 i	0.434 c	0.404 f	0.401 c
Mean	0.360 c	0.418 a	0.389 b		0.366 c	0.425 a	0.395 b	
				K %				
Mineral	2.82 k	3.06 i	2.95 j	2.94 d	2.89 i	3.14 g	3.03 h	3.02 d
Poultry	3.39 f	4.04 a	3.73 c	3.72 a	3.53 e	4.17 a	3.86 c	3.85 a
Cattle	3.26 g	3.88 b	3.62 d	3.58 b	3.34 f	4.06 b	3.71 d	3.70 b
Sheep	3.16 h	3.84 b	3.52 e	3.50 c	3.19 g	4.02 b	3.59 e	3.60 c
Mean	3.16 c	3.70 a	3.45 b		3.24 c	3.85 a	3.55 b	
				Ca %				
Mineral	0.686 l	0.730 j	0.707 k	0.708 d	0.692 l	0.738 j	0.716 k	0.715 d
Poultry	0.782 g	0.899 a	0.842 d	0.841 a	0.790 g	0.910 a	0.864 d	0.854 a
Cattle	0.760 h	0.881 b	0.825 e	0.822 b	0.771 h	0.888 b	0.832 e	0.830 b
Sheep	0.747 i	0.863 c	0.801 f	0.804 c	0.760 i	0.878 c	0.808 f	0.815 c
Mean	0.744 c	0.843 a	0.794 b		0.753 c	0.853 a	0.805 b	
				Mg %				
Mineral	0.475 k	0.504 i	0.487 j	0.489 d	0.483 k	0.509 i	0.495 j	0.495 d
Poultry	0.540 f	0.612 a	0.582 c	0.578 a	0.547 f	0.620 a	0.588 c	0.585 a
Cattle	0.526 g	0.604 b	0.566 d	0.565 b	0.533 g	0.613 b	0.575 d	0.573 b
Sheep	0.517 h	0.603 b	0.553 e	0.557 c	0.524 h	0.591 c	0.564 e	0.560 c
Mean	0.514 c	0.581 a	0.547 b		0.522 c	0.583 a	0.555 b	

Values followed by the same letters within a column are not significantly differed at 5% according to Duncan's multiple range test Con. Control & TPC. Traditional pest control program & IPM. Integrated pest management program.

TABLE 6. Average fruit fresh weight, fruit length, fruit width, fruit dry matter of tomato plants as affected by different organic fertilizer treatments under two pest control programs for Tuta absoluta and their interactions during 2016/2017 and 2017/2018 growing seasons

Treatments	2016/2017 season				2017/2018 season			
	Con.	TPC	IPM	Mean	Con.	TPC	IPM	Mean
				Average fruit fresh weight (g)				
Mineral	60.11 fg	81.97 a	79.79 a	73.96 a	63.58 f	84.79 a	82.58 ab	76.98 a
Poultry	58.85 gh	78.15 ab	75.68 bc	70.89 b	62.86 f	81.14 ab	79.12 bc	74.37 b
Cattle	56.27 gh	72.93 cd	70.03 d	66.41 c	61.46 fg	76.38 cd	73.52 d	70.45 c
Sheep	55.02 h	65.00 e	62.90 ef	60.97 d	58.58 g	68.27 e	67.96 e	64.94 d
Mean	57.56 c	74.51 a	72.10 b		61.62 b	77.64 a	75.79 a	
				Fruit length (cm)				
Mineral	5.76 fg	7.11 a	6.88 ab	6.58 a	5.86 gh	7.19 a	7.09 ab	6.71 a
Poultry	5.61 g	6.66 bc	6.54 c	6.27 b	5.68 h	6.88 bc	6.62 cd	6.39 b
Cattle	5.22 h	6.41 cd	6.22 de	5.95 c	5.28 i	6.57 d	6.44 de	6.10 c
Sheep	5.05 h	6.16 de	6.07 ef	5.76 d	5.21 i	6.19 ef	6.12 fg	5.84 d
Mean	5.41 b	6.58 a	6.43 a		5.51 b	6.71 a	6.57 a	
				Fruit width (cm)				
Mineral	4.29 f	5.39 a	5.34 a	5.01 a	4.41 g	5.44 a	5.39 ab	5.08 a
Poultry	4.02 g	5.27 ab	5.11 bc	4.80 b	4.17 h	5.29 bc	5.25 cd	4.90 b
Cattle	3.75 h	4.96 cd	4.84 de	4.51 c	3.78 i	5.12 de	5.07 e	4.66 c
Sheep	3.60 h	4.68 e	4.63 e	4.30 d	3.63 j	4.70 f	4.68 f	4.34 d
Mean	3.91 b	5.07 a	4.98 a		4.00 b	5.14 a	5.10 a	
				Fruit dry matter (%)				
Mineral	3.01 f	3.28 a	3.25 ab	3.18 a	3.02 ab	3.22 a	3.20 a	3.15 a
Poultry	3.02 ef	3.19 bc	3.09 de	3.10 b	2.84 bc	3.18 a	3.10 ab	3.04 a
Cattle	2.82 g	3.12 cd	3.20 ab	3.05 c	2.64 c	3.05 ab	3.11 ab	2.93 a
Sheep	2.76 g	3.24 ab	3.18 bc	3.06 c	2.63 c	3.20 a	3.01 ab	2.94 a
Mean	2.90 b	3.21 a	3.18 a		2.78 b	3.16 a	3.10 a	

Values followed by the same letters within a column are not significantly differed at 5% according to Duncan's multiple range test.
Con. Control & TPC. Traditional pest control program & IPM. Integrated pest management program.

TABLE 7. Number of fruits per plant, yield per plant, marketable yield, unmarketable yield and total yield of tomato plants as affected by different organic fertilizer treatments under two pest control programs for Tuta absoluta and their interactions during 2016/2017 and 2017/2018 growing seasons

Treatments	2016/2017 season				2017/2018 season			
	Con.	TPC	IPM	Mean	Con.	TPC	Na. pes.	Mean
				Number of fruits/plant				
Mineral	34.08 a	30.32 cd	30.59 cd	31.67 c	33.48 a	30.10 c	30.37 c	31.32 b
Poultry	34.24 a	30.28 d	30.64 cd	31.72 c	33.74 a	30.03 c	30.31 c	31.36 b
Cattle	34.07 a	31.23 cd	31.86 bc	32.39 b	33.25 a	30.77 c	31.34 bc	31.78 b
Sheep	34.20 a	32.94 ab	33.38 ab	33.51 a	33.49 a	32.44 ab	32.46 ab	32.80 a
Mean	34.15 a	31.19 b	31.62 b		33.49 a	30.84 b	31.12 b	
				Yield/plant (kg)				
Mineral	2.04 fg	2.48 a	2.43 ab	2.32 a	2.12 fg	2.55 a	2.50 ab	2.39 a
Poultry	2.01 gh	2.36 bc	2.32 cd	2.23 b	2.11 fg	2.43 bc	2.39 c	2.31 b
Cattle	1.91 hi	2.27 cd	2.22 de	2.14 c	2.03 gh	2.35 cd	2.30 de	2.23 c
Sheep	1.87 i	2.13 ef	2.10 fg	2.03 d	1.96 h	2.21 ef	2.20 f	2.12 d
Mean	1.96 b	2.31 a	2.27 a		2.06 b	2.38 a	2.35 a	
				Marketable yield (ton/fed.)				
Mineral	14.35 fg	18.63 a	18.23 ab	17.07 a	14.94 fg	19.18 a	18.77 ab	17.63 a
Poultry	13.97 gh	17.50 bc	17.07 cd	16.18 b	14.79 g	18.03 bc	17.69 c	16.84 b
Cattle	13.13 hi	16.59 cd	16.09 de	15.27 c	14.05 gh	17.14 cd	16.66 de	15.95 c
Sheep	12.77 i	15.25 ef	14.90 fg	14.31 d	13.36 h	15.79 ef	15.71 f	14.95 d
Mean	13.55 b	16.99 a	16.57 a		14.28 b	17.53 a	17.21 a	
				Unmarketable yield (ton/fed.)				
Mineral	2.01 bc	1.21 h	1.27 gh	1.50 d	2.07 bc	1.23 h	1.28 h	1.53 d
Poultry	2.11 ab	1.38 gh	1.46 fg	1.65 c	2.14 ab	1.42 gh	1.47 fg	1.68 c
Cattle	2.18 ab	1.61 ef	1.72 de	1.84 b	2.25 ab	1.63 ef	1.73 de	1.87 b
Sheep	2.24 a	1.83 cd	1.89 cd	1.99 a	2.31 a	1.89 cd	1.90 cd	2.03 a
Mean	2.13 a	1.51 b	1.58 b		2.19 a	1.54 b	1.59 b	
				Total yield (ton/fed.)				
Mineral	16.37 fg	19.85 a	19.50 ab	18.57 a	17.02 fg	20.41 a	20.05 ab	19.16 a
Poultry	16.09 gh	18.89 bc	18.54 cd	17.84 b	16.93 fg	19.45 bc	19.17 c	18.52 b
Cattle	15.31 hi	18.21 cd	17.82 de	17.11 c	16.31 gh	18.78 cd	18.40 de	17.83 c
Sheep	15.01 i	17.08 ef	16.79 fg	16.29 d	15.67 h	17.67 ef	17.61 f	16.98 d
Mean	15.69 b	18.51 a	18.16 a		16.48 b	19.08 a	18.81 a	

Values followed by the same letters within a column are not significantly differed at 5% according to Duncan's multiple range test.
Con. Control & TPC. Traditional pest control program & IPM. Integrated pest management program.

The superiority of chemical fertilizer on organic manures in crop yield may be due to the deficiency of an adequate supply of plant-available N from organic fertilizer, resulting from a slow rate of mineralization (Blatt, 1991). Moreover, probably, in the most demanding stage of tomato crop, organic manures did not provide the nutrients, especially N, P, K in the same amounts of the chemical fertilizers. The transformation of organic nitrogen in ammonia and nitrate, which are forms absorbed by plants is slow and cannot meet the needs of the plants during the greater nutritional requirement stage, explaining, perhaps the lower yield of organic treatments (Zuba et al., 2011).

Pest control programs

As seen in Tables 6 and 7, traditional program treatment exhibited the best results for average fruit fresh weight, fruit length, fruit width, fruit dry matter, yield/plant, marketable yield and total yield followed by IPM and control treatments, respectively in both seasons of the study. Only number of fruits/plant and unmarketable yield characters were highest in control plants in comparison to other treatments. The differences between IPM and traditional program were insignificant in the tow studied seasons. Both yield and fruit quality significantly reduced by infection of *T. absoluta*. The amount of marketable fruit production of tomato was significantly higher in the IPM program of *T. absuluta* (Trumble and Alvarado-Rodriguez, 1993).

Interaction between fertilizer treatments and pest control programs

Impacts of the interaction treatments on yield and its components of tomato plants are visible in Tables 6 and 7. Plants treated with inorganic fertilizers (mineral) as well as treated with traditional program ranked first in all previous studied characters, except number of fruits/plant and unmarketable yield (ton/fed.), followed by IPM treatment with no significant differences among them in both the seasons. Untreated plants fertilized with sheep manure recorded the lowest values of all investigated parameters, except in unmarketable yield (ton/fed.), which recorded the highest values in both seasons. Moreover, the highest number of fruits/plant was obtained in plants treated with poultry manure and untreated plants (control) in 2016/2017 and 2017/2018 seasons.

Chemical composition of fruits

Fertilizer treatments (organic and chemical fertilizers)

The results on fruits chemical content (N, P, K, Ca, Mg, carotenoid, vitamin C, total phenol, total flavonoid, licobin, water content, total soluble solids, total sugars and acidity) are presented in Tables (8, 9 and 10). Previous tables clearly showed that all organic fertilizer types (poultry, cattle and sheep manures) significantly surpassed chemical fertilizer in all previous characters in both seasons of the study, except carotenoid, total phenol, total flavonoid and water contents. Moreover, organic manures produced fruits with less content of acidity compared to mineral fertilizer.

Among organic types, poultry manure recorded the highest chemical content of fruits followed by cattle and sheep manures, respectively in both seasons. Additionally, the highest content of carotenoid, total phenol, total flavonoid, water content and acidity was obtained in fruits of chemical treatments.

These results are consistent with the findings of Arahunashi (2011). He stated that organic manures, especially poultry manure, recorded the highest contents of ascorbic acid, reducing sugars and TSS in tomato fruits compared to recommended chemical fertilizer application. Furthermore, the previous researcher stated that the enhancement of ascorbic acid content in tomato fruits by poultry manure treatment might be due to the reduction in the ascorbic acid-oxidase enzyme responsible for the destruction of ascorbic acid content in the plants. Moreover, Toor et al. (2006) showed that ascorbic acid contents in tomatoes from organic fertilized treatments were higher than in tomatoes from nitrate-fertilized treatments.

In addition to that, total soluble sugars content was higher under organic manure compared to chemical fertilization and that may be due to the lesser starch content when soils supplied with inorganic fertilizer which implies the starch metabolism and poor translocation of sugar to growing part (Ibrahim et al., 2013).

Organic fertilizers release nutrients not as fast as mineral fertilizers. Therefore, plants supplied with organic fertilizers often grow more slowly compared to plants fertilized with readily available mineral nutrients. This might reduce their water content leading to a higher concentration of plant compounds, e.g., sugars and acids (Guichard et al. 2001).

TABLE 8. N, P, K, Ca and Mg content of tomato fruits as affected by different organic fertilizer treatments under two pest control programs for Tuta absoluta and their interactions during 2016/2017 and 2017/2018 growing seasons

Treatments	2016/2017 season				2017/2018 season			
	Con.	TPC	IPM	Mean	Con.	TPC	IPM	Mean
				N %				
Mineral	1.67 l	1.97 j	1.82 k	1.82 d	1.74 l	2.04 j	1.89 k	1.89 d
Poultry	2.28 g	3.04 a	2.67 d	2.66 a	2.35 g	3.12 a	2.75 d	2.74 a
Cattle	2.17 h	2.90 b	2.57 e	2.55 b	2.25 h	2.97 b	2.64 e	2.62 b
Sheep	2.05 i	2.78 c	2.43 f	2.42 c	2.11 i	2.86 c	2.54 f	2.50 c
Mean	2.04 c	2.67 a	2.37 b		2.11 c	2.75 a	2.45 b	
				P %				
Mineral	0.303 l	0.325 j	0.318 k	0.315 d	0.311 k	0.335 i	0.324 j	0.323 d
Poultry	0.355 g	0.414 a	0.386 d	0.385 a	0.363 f	0.422 a	0.397 c	0.394 a
Cattle	0.345 h	0.404 b	0.374 e	0.374 b	0.351 g	0.414 b	0.384 d	0.383 b
Sheep	0.334 i	0.394 c	0.365 f	0.364 c	0.341 h	0.400 c	0.371 e	0.371 c
Mean	0.334 c	0.384 a	0.361 b		0.341 c	0.393 a	0.369 b	
				K %				
Mineral	2.57 l	2.85 j	2.72 k	2.71 d	2.66 l	2.89 j	2.82 k	2.79 d
Poultry	3.12 g	3.77 a	3.43 d	3.44 a	3.23 g	3.85 a	3.51 d	3.53 a
Cattle	3.03 h	3.69 b	3.36 e	3.36 b	3.14 h	3.75 b	3.43 e	3.44 b
Sheep	2.92 i	3.57 c	3.26 f	3.25 c	3.03 i	3.68 c	3.35 f	3.35 c
Mean	2.91 c	3.47 a	3.19 b		3.01 c	3.54 a	3.28 b	
				Ca %				
Mineral	0.823 l	0.858 j	0.838 k	0.840 d	0.828 i	0.864 g	0.845 h	0.846 d
Poultry	0.912 g	1.008 a	0.959 d	0.959 a	0.923 d	1.021 a	0.969 c	0.971 a
Cattle	0.893 h	0.995 b	0.943 e	0.944 b	0.904 e	1.008 a	0.959 c	0.957 b
Sheep	0.873 i	0.975 c	0.924 f	0.924 c	0.880 f	0.984 b	0.932 d	0.932 c
Mean	0.875 c	0.959 a	0.916 b		0.884 c	0.969 a	0.926 b	
				Mg %				
Mineral	0.511 k	0.543 i	0.524 j	0.526 d	0.523 l	0.551 j	0.534 k	0.536 d
Poultry	0.571 g	0.643 a	0.607 d	0.607 a	0.583 g	0.652 a	0.621 d	0.618 a
Cattle	0.560 h	0.632 b	0.597 e	0.596 b	0.572 h	0.644 b	0.606 e	0.607 b
Sheep	0.548 i	0.620 c	0.585 f	0.584 c	0.558 i	0.635 c	0.600 f	0.597 c
Mean	0.548 c	0.609 a	0.578 b		0.559 c	0.620 a	0.590 b	

Values followed by the same letters within a column are not significantly differed at 5% according to Duncan's multiple range test.
Con. Control & TPC. Traditional pest control program & IPM. Integrated pest management program.

TABLE 9. Carotenoid, vitamin C, total phenol, total flavonoid, licobin content of tomato fruits as affected by different organic fertilizer treatments under two pest control programs for Tuta absoluta and their interactions during 2016/2017 and 2017/2018 growing seasons

Treatments	2016/2017 season				2017/2018 season			
	Con.	TPC	IPM	Mean	Con.	TPC	IPM	Mean
			Carotiniod (mg/100 g F.W)					
Mineral	4.50 a	4.15 c	4.33 b	4.33 a	4.34 a	4.09 c	4.24 b	4.22 a
Poultry	3.76 f	2.84 l	3.31 i	3.30 d	3.67 f	2.70 k	3.18 i	3.18 d
Cattle	3.91 e	2.95 k	3.44 h	3.43 c	3.77 e	2.79 k	3.35 h	3.30 c
Sheep	4.01 d	3.14 j	3.59 g	3.58 b	3.95 d	3.04 j	3.48 g	3.49 b
Mean	4.04 a	3.27 c	3.67 b		3.93 a	3.15 c	3.56 b	
			Vitamin C (mg/100 g F.W)					
Mineral	28.69 l	29.06 j	28.86 k	28.87 d	28.80 k	29.17 i	29.05 j	29.00 d
Poultry	29.66 g	30.87 a	30.31 d	30.28 a	29.76 f	31.03 a	30.42 d	30.40 a
Cattle	29.50 h	30.69 b	30.19 e	30.13 b	29.63 g	30.82 b	30.38 d	30.27 b
Sheep	29.28 i	30.51 c	29.85 f	29.88 c	29.37 h	30.63 c	29.96 e	29.98 c
Mean	29.28 c	30.28 a	29.80 b		29.39 c	30.41 a	29.95 b	
			Total phenol (mg/100 g F.W)					
Mineral	568.46 a	545.46 c	555.96 b	556.63 a	562.76 a	539.00 c	551.76 b	551.17 a
Poultry	505.50 f	428.60 l	461.06 i	465.05 d	498.76 f	422.96 l	466.36 i	462.70 d
Cattle	517.76 e	441.60 k	478.03 h	479.13 c	512.30 e	436.16 k	473.80 h	474.08 c
Sheep	532.40 d	453.20 j	491.66 g	492.42 b	526.00 d	447.53 j	487.13 g	486.88 b
Mean	531.03 a	467.21 c	496.68 b		524.95 a	461.41 c	494.76 b	
			Total flavonoid (mg/100 g F.W)					
Mineral	142.23 a	134.23 c	138.33 b	138.26 a	138.30 a	131.70 c	135.46 b	135.15 a
Poultry	123.30 f	95.20 l	108.46 i	108.98 d	119.76 f	92.86 l	106.83 i	106.48 d
Cattle	127.10 e	99.96 k	114.96 h	114.01 c	124.06 e	97.03 k	110.90 h	110.66 c
Sheep	130.16 d	102.66 j	118.03 g	116.95 b	127.50 d	100.50 j	115.43 g	114.47 b
Mean	130.70 a	108.01 c	119.95 b		127.40 a	105.52 c	117.15 b	
			Licobin (mg/100 g F.W)					
Mineral	7.56 j	7.95 h	7.69 i	7.73 d	8.07 i	8.12 i	8.10 i	8.10 d
Poultry	8.66 e	9.53 a	8.94 d	9.04 a	8.70 f	9.67 a	9.12 d	9.16 a
Cattle	8.37 f	9.41 b	8.85 d	8.87 b	8.46 g	9.47 b	9.02 e	8.98 b
Sheep	8.14 g	9.16 c	8.84 d	8.71 c	8.28 h	9.27 c	8.94 e	8.83 c
Mean	8.18 c	9.01 a	8.58 b		8.38 c	9.13 a	8.79 b	

Values followed by the same letters within a column are not significantly differed at 5% according to Duncan's multiple range test.
Con. Control & TPC. Traditional pest control program & IPM. Integrated pest management program.

TABLE 10. Water content, total soluble solids, total sugars and acidity of tomato fruits as affected by different organic fertilizer treatments under two pest control programs for Tuta absoluta and their interactions during 2016/2017 and 2017/2018 growing seasons

Treatments	2016/2017 season				2017/2018 season			
	Con.	TPC	IPM	Mean	Con.	TPC	IPM	Mean
				Water content %				
Mineral	74.30 a	72.43 c	73.46 b	73.40 a	73.50 a	71.80 c	72.40 b	72.56 a
Poultry	70.60 f	66.30 l	68.53 i	68.47 d	69.93 e	65.36 j	67.90 g	67.73 d
Cattle	71.40 e	66.93 k	69.00 h	69.11 c	70.60 d	66.00 i	68.43 f	68.34 c
Sheep	71.83 d	67.96 j	69.63 g	69.81 b	71.03 d	67.26 h	68.83 f	69.04 b
Mean	72.03 a	68.40 c	70.15 b		71.26 a	67.60 c	69.39 b	
				Total soluble solids (TSS) %				
Mineral	4.77 k	4.87 i	4.83 j	4.82 d	4.84 j	4.94 h	4.88 i	4.88 d
Poultry	5.04 f	5.38 a	5.18 d	5.20 a	5.11 f	5.46 a	5.25 d	5.27 a
Cattle	4.97 g	5.34 b	5.14 e	5.15 b	5.03 g	5.39 b	5.21 e	5.21 b
Sheep	4.91 h	5.25 c	5.05 f	5.07 c	4.96 h	5.32 c	5.12 f	5.13 c
Mean	4.92 c	5.21 a	5.05 b		4.98 c	5.28 a	5.11 b	
				Total sugar %				
Mineral	5.45 i	5.61 i	5.58 i	5.55 d	5.61 k	5.77 j	5.64 k	5.67 d
Poultry	6.05 fg	7.79 a	6.41 cd	6.75 a	6.15 g	7.91 a	6.53 d	6.86 a
Cattle	5.92 gh	6.65 b	6.26 de	6.28 b	6.07 h	6.72 b	6.39 e	6.39 b
Sheep	5.79 h	6.53 bc	6.14 ef	6.15 c	5.89 i	6.64 c	6.22 f	6.25 c
Mean	5.80 c	6.64 a	6.10 b		5.93 c	6.76 a	6.19 b	
				Acidity %				
Mineral	1.07 a	0.97 b	1.04 a	1.02 a	1.00 a	0.93 bc	0.95 b	0.96 a
Poultry	0.87 c	0.64 f	0.74 de	0.75 d	0.84 d	0.57 h	0.69 fg	0.70 d
Cattle	0.92 b	0.66 f	0.77 d	0.78 c	0.84 d	0.61 h	0.72 ef	0.72 c
Sheep	0.95 b	0.72 e	0.83 c	0.83 b	0.89 c	0.66 g	0.76 e	0.77 b
Mean	0.95 a	0.74 c	0.84 b		0.89 a	0.69 c	0.78 b	

Values followed by the same letters within a column are not significantly differed at 5% according to Duncan's multiple range test.
Con. Control & TPC. Traditional pest control program & IPM. Integrated pest management program.

Pest control programs

The results given in Tables 8, 9 and 10 represent the response of chemical contents of tomato fruits to IPM and traditional program in the experiments. It is clear from the previous data that fruits of chemical pesticide treatment contained more N, P, K, Ca, Mg, vitamin C, lycobin, total soluble solids and total sugars contents, while control treatment produced fruits with more contents of carotenoid, total phenol, total flavonoid, water content and acidity.

Interaction between fertilizer treatments and pest control programs

Concerning the effect of different interactions between fertilization and pest control programs on tomato fruits chemical content, Tables 8, 9 and 10 illustrated that increased levels of N, P, K, Ca, Mg, vitamin C, licobin, total soluble solids and total sugars were recorded in fruits of the plants treated with poultry manure under traditional program. In addition to that, fruits content of carotenoid, total phenol, total flavonoid, water content and acidity were higher in control plants which fertilized with mineral application and without pest control programs.

Monitoring of T. absoluta

Fertilizer treatments (organic and chemical fertilizers)

Results in Tables 11& 12 represent the effect of different fertilization treatments on no. of infested leaflets with T. absoluta larvae, no. of adult moths/trap/day.The analysis of variance results showed that mineral fertilizer source (recommended NPK) give highly significant no. of infested leaflets (11.7,9.6) and no. of adult moths/trap/day (51.7, 47.7) with T. absoluta at plant age 45 days (pre-treatment) during both planting seasons 2017/2018, respectively as a result of mineral fertilizer source may be due to the increase in

TABLE 11. Efficacy of different programs in controlling the leafminer, Tuta absoluta on tomato plants in two plantations seasons 2017,2018

Seasons	Plant age / Treatment	45 days (Pre-treatment) control No.	TPC* No.	IPM‡ No.	Means	90 days Control No.	R§ %	TPC* No.	R %	IPM‡ No.	R %	Means	135 days control No.	R %	TPC* No.	R %	IPM‡ No.	R %	Means
2016-2017	Mineral	11.7^{a}	11.4^{ab}	12.0^{a}	11.7a	12.0	00.0^{f}	06.4	45.8^{c}	05.6	54.4^{a}	33.4a	12.7	00.0^{g}	2.4	81.0^{d}	0.4	97.4^{a}	59.4a
	Poultry	10.4^{bcd}	11.0^{abc}	11.0^{abc}	10.7b	11.7	00.0^{f}	07.7	38.1^{d}	06.4	49.2^{bc}	29.1b	14.4	00.0^{g}	6.0	61.0^{f}	0.7	95.7^{ab}	52.2b
	Cattle	09.7^{de}	10.0^{cd}	09.4^{def}	9.7c	11.4	00.0^{f}	07.4	35.4^{d}	0.5.7	48.3^{bc}	27.9b	12.6	00.0^{g}	3.7	71.0^{e}	1.4	89.7^{bc}	53.6b
	Sheep	08.4^{fg}	07.7^{g}	08.7^{efg}	8.3d	10.4	00.0^{f}	06.7	30.4^{e}	05.4	50.4^{a}	26.9b	11	00.0^{g}	3	70.4^{e}	1.4	88.7^{e}	53.6b
	Means	10.0^{A}	10.0^{A}	10.3^{A}	-------	11.4	00.0^{C}	07.0	37.4^{B}	05.8	50.6^{A}	-------	12.7	00.0^{C}	3.8	70.8^{B}	0.9	92.8^{A}	-------
2017-2018	Mineral	09.3^{ab}	09.3^{ab}	10.0^{a}	09.6a	11.0	00.0^{d}	05.3	51.3^{b}	04.3	63.1^{a}	38.2a	13.0	00.0^{e}	3.3	74.3^{c}	0.3	97.6^{a}	57.3a
	Poultry	08.3^{abc}	07.3^{cde}	08.0^{bcd}	07.9b	10.3	00.0^{d}	05.0	44.6^{c}	04.7	53.2^{b}	32.6b	11.3	00.0^{e}	3.3	66.4^{d}	0.7	93.7^{ab}	53.ab
	Cattle	07.7^{bcd}	06.3^{def}	07.3^{cde}	07.1b	10.0	00.0^{d}	04.7	44.1^{c}	04.7	52.3^{b}	32.3b	10.0	00.0^{e}	2.3	71.7^{cd}	1.7	83.1^{b}	51.6b
	Sheep	05.3^{fg}	05.7^{efg}	04.0^{g}	05.0c	07.0	00.0^{d}	04.3	41.6^{c}	02.3	55.2^{b}	32.1b	07.7	00.0^{e}	2.3	71.2^{cd}	1.0	81.9^{b}	51.0b
	Means	07.7^{A}	07.2^{A}	7.3^{A}	-------	09.5	00.0^{C}	04.8	45.4^{B}	04.0	56.0^{A}	-------	10.5	00.0^{C}	2.8	70.1^{B}	0.9	89.1^{A}	-------

Means No.† of infested leaflets with T. absoluta larval

Number of infested leaflets/5 plant†
Integrated Pest Management program‡
Reduction percentage§
.Means with the same superscript letter are not significantly different at P<0.05

TABLE 12. Reduction percentage (% R) of catch moths, Tuta absoluta on tomato plants after applied with different control programs in two seasons 2017 and 2018.

Seasons	Plant age	45 days (Pre-treatment)				90 days							135 days						
	Treatment	Control No.	TPC* No.	IPM‡ No.	Means	Control No.	Control R %	TPC No.	TPC R %	IPM No.	IPM R %	Means	Control No.	Control R %	TPC No.	TPC R %	IPM No.	IPM R %	Means
2016-2017	Mineral	53.3^{a}	51.6^{ab}	50.0^{bc}	51.7a	70.3	00.0^{d}	26.0	62.0^{ab}	23.6	64.3^{a}	42.1a	57.9	00.0^{d}	10.4	81.5^{c}	6.7	87.7^{a}	56.4a
	Poultry	50.3^{bc}	49.3^{c}	46.7^{d}	48.8b	68.3	00.0^{d}	25.0	62.3^{ab}	22.9	64.0^{a}	42.1a	55.0	00.0^{d}	09.7	82.0^{c}	6.6	87.1^{ab}	56.4a
	Cattle	47.0^{d}	46.2^{de}	44.8^{e}	46.0c	61.5	00.0^{d}	23.9	60.3^{bc}	22.0	62.7^{ab}	41.0ab	54.4	00.0^{d}	10.3	80.7^{c}	7.5	85.6^{ab}	55.5a
	Sheep	38.2^{f}	35.4^{g}	36.7^{fg}	36.7d	58.7	00.0^{d}	22.7	58.0^{c}	22.8	61.3^{abc}	39.7b	52.0	00.0^{d}	09.2	80.9^{c}	7.2	85.5^{b}	55.4a
	Means	47.2^{A}	45.6^{B}	44.6^{C}	-------	64.7	00.0^{C}	24.4	60.7^{B}	22.6	63.0^{A}	-------	54.8	00.0^{C}	09.9	81.3^{B}	7	86.5^{A}	-------
2017-2018	Mineral	48.1^{a}	47.9a	46.4^{ab}	47.4a	60,1	00.0^{c}	21.7	63.7^{a}	20.4	64.8^{a}	42.8a	61.3	00.0^{e}	8.7	85.7^{cd}	2.2	96.2^{a}	60.6a
	Poultry	45.0^{ab}	46.4ab	45.4^{ab}	45.6a	52.6	00.0^{c}	20.4	62.5^{a}	18.4	65.5^{a}	42.3a	53.1	00.0^{e}	7.9	85.6^{cd}	3.3	93.7^{ab}	59.8ab
	Cattle	42.3^{b}	45.0ab	42.2^{b}	43.2b	45.7	00.0^{c}	21.6	55.6^{b}	19.3	58.0^{b}	38.5b	52.0	00.0^{e}	8.4	84.8^{d}	4.3	91.8^{b}	58.9ab
	Sheep	33.1^{c}	36.1c	35.9c	35.0c	41.1	00.0^{c}	19.3	57.3^{b}	18.6	58.3^{b}	37.9b	42.8	00.0^{e}	7.2	84.2^{d}	5.7	87.8^{c}	57.3b
	Means	42.1^{A}	43.8^{A}	42.5^{A}	-------	49.9	00.0^{C}	20.7	59.8^{B}	19.2	61.7^{A}	-------	52.3	00.0^{C}	8.0	85.1^{B}	3.9	92.a^{A}	-------

Means No.† of adult moths/trap/day

Mean number of adult catch/water trap/day†
Traditional pest control program *
Integrated Pest Management program‡
.Means with the same superscript letter are not significantly different at $P<0.05$

vegetative growth (Table, 3) compared to organic manures. High level of N , K had a significantly shorter development time and laid more eggs of T. absoluta (Blazhevski et al., 2018).

However mineral fertilizer source showed highly reduction percentage followed by organic fertilizer treatments without any significant deferent between organic sources.

On the other hand the increment in the yield (Tables 6 and 7) resulting from the highest vegetative growth under mineral fertilizer source. In contrast to mineral fertilizer source, organic manures recorded the lowest values of no. of infested leaflets with T. absoluta and no. of adult moths/trap/day and it is due to the increase in the tolerance of plants to pest and diseases (Ghorbani et al., 2008). Moreover, organic soil amendments can result in a better soil quality and greater plant disease suppression and have the potential to reduce pest attacks in long term (Bulluck and Ristaino, 2002 and Yardim and Edwards, 2003).

Pest control programs

The impact of pest control programs on the reduction percentage of infested leaflets with T. absoluta larvae and of adult moths/trap/day the data in Tables 11 and 12 showed that the most effective pest control method was IPM program (50.6 , 92.8%) and (56.0 , 89.1%) at plant age 90 and 135 days , for infested leaflets with *T. absoluta* larval. While for reduction percentage (% R) of catch moths, *Tuta absoluta* (63.0, 86.5) and (61.7, 92.0) at 90 and 135 days in 16/2017 and 17/2018, respectively. Several studies recommend use of Integrated Pest Management (IPM) strategy for effective management of T. absoluta compared with conventional program (Miranda et al., 2005).

Finally, Fig. 1 illustrates that IPM program was effective in reducing *T. absoluta* infestation fruits in both seasons followed by traditional program under mineral fertilizer compared with rest sources of fertilizer.

Interaction between fertilizer treatments and pest control programs:

Tables 11 and 12 indicated the obtained data with all the conducted programs under all fertilizer sources. Based on the reduction percentage of infested leaflets with *T. absoluta* larvae and of adult moths/trap/day. IPM gave high significant reduction percentage compared with the control and traditional program under all fertilizer sources. Data reflected that the highest reduction percentage of infested leaflets with larvae was recorded under mineral fertilizer source with all pest control programs (97.4 and 97.6 under IPM in 16/2017 and 17/2018 seasons, respectively). While reduction percentage of infested leaflets with larvae was recorded as 88.7 and 81.9 under IPM in 16/2017 and 17/2018 seasons respectively, when plants treated with sheep fertilizer.

This order coincided with the aforementioned order of efficiency for these programs. It can be observed that additive yield was produced when IPM was applied over any basic treatments. This means that these additional treatments improved plant quality and quantity with less infestation and therefore increased the final yield.

However, many authors stated that demonstration of IPM program on tomato or other plants improved of quality and yield. The actual target of any farmer is achieved depending on the net profit of the crop. Therefore, when control costs are taken in consideration, the position of some programs will be differed. For example the involving of the biological control as a safe method which is the most environmentally-friendly treatment, but its cost equals to 1800 LE/feddan, while the additive value to the yield was not paralleled with this value except when applied with male trapping which resulted in a sharp decrease in the net profit of all treatments included this technique. On the other side, IPM was the cheapest treatment, and so the resulted net profit was relatively higher with all fertilizer treatments comparing with those obtained with the control and chemical method (pesticides only) The obtained results suggested that any single treatment whatever, an insecticide and time of application or improving plant quality using pestcides only or mass trapping as a single method didn't give satisfactory control for *Tuta absoluta*, while the use of IPM programs proved to be the most reliable strategy. These results are cosistent and in a good harmony with those obtained by many authors. Plant protection systems for control *Tuta absoluta* include a complex of practice, crop rotation, application of pheromone traps, installation of insect nets, application of bioagents and byproducts and treatments with insecticides (EPPO, 2005, Benvenga et al., 2007 and Yankova & Ganeva, 2013).. Moreover, the use of insecticide in a minimum use of an IPM program was recommended by some authors. said that the importance of using a sound chemical control to the success of the IPM programme when less noxious insecticides are chosen and applied only when necessary avoiding the side effects on the beneficial arthropods and unisonant. Moreover, Yücel et al. (2012) reported that when chemical control is a must specific pesticides have to be suggested in order to minimize adverse effect on natural enemies, human and environment. The authors added in such a case, the criterion is based on the minimum use of such chemicals.

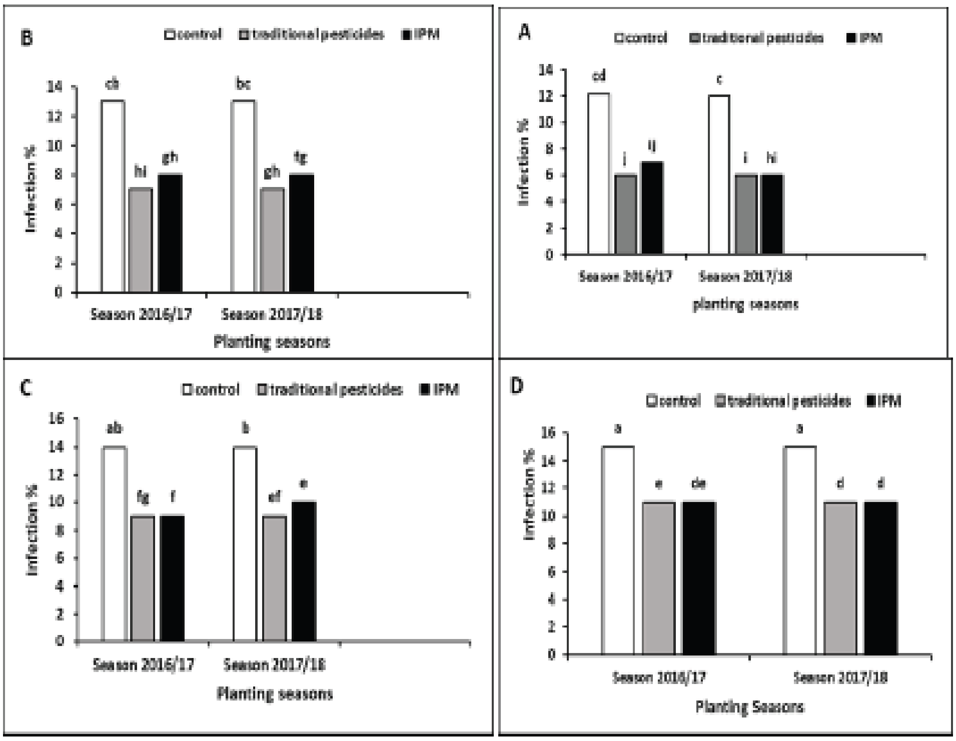

Fig. 1.The efficiency of all the conducted treatments A(miniral), B (Poultry), C(Cattel), D(Sheep) under pesticides control programs on tomato infection percentage at two seasons 2017 and 2018.

Conclusion

This study evaluated the efficiency of interaction between four fertilizer sources (poultry, cattle and sheep manures) and recommended mineral fertilizers under two pest control programs, Traditional pest control (TPC) and Integrated pest management (IPM) on growth, yield and fruit quality of tomato cv. Rawan F1. The obtained results indicated that chemical fertilization significantly surpassed organic manures in all vegetative growth characters. Based on the results, it could be recommended that fertilized tomato plants with mineral treatment (NPK) under IPM gave the best yield and the highest reduction percentage of infested leaflets with *T. absoluta* larvae and of adult moths/trap/day, although traditional program gave a slight insignificant increment in tomato yield, while soil application of composted poultry manure before tomato planting by 10.76 ton/fed. and spraying with chemical pesticide improved the quality of tomato fruits. According to our knowledge the study provides novel results in Egypt that can support tomato farmers worldwide to control this insect and prevent environmental pollution due to use of pesticides which are not only costly but also cause severe human diseases because of their residual harmful effects.

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إستجابة نمو ومحصول وجودة ثمار الطماطم لبعض معاملات التسميد العضوى تحت برنامجين من برامج مكافحة الآفات للتحكم فى حشرة التوتا أبسليوتا بالوادى الجديد-مصر

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أجريت تجربتان حقليتان فى المزرعة البحثية بكلية الزراعة – جامعة الوادى الجديد خلال موسمى الزراعة ٢٠١٧/٢٠١٦ و ٢٠١٨/٢٠١٧ م لدراسة تأثير بعض الأسمدة العضوية (سماد الدواجن ، سماد الأبقار ، وسماد الأغنام) إضافة إلى التسميد الكيماوى الموصى به تحت برنامج المكافحة التقليدية (المبيدات الكيميائية) وبرنامج المكافحة المتكاملة للآفات على النمو ، المحصول وجودة ثمار الطماطم (هجين روان).
أظهرت النتائج تفوق الأسمدة الكيماوية معنوياً على الأسمدة العضوية في جميع صفات النمو الخضري وكذلك المحصول ومكوناته. بينما أدت معاملات الأسمدة العضوية إلى زيادة معنوية فى محتوى الثمار من النيتروجين ، الفوسفور ، البوتاسيوم ، الكالسيوم ، الماغنسيوم ، فيتامين ج ، الليكوبين ، المواد الصلبة الذائبة الكلية والسكريات الكلية مقارنة بالأسمدة الكيماوية فى كلا موسمى الزراعة. برنامج المكافحة التقليدية متبوعا ببرنامج المكافحة المتكاملة للآفات أظهرا أفضل النتائج في جميع الصفات المدروسة مقارنة بمعاملة الكنترول فيما عدا عدد الثمار/ نبات ، المحصول غير التسويقى ، محتوى الثمار من الكاروتين ، الفينولات الكلية ، الفلافينولات الكلية ، محتوى الماء والحموضة. كانت الإختلافات بين برنامج المكافحة التقليدية وبرنامج المكافحة المتكاملة للآفات غير معنوية بالنسبة للمحصول ومكوناته. إضافة إلى ذلك أعطى التفاعل بين الأسمدة الكيماوية وبرنامج المكافحة التقليدية أفضل صفات النمو الخضرى والمحصول ، بينما أعطى التفاعل بين سماد الدواجن وبرنامج المكافحة التقليدية ثمار غنية فى المحتوى الكيماوي مقارنة بالتفاعلات الأخرى.
بناءً على النتائج السابقة يمكن التوصية بتسميد نباتات الطماطم بالأسمدة الكيماوية الموصى بها تحت برنامج المكافحة المتكاملة للآفات للحصول على أفضل محصول مع أعلى نسبة خفض للوريقات المصابة بيرقات التوتا أبسليوتا وأيضا الحشرة الكاملة/يوم ، على الرغم من أن الزيادة فى محصول الطماطم الناتجة عن أستخدام برنامج المكافحة التقليدية لم تكن معنوية ، فى حين أن إضافة سماد الدواجن للتربة قبل زراعة الطماطم بمعدل ١٠,٧٦ طن/فدان والرش الورقى بمبيدات الآفات الكيماوية أدى إلى تحسين جودة ثمار الطماطم.