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Organic Farming for Producing Tomato (*Solanumlycopersicum L.*) in clay Soils of Gezira, Sudan

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Abstract

Fields experiments were carried out for two consecutive seasons (2014/15 and 2015/16) at Gezira Research Station Farm. The main objective was to evaluate the effects of farm yard manure (0, 5 and 10 ton/ha), repellent plant (coriander) and Thiovit Jet 80% Wettable (0 and 8.8 gram per liter) as an elemental sulfur for controlling the powdery mildew on organic tomato production. The treatments were arranged in split split and split plot design replicated three times in the first and second season, respectively. The results showed that the repellent plant numerically increased the marketable yield of tomato in the first season by 87% and significantly by 46% in the second season. Tomato grown with repellent plant recorded the high marketable yield in the two seasons. The addition of 5 ton/ha of farm yard manure recorded the high marketable yield (3359 kg/ha) in the first season while application of 10 tons FYM gave the high yield (7466 kg/ha) in the second season. However, the addition of sulfur resulted in insignificant effect on all the studied traits of tomato and this may be attributed to its late application which was at fruit setting stage. The repellent plant significantly increased the number of branches per plant in the first season and only numerical increase in the second season, whereas both doses of FYM only recorded a slight increase in the plant height in the second season. The interaction between the three studied factors on all tomato traits was not significant except for the number of branches and the percent of the total soluble solids in the first season. Also a significant interaction was obtained between farm yard manure and sulfur which was reflected in plant height and sun scald where that between repellent plant and farm yard manure was shown in the percent of total soluble solids.

Key words: farm yard manure, repellent plant, elemental sulfur, organic farming, organic tomato

الزراعةالعضوية لانتاج الطماطم في الترب الطينية بالجزيرة، السودان

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المستخلص

نفذت تجارب حقلية لموسمين متتالين (15/2014 و 16/2015) في المزرعة البحثية لمحطة بحوث الجزيرة بهدف تقييم تاثير روث الابقار (صفر، 5 و 10 طن/هكتار)، نبات طارد للحشرات(كسبرة) و الكبريت العضوي (صفر و 8.8 جم/لتر) للتحكم في مرض البياض الدقيقي وذلك لانتاج طماطم عضوية. نظمت التجارب في نظام القطع المنشقة – المنشقة في ثلاث مكررات في الموسم الاول. وضع نبات الكسبرة في الاحواض الرئيسية، روث الابقار في الاحواض المنشقة والكبريت في الاحواض المنشقة-المنشقة. لم تتم اضافة الكبريت في الموسم الثاني، عليه وضع نبات الكسبرة في الاحواض الرئيسية وروث الابقار في الاحواض المنشقة.اشارت النتائج لزيادة رقمية (غير معنوية) في انتاج الطماطم التسويقي في الموسم الاول بلغت 86% وفي الموسم الثاني بزيادة معنوية بلغت 46%.سجلت الطماطم المنتجة في معية نبات الكسبرة انتاج تسويقي عالي في الموسمين المتتاليين. كما سجلت اضافة 5 طن روث ابقار/هكتار انتاج تسويقي عالي بلغ 3359 كجم طماطم/هكتار في الموسم الاول، بينما سجلت اضافة 10 طن روث ابقار/هكتار انتاجية عالية بلغت 7466 كجم طماطم/هكتار في الموسم الثاني. ولكن لم تسجل اضافة الكبريت المعدني اي زيادة معنوية في انتاج الطماطم في كل الصفات التي درست. هذا وقد سجلت معية نبات الكسبرة في وجود روث الابقار زيادة معنوية في عدد الفروع لنبات الطماطم في الموسم الاول وزيادة رقمية (غير معنوية) في طول النبات في الموسمين. وهذا ولم تسجل اي من جرعتي روث الابقار اي زيادة معنوية في كل الصفات التي درست ما عدا زيادة طفيفة جدا في طول النبات في الموسم الثاني. لم يكن التفاعل بين العوامل الثلاثة (روث الابقار، نبات الكسبرة والكبريت) اي زيادة معنوية في كل الصفات التي درست الا في كل من عدد الفروع للنبات والمواد الصلبة الزائبة في الموسم الاول. كما كان هنالك تاثير معنوي للتفاعل بين نبات الكسبرة وروث الابقار علي النسبة المئوية للمواد الصلبة الذائبة.

كلمات مفتاحية:روث الابقار، نبات طارد للحشرات، الكبريت العنصري، الزراعة العضوية، طماطم عضوية

Introduction

Tomato (*Solanumlycopersicum* L.) is widely cultivated vegetable crop in the world. It is an important cash crop for smallholders and medium scale commercial farmers (Naika*et al.*, 2005). Tomato is considered as one of the most important vegetables in Sudan due to its economic and nutritional values, it occupies about 28% of the total area of vegetables in Sudan which produces about 950 thousand tons of tomatoes per year (Mohammed 2009).Tomatoes prefer light textured soils with optimum pH ranges from 6.0 to 7.5 and the crop is most sensitive to salinity particularly at germination stage and the yield reduction is 25% at 5 dS/m (SYS, 1993).Nitrogen, phosphorus and potassium are critical nutrient elements for tomato growth and development. Nitrogen is associated with vegetative growth and biomass accumulation, phosphorus to seed and root development, while potassium is associated with fruit development and quality (Jones, 2008). Tomato is considered a crop with major fertilization requirements. It is considered as the second important significant vegetable crop in the world after onion. Tomato contains valuable vitamins, for instance vitamins A and C and also it contains fibers, and is known as free from cholesterol. At present, tomatoes are utilized at a higher rate in the developed countries than in

the developing countries (Badr *et al.*, 2010). The main producing areas of tomato in Sudan are: Gezira, Khartoum, Kassala, Gadarif, Sennar and the Blue Nile States.

Organic farming is a production system that avoids the use of chemical fertilizers, pesticides and growth regulating hormones. Tomato crop is raisedby the use of organic manures; crop rotation; legumes, green manure and biological pest control (Panda, 2011). Different vegetable crops are produced in the Sudan using the conventional system which allows the use of chemical compounds. Recently, world - wide, more attention has been given to organic farming.This kind of agriculture sustains the health of soils, ecosystems and people (human beings). Organic farming is considered as a result of the increasing global health awareness, which necessitates a high need for finding other options for producing safety products and at the same time keeps the soil environment healthy. As known, these products can only be accepted and marked as organic if they are produced under soils not treated with chemical compounds for at least three years.The United States Composting Council (USCC) (2008) stated that humus provides plant nutrients, beneficial microorganisms; improves soil structure, water holding capacity and stabilized soil pH; helps to control weeds, pests and diseases, and the soil to resist erosion by wind and water. Panda (2011) stated that the various benefits of organic farming are: a) organic food is normally priced 20-30% higher than conventional food; b) it does not involve capital investment as high as that required in chemical farming; c) farmers have a wealth of traditional knowledge that can be used in this kind of agriculture rather than for chemical farming.

Production of organic vegetables in the Gezira is lacking. Generally, organic agriculture is of low cost, more profitable, and safe to the environment compared to the conventional system. Tomato is very important for human nutrition and mostly consumed directly after harvest without cooking and for this reason it is better to be produced under organic system rather than under conventional system. Most of the soils in the Sudan are deficient in nitrogen and available phosphorus and have low contents of organic matter. Therefore, addition of different organic manures to these soils is expected to improve their chemical fertility, increase the moisture retention and water percolation, decrease the soil bulk density, enhance root penetration and encourage the overall plant growth.

Pests are the main constraint facing tomato production in the Sudan and farmers mostly rely on chemical pesticides for the control of these pests. However, the abuse of pesticidesis becoming a human concern. Now the tendency is to use non-chemical measures such as botanical materials and cultural practices for the management of the pests.

The main objectives of the study were to:

- Assess the effect of farm yard manure, coriander (as a repellent plant) and sulfur on growth and productivity of organic tomato.
- Reduce the use of synthetic chemical compounds.
- Improve the physical, chemical and biological properties of the soil.
- Avail healthy and safety organic tomato for human consumption.

Materials and methods

The experiments were conducted for two consecutive seasons at Gezira Research Station farm (2014/15 and 2015/16). Soil samples were collected from four depths (0 – 25, 25 – 50, 50 – 75 and 75 – 100 cm) for routine analysis. In the first season, the treatments were consisted of three levels of farm yard manure (FYM): 0, 5 and 10 t/ha; two rates of sulfur (S):0 and 8.8 gram per liter; the trade name of the used sulfur is Thiovit Jet 80% Wettable Granule. It is a fungicide for

controlling the powdery mildew. The combinations of the two factors (FYM and S) were evaluated under two conditions; with or without coriander (*Corianderum sativum*L) which was used as a repellent plant (RP). The treatments were arranged in split split plot design replicated three times in the first season; the main plots, sub plots and sub - sub plots were assigned to RP, FYM and S, respectively. In the second season, RP was assigned to main plots whereas FYM to sub plots and S was not used. A trench was manually made on the top of the two sides of each bed (140 cm apart), then the FYM was added and covered with soil before transplanting of tomato seedlings. Seeds of tomato (Joddy variety) were sown on 17/11/2014under the supervision of Central Trading Company in Khartoum and transplanting of seedlings was on 27.12.2014 and on 21/12/2015 in the second season. The seedlings were spaced at 50 cm on each side of the bed. The coriander was sown three weeks before transplanting of tomato seedlings; whereas sulfur was only applied in the first season on 18/2/2015 (at fruit setting). Data were collected on plant height, number of branches per plant, percent of total soluble solids (%TSS) and yield of tomato which included the marketable and none marketable yields. None marketable yield consists of fruits infested by blossom end rot, sun scald, insects and culls.

Results and discussion

The soil of the experimental site is none saline and slightly sodic at the top 50 cm. It has clay texture, alkaline reaction and low nitrogen content, organic carbon and available phosphorus. Generally, the soil bulk density is high especially in 25 –50 cm (1.9 g/cm^3) and 75 – 100 cm (1.91 g/cm^3) soil depths. In the first depth (25-50 cm), the high bulk density may be attributed to plowing at a fixed depth (20-25 cm) for a long time especially when the soil was moist, whereas the high values of bulk density below 75 cm are presumably attributed to overburden. Generally, the soil is classified as fine, smectitc, super activeisohyperthermic, TypicHaplusterts and was correlated to Remaitab none sodic soil series.

Table (1): Some physical and chemical soil properties of the experimental site

Soil property	Soil depth (cm)			
	0 - 25	25–50	50– 75	75 – 100
% Sand	8	10	7	8
% Silt	44	26	25	31
% Clay	48	64	68	61
pH (paste)	8.4	8.7	8.1	8.1
EC (dS/m)	0.7	2.0	0.9	0.5
ESP	14	15	2	3
% N	0.080	0.040	0.172	0.218
% O.C	0.250	0.281	0.125	0.125
CEC (cmol (+)/ kg soil	54	50	54	51
Avail P (ppm)	4.6	7.2	5.2	6.0
Soil bulk density (g/cm^3)	1.85	1.90	1.86	1.91

The data of the main effect of repellent plant and farm yard manure in the two seasons and sulfur in first season on marketable yield, blossom end rot, sun scald and culls of tomato fruits are displayed in Tables (2, 3 and 4), respectively. The data in Table 2 showed that the repellent plant numerically increased the marketable yield of tomato from 1525 to 2845 kg/ha which was equivalent to87%, whereas in the second season, it statistically significantly increased the marketable yield by 46% (i.e. from 4748 to 6926 kg/ha). This high increment indicated the effect of the repellent plant in promoting and increasing the production of marketable organic tomato. It was observed that tomato grown under repellent plant recorded the higher marketable yield in the two seasons compared to that without repellent plant. The effect of repellent plant was significant

on blossom end rot, sun scald, culls in the first season, significant on the marketable yield in the second season (Table 2).

Table (2): Effect of repellent plant on tomato (kg/ha) marketable yield, blossom end rot, sun scald and culls (2014/15 and 2015/16)

Treatment	Marketable yield	Blossom end rot	Sun scald	Culls	Marketable yield	Blossom end rot	Sun scald	Culls
	Season 2014/15				Season 2015/16			
With RP	2845	2864	753	1641	6926	165.1	956	6425
Without RP	1525	1458	471	799	4748	146.9	804	5102
S.E±	493	102	31	234	482.4	56.7	216.7	1181.5
Sig.	NS	*	*	*	*	NS	NS	NS
C.V	17	31	35	34	16.9	36.2	24.6	20.5

*, **, *** and NS indicated significance at ($P \leq 0.05$), ($P \leq 0.01$), ($P \leq 0.001$) and not significant, respectively. RP = repellent plant.

The farm yard manure in the first season significantly increased the culls whereas in the second season it significantly increased the marketable yield, blossom end rot, sun scald and culls. Generally, the positive influence of farm yard manure on crop production was reported by Elaagib (2007) Ibrahim *et al*(2002) and Elghball (2002). In this context Ali (1998) found that the use of organic manures is highly encouraged for sustainable agriculture and conservation of soil fertility. Also the benefits of compost for plant production and soil properties were reported by Kassim and Ali (1989).

The data in Table (3) indicated that the addition of 5 tons FYM/ha in the first season numerically increased each of the marketable yield of tomato, blossom end rot and sun scald over their respective values of the addition of 10 tons FYM/ha, whereas the increase of culls was significant ($P \leq 0.05$). These results are rather difficult to justify because it is generally known that an increase in addition of FYM is usually associated with an increase of water holding capacity, soil aeration (reduction of soil bulk density), good root penetration and ramification and plant nutrients. However, these results were completely reversed in the second season because the addition of 10 tons FYM/ha invariably and statistically increased each of the marketable yield of tomato, blossom end rot, sun scald and culls over their respective values of the addition of 5 tons FYM/ha.

Table (3): Effect of FYM (ton/ha) on marketable yield of tomato (kg/ha), blossom end rot, sun scald and culls (2014/15 and 2015/16).

FYM (ton/ha)	Marketable yield	Blossom end rot	Sun scald	Culls	Marketable yield	Blossom end rot	Sun scald	Culls
	Season 2014/15				Season 2015/16			
0	1260	1593	433	863	3833	80.5	661	3537
5	3359	2751	731	1603	6212	156.3	905	5796
10	1937	2138	672	1194	7466	231.2	1074	7957
S.E±	504	386	112	244	342.9	46.73	276	1186.3
Sig.	NS	NS	NS	*	***	***	*	***
C.V	17	31	35	34	16.6	30	31.4	20.6

*, ***, NS = Significant at $P \leq 0.5$, $P \leq 0.001$ and not significant, respectively.

The data in Table 4 showed the insignificant effect of sulfur on the four studied traits in the first season and this might be attributed to the late application of sulfur at fruit setting stage of tomato.

Table (4): Main effect of sulfur on tomato marketable yield, blossom end rot, sun scalds and culls, season 2014/15.

Treatment)	Marketable Yield (kg/ha)	Blossom end rot (kg/ha)	Sun scald (kg/ha)	Culls (kg/ha)
Sulfur (8.8 g/l)	2194	2180	599	1180
Without sulfur	2176	2141	623	1260
S.E±	87	157	50	99
Level of Sig.	NS	NS	NS	NS
%C.V	17	31	35	34

NS = Not significant.

The data of the effect of the three studied factors RP, FYM and sulfur on tomato 50% flowering, plant height, number of branches per plant and percentage of total soluble solids (TSS %) are presented in Tables (5, 6 and 7), respectively. As is evident from Table (5) the repellent plant had only significant increase in the number of branches per plant in the first season.

Table (5): Effect of repellent plant on fruits of tomato, 50% flowering, plant height (cm), branches/plant and TSS%, (2014/15 and 2015/16).

Treatment	50% Flowering	Plant height	Branches per plant	TSS %	50% Flowering	Plant height	Branches per plant	TSS %
	Season 2014/15				Season 2015/16			
With RP	38	44.5	11	3.8	47.04	60.83	4	3.4
Without RP	40	42.8	9	4.1	47.50	56.49	4	3.4
S.E±	0.3	0.7	0.2	0.1	0.274	3.33	0.19	0.064
Sig.	NS	NS	*	NS	NS	NS	NS	NS
C.V	3	8	13	22	1.2	5.7	4.7	1.9

*, NS = Significant at $P \leq 0.5$, and not significant, respectively

The data in Table (6) revealed that the control treatment in season 2014/15 invariably gave higher values of each of 50% flowering, plant height and number of branches /plant than their respective values of the 5 tons/ha and 10 tons/ha treatments. However, in season two the control treatment only recorded higher values of 50% flowering and number of branches/plant over their corresponding values of the 5 tons FYM/ha and 10 tons FYM/ha treatments. It was observed that for all the studied traits the data of 5 tons FYM/ha and the 10 tons FYM/ha were very comparable implying the futility of applying 10 tons FYM/ha.

Table (6): Effect of FYM (ton/ha) on tomato 50% flowering, plant height (cm), branches/plant and TSS%, (2014/15 and 2015/16).

FYM (ton/ha)	50% Flowering	Plant height	Branches per plant	TSS%	50% Flowering	Plant height	Branches per plant	TSS%
	Season 2014/15				Season 2015/16			
0	40	45.3	11	4	48.69	58.6	4.1	3.4
5	38	43.0	9	4	46.75	58.7	3.8	3.5
10	38	42.7	10	4	46.38	58.7	4.0	3.4
S.E±	0.6	1.1	0.3	0.1	0.323	3.03	0.32	0.17
Sig.	NS	NS	*	NS	***	NS	NS	NS
C.V	3	8	13	22	1.9	5.2	8.0	5.1

*, ***, NS = Significant at $P \leq 0.5$, $P \leq 0.001$ and not significant, respectively.

The effect of sulfur in the first season (2014/15) on 50% flowering, plant height, number of branches per plant and %TSS was not significant (Table 7).

Table (7):Effect of sulfur on traits of tomato (50% flowering, plant height, number of branches/plant and %TSS) season 2014/15

Treatment)	50% Flowering (days)	Plant height (cm)	No. of branches/plant	TSS (%)
Sulfur (8.8 g/l)	39	43.5	11	4.1
Without sulfur	39	43.9	10	3.9
S.E±	0.3	0.9	0.3	0.2
Level of Sig.	NS	NS	NS	NS
%C.V	3	8	13	22

NS = Not significant

A significant ($P \leq 0.05$) interaction between RP, FYM and S was reflected in the number of branches per plant and %TSS in the first season (Table 8).

Table (8): Effect of repellent plant, farm yard manure and sulfur on traits of tomato (number of branches/plant and %TSS), season 2014/15

Repellent plant	CFYM	Sulfur (g/l)	Branches/plant	TSS (%)
With repellent plant	0	0	12	4.0
		8.8	13	3.3
	5	0	11	4.0
		8.8	9	4.3
	10	0	11	4.0
		8.8	11	3.3
Without repellent plant	0	0	12	3.3
		8.8	9	5.3
	5	0	8	4.3
		8.8	8	3.3
	10	0	10	4.7
		8.8	8	4.
SE±			0.7	0.5
Level of Sig.			*	*
%C.V			13	22

* = Significant at $P \leq 0.05$

Also a significant ($P \leq 0.05$) interaction was observed between FYM and S in plant height and tomato fruits damaged by sun scald (Table 9), and between RP and FYM in the %TSS (Table 10).

Table (9):Effect of farm yard manure and sulfur on sun scald and plant height of tomato, season 2014/15

CFYM (t/ha)	Sulfur (g/l)	Sun scald (kg/ha)	Plant height (cm)
0	0	449	42.3
	8.8	417	48.3
5	0	572	44.1
	8.8	889	41.8
10	0	778	43.9
	8.8	566	41.5
SE±		86	1.5
Level of Sig.		*	*
%C.V		35	8

* = Significant at P ≤ 0.05

Table (10): Effect of repellent plant and farm yard manure on tomato TSS (%), season 2014/15

Repellent plant	CFYM (t/ha)	TSS (%)
With RP	0	3.7
	5	4.2
	10	3.7
Without RP	0	4.3
	5	3.8
	10	4.3
SE±		0.17
Level of Sig.		*
%C.V		22

* = Significant at P ≤ 0.05

Conclusions

1. Tomato grown with repellent plant (coriander) recorded the high marketable yields.
2. The insignificant effect of sulfur on all studied traits of tomato may be attributed to its late application at fruit setting stage.
3. Addition of 5 tons/ha of FYM was seemed to be quite enough for producing organic tomato in the soil under investigation.
4. The results revealed the possibility of producing organic tomato in Gezira Vertisols.
5. The interactions between the three studied factors on all tomato traits were not significant except for the number of branches and TSS.
6. Since the application of any chemical compounds is not allowed in the organic farming, therefore for successful and sustainable organic production of tomato, the following points shall be considered:

- Transplanting of tomato seedlings is recommended at the end of October or first week of November.
- Good selection of a uniform site that not infested by weeds especially noxious weeds such as Ankog and Nageila.

Recommendation

Based on the results of the present study, the application of 5 tons of FYM/ha coupled with growth of coriander as a repellent plant are recommended for production of organic tomato under the Remaitab none sodic phase of the Gezira Vertisols only on very small farms because huge quantities of FYM for large farms at present are unattainable in Sudan.

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