J. of Plant Production, Mansoura Univ., Vol. 12 (3):287-298, 2021

Journal of Plant Production

Journal homepage: www.jpp.mans.edu.eg
Available online at: www.jpp.journals.ekb.eg

Effect of Maize Plant Density, Compost and Sulfur on Productivity of Intercropped Maize and Tomato and some Soil Properties

Sheha, A. M.[1] ; Y. A. M. Abd-Allah[2*] and H. M. Elshahed[3]

[1] Crop Intensification Research Department - Field Crops Research Institute - Agricultural Research Center, Giza - Egypt
[2] Soil Water and Environment Research Institute, Agricultural Research Center, Giza - Egypt
[3] Maize Research Department - Field Crops Research Institute - Agricultural Research Center, Giza – Egypt

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ABSTRACT

Two field experiments were carried out at the Experimental Farm, EL- Gemmeiza Agricultural Research Station, El-Gharbia Governorate, ARC, during the two seasons 2019 and 2020 to study the effect of maize plant density (10, 12 and 14 thousand plant fed^{-1}), compost and sulfur on some soil physical and hydro physical properties and productivity of intercropped yellow maize with tomato and net economic return. A split- plot design with three replicates was used. The main-plots were assigned to the three plant densities (D1, 100% tomato + 50% maize ; D2, 100% tomato + 60% maize ; D3, 100% tomato + 70% maize) under different intercropping patterns. The sub-plots were allocated for soil conditioners (compost, sulfur and compost + sulfur as well as recommended doses of NPK).The results revealed that the maximum values of the all traits of maize and tomato were obtained when high plant density (D3) with compost + sulfur in both seasons. The lowest soil bulk density and settling percentage values and the highest total porosity ,void ratio and pore size distribution values were recorded with the high plant density (D3) and compost + sulfur in both seasons. Soil hydraulic conductivity and soil moisture characters were increased in all treatments at the two soil depths in both seasons compared with the sole planting of maize or tomato. The high plant density (D3) with compost + sulfur gave the highest values of water use efficiency, LER, ATER, LEC, MAI and Net economic return in both seasons.

Keywords: Compost, sulfur, plant density, intercropping, tomato and maize.

INTRODUCTION

Maize (*Zea mays* L.) is the most important cereal crop, comes the third after wheat and rice in Egypt. Maize is very essential either for the human food or animal feeding and as a common ingredient for several industrial products. Also, maize is used as a feed for livestock whether fresh, silage or grains. Recently, it is necessary to increase maize yield to face the wide gap between production and consumption. Increasing maize production can be achieved by improving cultural practices and planting the promising hybrids. Maize agronomists are continually looking for the best ways that help farmers to increase grain yield and net return of the crop, such as suitable intercropping pattern, optimum plant distributions and nitrogen fertilizer levels. Tomato (*Solanum lycopersicum* L.) is one of the most important vegetable crops grown in large areas in Egypt for local market, processing and exportation. In Egypt, the climate is relatively cold in winter and hot in the summer with dry conditions. If temperature increases up to 40 °C, it causes heat injury, i.e. burning leaves, no growth (Gent, 1990). Flowering and fruit setting of tomato are influenced by air and soil temperature during summer season in middle Egypt. Thus, providing natural protection from heat weather may be achieved by intercropping maize with tomato. by maize shading and increasing economic feture for the farmers as well as increasing maize production .This achiev by inproving cultural practices sueh as using differnt fertilizer rates, fertilizer sources, maize plant densities...*ect*(Stumiatie 1989,Gent 1990 and Saleh 1992) several researchers have conducted trails on the effect of intercropping some field crops to protect tomato plants. Abd El-Aal and Zohry (2004) found that intercropping tomato with faba bean maximized utilization of irrigation water quantity by saving 31% compared to solid treatment. Also, tomato fruit yield and marketable fruits yield were increased by intercropping. Ibrahim *et al* . (2010) found that the highest yield of intercropped tomato with faba bean was 20.19 ton fed^{-1} compared to 14.8 ton fed^{-1} for solid tomato. The total income of tomato in all intercropping treatments were evidently higher than that of the solid. The maximum value of total land equivalent ratio (2.21) and total income (LE 18650) were obtained when four rows of faba bean were grown on both sides of tomato terraces (Mohammed, Wafaa *et al.*, 2013 and El–Sadany and El-Shamy 2016). Sutoyo *et al.* (2020) found that addition of soil amendments (biochar, compost and chicken manurs) to clay soil led to decrease soil bulk density and increase soil organic matter, soil particle, field capacity, available water, hydraulic conductivity and water content at wilting point compared with the control. Seidel *et al.* (2017) obtained that intercropping system increases the aggregate stability and macroporosity. They added that , intercropping maintains soil function, such as aeration, water infiltration, retention and nutrient availability. Yeshpal *et al.* (2017) conclude that the treatment consisting of 100% NPK with FYM and Sulphur proved most effective on organic carbon (O.C) content and water holding capacity and promising for sustained crop productivity and better soil health. Udom *et al.* (2019) showed that bulk density, total porosity, water content and hydraulic conductivity of the soil were significantly improved by the application of poultry manure to maize and aerial yam intercrop compared to the control. Intercropping has been advanced as one of the integrated soil fertility management practices (Matusso *et al.* 2014) and is considered as an important

* **Corresponding author.**
E-mail address: dr-yosri@hotmail.com
DOI: 10.21608/jpp.2021.160667

way to increase the yield of unit area. Soil and water conservation practices including terrace structures have ability to enhance the soil moisture contents for crop use by significantly increased (16%) and minimized the soil sediment loss consequently soil nutrients loss were diminished which in response increased the wheat yield 20% (Rashid *et al.* 2016). Zhang *et al.* (2012) reported that intercropping can promote the full use of cropland water by plant roots, increase the water storage in root zone, reduce the inter-row evaporation and control excessive transpiration, and create a special microclimate advantageous to the plant growth, therefore increasing the crop yield per unit area greatly in comparison to mono-cropping systems. El-Tantawy (2017) revealed that the most of growth and yield parameters of both crops were increased with intercropping pattern treatments which was fertilized by 6 ton compost fed^{-1}, compared to tomato or cowpea sole crop in the first and second seasons. Qiao *et al.* (2017) found that water consumption (CU) for maize plants decreased with low plant density more than medium and high plant density, while water use efficiency (WUE) increased under high and medium plant density more than low plant density. Suman *et al.* (2018) obtained that the treatment of 100% NPK+FYM or 100 NPK + sulfur caused increasing in both aggregates and soil moisture content and decreasing bulk density in the two soil depths (0-15 and 15-30 cm) compared with the control. Bhatt *et al.* (2019) observed that the lowest bulk density was found due to application of 50% N dose through FYM and 50 % NPK as a result to organic matter resulted in considerable increase in polysaccharides and microbial synthesis in the soil. Bharose *et al.* (2014) observed that soil bulk density was gradually decreased and water holding capacity was gradually increased with increase of sulfur and FYM. El-Nady, Manal (2015) showed that planting on terrace width reduced the amounts of irrigation water applied and increased irrigation water productivity under the two cropping systems maize and soybean which improved soil properties.

Flowering and fruit setting of tomato were influenced by higher temperatures which reach up to 45ºC, it causes heat in July, *i.e* burning leaves, fruits damage and reducing tomato yield/fed. Therefore, the objective of the present investigation is intercropping maize with tomato to protect it from higher temperature as a result of maize shading; and adding some soil amendments *i.e* compost and sulfur to improve physical and hydro physical properties, yield and its components of both crops ,competitive relationships and total income for farmer.

MATERIALS AND METHODS

Two field experiments were carried out at EL-Gemmeiza Agricultural Research Station, El-Gharbia Governorate, ARC, Egypt during 2019 and 2020 seasons to evaluate the effect of maize plant density and soil conditioners i.e compost and sulfur on some soil physical and hydro physical properties and on maize and tomato association competitive relationships and yield advantages. As well as the economical value.

Studied factors (treatments and experimental design):

A split- plot design with three replicates was used where the plot area was $21m^2$ as five terraces, each of 1.4 m width and 3.0 m length. The main-plots were used for the three maize plant dentists under different intercropping patterns as follows:

D1-(100% tomato + 50% maize) by growing maize plants on the other side of tomato terraces at 60 cm apart between hills and leaving two plants /hill to give 10000 maize plants .

D2-(100% tomato + 60% maize) by growing maize plants on the other side of tomato terraces at 50 cm apart between hills and leaving two plants /hill to give 12000 maize plants .

D3-(100% tomato +70% maize) by growing maize plants on the other side of tomato terraces at 43 cm apart between hills and leaving two plants /hill to give 14000 maize plants.

Beside of pure stands of tomato and maize as recommended. Tomato was planted on one side of terraces at 30 cm a part between hills and leave one plant/hill either in intercropping patterns or in pure stand to give 10000 plants/fed .

The sub-plots were allocated to soil conditioners treatments as follows:

1- Recommended doses of NPK.
2- Compost (5 ton fed^{-1}) + 75% N fertilizer + recommended doses of P and K.
3- Sulfur (200 kg fed^{-1}) + recommended doses of NPK.
4- Compost (5 ton fed^{-1}) + sulfur (200 kg fed^{-1}) + 75% N fertilizer + recommended doses of P and K.

Some physical and chemical soil properties of the two soil depths (0-20 and 20-40cm) of the experimental site before planting are shown in table (1) and analysis of the used compost are presented in Table (2).

Table 1. The initial physical properties of the used soil in the first and second seasons.

Properties		First season		Second season	
Soil depth, cm		0-20	20-40	0-20	20-40
Particle size distribution, %	Sand	21.60	21.33	21.60	20.33
	Silt	34.82	34.59	34.82	34.19
	Clay	43.58	44.08	44.58	44.48
Texture class		Clay	Clay	Clay	Clay
Bulk density (Db, g cm^{-3})		1.44	1.45	1.43	1.44
Total porosity (E, %)		45.66	45.28	46.04	45.66
Void ratio (e)		0.84	0.83	0.85	0.84
Settling, %		30.75	30.92	30.01	30.57
$CaCO_3$, %		3.87	3.64	3.57	3.35
Hydraulic conductivity (Kh, cm hr^{-1})		0.42	0.41	0.43	0.42
Pore size distribution, %	> 9 µ	22.13	22.08	22.75	22.61
	9 - 0.2 µ	11.10	10.89	10.72	10.63
	< 0.2 µ	12.43	12.31	12.57	12.42
Soil moisture content, %	Saturation percentage (SP)	71.16	70.93	71.21	71.06
	Field capacity (FC)	37.15	36.09	37.92	36.89
	Wilting point (WP)	19.40	18.56	19.95	19.74
	Available water (AW)	17.65	17.49	17.83	17.13

Table 2. Some properties of the used compost.

Properties	Value
Density (g cm^{-3})	0.57
pH (1:10 compost: water)	7.43
EC, dS m^{-1}(1:10 compost:water) extract	3.15
Ca, %	0.82
Mg, %	0.25
Na, %	0.23
Available Fe, mg kg^{-1}	1197
Available Zn, mg kg^{-1}	79.68
Available Mn, mg kg^{-1}	64.18
Available Cu, mg kg^{-1}	28.92
Ash, %	67.66
*Organic matter, %	32.34
Organic carbon, %	18.76
Total N, %	1.54
C/N ratio	12.18
Total P, %	0.86
Total K, %	2.11

*** Organic matter (O.M.) = Organic carbon (O.C.) X 1.724 (Waksman, 1952)**

The previous crop was sugar beet in both seasons. The tomato hybrid (G.S12) was planted on 23th and 27th April in the first and second seasons, respectively. Yellow maize hybrid

(TWC 352) was planted on on 5th and 7th June in the first and second seasons, respectively. Recommended pest control was applied when necessary. Compost and phosphour were added and homogenously mixed with 0-20cm surface soil layer before planting in the first and second seasons. Sulfur mixed with *thiobacillus* and added to soil before planting. NPK chemical fertilizers were applied in both seasons, where N fertilizers were applied at the rats of 200 and 120 kg fed^{-1} as a recommended dose for tomato and maize plants, respectively in the form of ammonium nitrate (33.5%). P and K fertilizers were applied as a recommended dose for tomato and maize, 31 kg P_2O_5 fed^{-1} for both tomato and maize plants in the form of mono super phosphate (15.50% P_2O_5) and 72, 48 kg K_2O fed^{-1} for tomato and maize plants, respectively in the form of potassium sulphate (48% K_2O) while the sole of tomato and maize were applied NPK as a recommended doses. N and K fertilizers were applied in equal four doses for tomato, the first two doses were applied before maize planting, while the other two doses were applied with two doses of maize.The normal agricultural practices except those under study were carried out as usual for each crop according to the recommendations of El-Gemmeiza Research Station. Harvesting was done for tomato on 13th and 15th August in both seasons. Also, the hybrid maize was harvested on 14th and 16th September in both seasons.

After harvesting of each growing season, soil samples (0-20 and 20-40 cm) were taken from each sub plot to determine some soil physical and hydrophysical properties. Soil bulk density (Db, gcm^{-3}) was determined using the core methods (Vomocil, 1986). Total porosity (E,%) and void ratio (e) were calculated using the following equations:-

$$E,\ \% = \left(1 - \frac{Db}{Dr}\right) \times 100 \qquad e = \frac{Dr}{Db} - 1$$

Where: Db = the bulk density, g cm^{-3}
Dr = the real density, taken as 2.65 g cm^{-3}

Settling percentage of the soil aggregates was determined in soil aggregates of 2–5 mm size, as the method described by Williams and Cooke (1961). Pore size distribution was calculated according to De Leenher and De Boodt (1965).

Hydraulic conductivity (cm hr^{-1}) was determined using undisturbed soil cores using a constant water head according to Richards (1954). Soil moisture characteristics and soil moisture content (ϴw,%) were determined using the method outlined by Stakman (1969). Water consumption (CU) was determined by collecting soil samples from each plot before and after 48 hours of every irrigation and computed according to the equation of Israelsen and Hansen (1962).

$$Water\ \text{consumption},\ m.m = \frac{\theta_2 - \theta_1}{100} \times Db \times D$$

Where:
θ2 = Soil moisture percentage on weight basis after 48 hours from irrigation.
θ1 = Soil moisture percentage before irrigation.
Db = Bulk density, g/cm^{3}
D = Soil depth, cm

Water use efficiency (WUE) was calculated by dividing the fruit yield of tomato and grain yield maize (kg fed^{-1}.) by water consumptive use (m.m) according to the equation Jensen (1983):

$$WUE,\ \text{kg fed}^{-1}\text{m.m}^{-1} = \frac{Grain\ \ yield, (kg\ fed^{-1})}{Water\ consumption\ \ (m.m)}$$

Data recorded:

At harvest time, random samples of ten guarded plants were taken from each plot to determine the following characters:

Maize traits:

Plant height (cm), ear height (cm), ear leaf area (ELA), ear length (cm), ear diameter (cm), number of rows ear^{-1}, number of kernels row^{-1}, 100- kernel weight (g) and grain yield (ardab fed^{-1}). Grain yield was adjusted to moisture content of 15.5 % and transformed to ardab per feddan (ardab = 140 kg).

Tomato traits:

Plant height (cm), number of branches/plant, fruit diameter (m.m.), number of fruits/ plant, fruit weight (g),fruit weight / plant (kg) and fruit yield (ton/fed).

Competitive relationships and yield advantages:

The following competitive relationships and yield advantages were calculated:

1- Land equivalent ratio (LER): It was determined according to the formula described by Willey and Rao (1980):

$$\textbf{LER} = \frac{Yab}{Yaa} + \frac{Yba}{Ybb}$$

Where: Yaa and Ybb were pure stand of crops, a (tomato) and b(maize), respectively. Yab is intercropped yield of (a) crop and Yba is intercropped yield of (b) crop.

2- Land equivalent coefficient (LEC): It is a measure of interaction concerned with the strength of relationship and was calculated according to Adetiloye and Ezedinma. (1983) as following:

LEC = La x Lb

Where : La = RYt Relative yield of Tomato and Lb = RYM Relative yield of maize

3- Monetary advantage index (MAI) fed^{-1}: Suggests that the economic assessment should be in terms of the soil saved value, this could probably to assessed on the basis of rentable value of soil. MAI was calculated according to the formula, suggested by Willey (1979).

$$MAI = \frac{value\ of\ combined\ intercrop\ x\ (LER - 1)}{LER}$$

4- Area time equivalent ratio (ATER): The ratio between number of hectare-days required in monoculture to the number of hectare-days used in the intercrop to produce identical quantities of each component, was calculated according to Hiebsch and Mc-Collum (1987) as follows:

$$\text{ATER} = (\text{RYa} \times \text{ta}) + (\text{RYb} \times \text{tb})/\text{T or ATER} = \left(\frac{\text{Yab}}{\text{Yaa}} \times \text{ta}\right) + \left(\frac{\text{Yba}}{\text{Ybb}} \times \text{tb}\right)/\text{T}.$$

Where: RY = Relative yield of crop a (tomato) or crop b (maize). *i.e.*, yield of intercrop/yield of main crop, t = duration (days) for species a or b and T = duration (days) of the intercropping system.

5- Economic evaluations: Gross return from each treatment was calculated in Egyptian pounds (LE):

Tomato fruits /fed(ton)=1750L.E
Maize grains./fed.(ard) = 400 LE

In 2019 and 2020 seasons, market price of the yield was determined according to the ministry of agriculture and land reclamation, economic affairs sector, agricultural statistics.

Statistical analysis:

The obtained data were statistically analyzed according to the technique of analysis of variance (ANOVA) for the strip-plot design as published by Gomez and Gomez (1984) using “MSTAT-C” computer software package.

RESULTS AND DISCUSSION

Effect of different treatments on some soil physical properties.

Soil bulk density (Db), Total porosity (E) and Void ratio (e)

The results presented in Table (3) purported that the effect of plant density (D1, D2 and D3) was not significant on either decreasing bulk density or increasing both total porosity and void ratio. Soil conditioners led to significant decreases in bulk density (Db) values and significant increases in total porosity (E) and void ratio (e) where (Db) values decreased from 1.41 to 1.15 g cm^{-3} and from 1.42 to 1.21 g cm^{-3} at (0-20 and 20-40 cm) soil depths, respectively in the first season and were from 1.39 to 1.10 g cm^{-3} and from 1.40 to 1.15g cm^{3} at the two soil layers, respectively in the second season. On the other hand, total porosity (E) values increased from 46.79 to 56.60% and from 46.42 to 54.47% at the two soil layers, respectively in the first season and were from 47.55 to 58.49% and from 47.17 to 56.48% at (0-20 and 20-40 cm) soil depths, respectively in the second season. These results can be attributed to the major role of compost on improvement soil physical properties. Similar results were obtained by Bharose *et al.* (2014), El-Tantawy (2017) and Yeshpal *et al* (2017).

The obtained results in Table (4) indicated that soil bulk density values decreased, while total porosity and void ratio values increased with all the experimental treatments at the two soil depths (0- 20 and 20- 40cm) at the end of the two growing seasons compared with the sole planting of maize or tomato, where the lowest (Db) values were 1.10 and 1.17 gcm^{-3} at (0- 20 and 20- 40 cum) soil depths, respectively in the first season and were 1.05 and 1.11 gcm^{-3} at the same soil depths, respectively in the second season. On the other hand, soil total porosity (E) and void ratio (e) values took the opposite trend, where the highest (E) values were 58.49 and 55.85% at the two soil depths, respectively in the first season and were 60.38 and 58.11% at the surface soil layer (0-20cm) and sub surface soil layer (20-40cm), respectively in the second one, on the same contextually the highest (e) values were 1.41 and 1.26 at (0-20and 20-40cm) soil depths, respectively in the first season and were 1.52 and 1.39 at the two soil layers, respectively in the second season. From the previous results, it can be deduced that, the lowest (Db) values and the highest (E) and (e) values were recorded due to the interaction effect of plant density(D3) with (compost + sulfur). These results assure the major role for compost in improvement soil structure by compost organic matter decomposition, consequently caused lowering soil bulk density and increasing both total porosity and void ratio. These results are in harmony with those obtained by Suman *et al.* (2018), Bhatt *et al.* (2019) , Udom *et al.* (2019)and Sutoyo *et al.* (2020).

Table 3. Effect of maize plant density and soil conditioners on some soil physical properties during 2019 and 2020 seasons.

Characters		Bulk density (Db, gcm^{3})				Total porosity (E,%)				Void ratio (e)				Settling, %				Pore size distribution, % >9µ				9-0.2µ				<0.2µ			
		2019		2020		2019		2020		2019		2020		2019		2020		2019		2020		2019		2020		2019		2020	
Factors		0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm
Intercropping patterns	D1-(100% tomato + 50% maize)	1.32	1.35	1.29	1.32	50.19	48.96	51.42	50.28	1.02	0.97	1.07	1.02	28.68	29.58	26.90	28.28	23.55	23.23	24.82	24.28	12.41	12.18	12.18	11.87	14.23	13.56	14.42	14.13
	D2-(100% tomato + 60% maize)	1.30	1.33	1.26	1.29	51.04	50.00	52.55	51.32	1.05	1.01	1.12	1.06	27.85	28.85	25.97	27.37	23.86	23.57	25.42	24.68	12.66	12.28	12.28	11.85	14.52	14.15	14.86	14.80
	D3-(100% tomato +70%maize)	1.27	1.31	1.23	1.27	52.17	50.76	53.49	52.26	1.11	1.04	1.17	1.11	27.15	28.36	25.41	27.04	24.29	23.78	25.74	25.48	13.05	12.60	12.32	12.08	14.83	14.38	15.44	14.71
	F - test	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
	L.S.D 0.05	0.06	0.06	0.06	0.06	2.19	2.12	2.55	2.18	0.28	0.26	0.30	0.28	2.26	1.52	1.33	2.58	1.17	0.55	2.02	1.61	1.33	0.53	3.55	1.11	1.84	1.49	1.49	1.80
Soil conditioners	Recommended of (NPK)	1.41	1.42	1.39	1.40	46.79	46.42	47.55	47.17	0.88	0.87	0.91	0.89	30.54	30.73	29.94	30.34	22.71	22.59	23.35	23.38	11.49	11.38	10.71	10.56	12.59	12.44	13.37	13.24
	Compost	1.26	1.30	1.23	1.27	52.33	51.07	53.58	52.20	1.10	1.04	1.15	1.09	26.49	28.06	24.20	26.63	24.18	23.71	26.16	25.54	13.03	12.73	12.26	11.71	15.12	14.63	15.16	14.96
	sulfur	1.36	1.39	1.32	1.34	48.80	47.67	50.32	49.31	0.95	0.91	1.01	0.97	28.90	29.75	27.84	28.85	23.40	23.21	24.45	24.20	12.20	11.96	11.65	11.53	13.21	12.50	14.21	13.58
	Compost + Sulfur	1.15	1.21	1.10	1.15	56.60	54.47	58.49	56.48	1.31	1.20	1.41	1.30	25.64	27.18	22.41	24.43	25.31	24.59	27.20	26.13	14.11	13.33	14.42	13.94	17.19	16.54	16.87	16.41
F - test		**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	*	**	**	**	**	*	**	**	**	**	**
L.S.D 0.05		0.06	0.06	0.06	0.06	2.17	2.13	5.28	2.19	0.08	0.07	0.09	0.08	2.26	1.99	1.32	1.40	1.25	1.36	0.76	1.27	1.35	0.51	2.59	1.12	1.17	1.50	1.60	1.41

Settling percentage (structural stability)

The percentage of settling of soil aggregates was determined as aspect of structural stability. The values of settling percentage indicate a high degree of structural stability and vice versa. Results in Table (3) reveal that settling percent significantly decreased by the application of compost and sulfur, where values ranged from 30.54 to 25.64% and from 30.73 to 27.18% at the two soil layers, respectively in the first season and were from 29.94 to 22.41% and from 30.34 to 24.43% at (0 – 20 and 20- 40 cm) soil depths, respectively in the second season, also results showed that settling percent values were insignificant under the effect of plant density (D1, D2 and D3) where the mean values decreased from 28.68 to 27.15% and from 29.58 to 28.36% at the two soil layers, respectively in the first season and were from 26.90 to 25.41% and from 28.28 to 2.04% at the same layers, respectively in the second season.

The results in Table (4) point to that the settling percentage values were decreased with all treatments at (0-20 and 20-40cm) soil depths in the two growing seasons compared with the sole treatments of maize or tomato. The lowest settling values were 24.53 and 26.23% at the two soil depth, respectively in the first season and were 21.47 and 23.26% at the same depths, respectively in the second season. The results confirmed that interaction effect of the treatment (compost + sulfur + plant density (D3)) gave the lowest values settling percent (high degree of structural stability). These results agree with those obtained by Seidel *et al.* (2017) and Sutoyo *et al.* (2020).

Pore size distribution.

Results in Table (3) cleared that the effect of plant densities were not significant on increasing the pore size distribution values. On the other hand, macro, medium and micro pores values significantly increased with compost and sulfur added to soil, where the macro pores values ranged from 22.71 to 25.31% and from 22.59 to 24.59 at (0- 20 and 20- 40 cm) soil depths, respectively in the first season, while in the second season they were 23.35 to 27.20% and from 23.38 to 26.13% at the two soil layers, respectively. Also the medium and micro pores values took the same trend.

Data in Table (4) refer that the pore size distribution as a percent of total porosity, it can be observed that, all treatments led to increase in the values of large, medium and micro pores at the two soil depths at the end of the two growing seasons compared with the sole planting of maize or tomato. The highest large pores values were 25.96 and 24.97% at the two soil depths, respectively in the first season and were 27.87 and 26.93% at the same soil depths, respectively in the second one, while the highest medium pores values were 14.82 and 13.92% at the same soil layers, respectively in the first season and were 14.94 and 14.55% at the soil depths (0 – 20 and 20- 40cm), respectively in the second season, in terms the highest micro pores values were 17.71 and 16.96% at the two soil layers, respectively, while in the second season they were 17.57 and 16.63% at the same depths, respectively. From these results it can be noticed that, the highest macro, medium and micro pores values were achieved under interaction effect of the treatment plant density (D3) with compost + sulfur. These results may be attributed to improve soil structure by binding soil properties into aggregates a sequence of increased microbial activity in soil after compost application. These results corroborated by Bharose *et al.* (2014) and Suman *et al.* (2018).

Table 4. Effect of the interaction between maize plant density and soil conditioners on some soil physical properties during 2019 and 2020 seasons.

Treatments		Bulk density (Db, gcm^{-3})				Total porosity (E,%)				Void ratio (e)				Settling, %				Pore size distribution, %											
																		>9μ				9-0.2μ				<0.2μ			
		2019		2020		2019		2020		2019		2020		2019		2020		2019		2020		2019		2020		2019		2020	
Intercropping patterns	Soil conditioners	0-20cm	20-40cm	0-20cm	20-40cm	0-20cm	20-40cm	0-20cm	20-40cm	0-20cm	20-40cm	0-20cm	20-40cm	0-20cm	20-40cm	0-20cm	20-40cm	0-20cm	20-40cm	0-20cm	20-40cm	0-20cm	20-40cm	0-20cm	20-40cm	0-20cm	20-40cm	0-20cm	20-40cm
D1- (100% tomato +50% maize)	Recommended of (NPK)	1.41	1.42	1.39	1.40	46.79	46.42	47.55	47.17	0.88	0.87	0.91	0.89	30.75	30.92	30.01	30.57	22.51	22.48	23.15	23.13	11.33	11.21	10.95	10.74	12.95	12.73	13.45	13.30
	Compost	1.30	1.33	1.26	1.31	50.94	49.81	52.45	50.57	1.04	0.99	1.10	1.02	27.48	28.76	25.54	27.75	23.82	23.54	25.57	24.47	12.76	12.57	12.21	11.51	14.36	13.70	14.67	14.59
	sulfur	1.38	1.41	1.35	1.37	47.92	46.79	49.06	48.30	0.92	0.88	0.96	0.93	29.92	30.19	28.43	29.63	23.09	22.96	24.13	23.98	11.96	11.82	11.50	11.41	12.87	12.01	13.43	12.91
	Compost + Sulfur	1.19	1.25	1.15	1.19	55.09	52.83	56.60	55.09	1.23	1.12	1.30	1.23	26.57	28.45	23.63	25.18	24.78	23.93	26.41	25.53	13.57	13.11	14.06	13.83	16.74	15.79	16.13	15.73
D2- (100% tomato +60% maize)	Recommended of (NPK)	1.41	1.42	1.39	1.40	46.79	46.42	47.55	47.17	0.88	0.87	0.91	0.89	30.65	30.82	29.96	30.33	22.73	22.54	23.62	23.40	11.52	11.42	10.92	10.82	12.54	12.46	13.01	12.95
	Compost	1.26	1.29	1.23	1.26	52.46	51.32	53.58	52.45	1.10	1.05	1.15	1.10	26.26	27.85	23.87	26.16	24.11	23.76	26.21	25.38	13.09	12.77	12.24	11.62	15.26	14.79	15.13	15.46
	sulfur	1.36	1.39	1.31	1.34	48.68	47.55	50.57	49.43	0.95	0.91	1.02	0.98	28.68	29.87	27.92	28.11	23.43	23.11	24.51	24.01	12.11	11.96	11.69	11.51	13.14	12.48	14.37	13.91
	Compost + Sulfur	1.16	1.20	1.10	1.16	56.23	54.72	58.49	56.23	1.28	1.21	1.41	1.28	25.82	26.86	22.13	24.86	25.18	24.87	27.32	25.93	13.93	12.97	14.25	13.43	17.12	16.88	16.92	16.87
D3- (100% tomato +70% maize)	Recommended of (NPK)	1.41	1.42	1.39	1.40	46.79	46.42	47.55	47.17	0.88	0.87	0.91	0.89	30.23	30.46	29.84	30.11	22.89	22.76	23.65	23.60	11.63	11.52	10.25	10.11	12.27	12.14	13.65	13.46
	Compost	1.23	1.27	1.20	1.23	53.58	52.08	54.72	53.58	1.15	1.09	1.21	1.15	25.72	27.56	23.18	25.97	24.62	23.82	26.71	26.76	13.23	12.86	12.32	11.99	15.73	15.40	15.69	14.83
	sulfur	1.33	1.36	1.29	1.32	49.81	48.68	51.32	50.19	0.99	0.95	1.05	1.01	28.11	29.18	27.16	28.82	23.67	23.56	24.72	24.61	12.53	12.11	11.77	11.66	13.61	13.01	14.83	13.92
	Compost + Sulfur	1.10	1.17	1.05	1.11	58.49	55.85	60.38	58.11	1.41	1.26	1.52	1.39	24.53	26.23	21.47	23.26	25.96	24.97	27.87	26.93	14.82	13.92	14.94	14.55	17.71	16.96	17.57	16.63
F-test		N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
L.S.D 0.05		0.11	0.11	0.10	0.11	3.76	3.69	9.14	3.79	0.14	0.12	0.15	0.14	3.92	3.45	2.29	2.42	2.16	2.36	1.32	2.20	2.34	0.89	4.48	1.94	2.02	2.59	2.76	2.44
Soled Maize		1.43	1.44	1.42	1.43	46.04	45.66	46.42	46.04	0.85	0.84	0.87	0.85	31.18	31.21	30.95	31.10	22.19	22.15	22.88	22.73	11.13	11.12	10.86	10.75	12.72	12.39	12.68	12.56
Soled Tomato		1.42	1.43	1.41	1.42	46.42	46.04	46.79	46.42	0.87	0.85	0.88	0.87	30.93	31.09	30.33	30.96	22.31	22.16	22.93	22.73	11.18	11.15	11.00	10.88	12.93	12.73	12.86	12.81

Effect of different treatments on some soil hydrophsical properties.

Soil hydraulic conductivity (Kh).

Results in Table (5) obtained that the (kh) values were not significantly increased with plant density (D1, D2 and D3) while (kh) values significantly increased with compost and sulfur added to soil, where (kh) values ranged from 0.46 to 0.66 and from 0.45 to 0.65 cm hr^{-1} at (0- 20 and 20- 40 cm) soil depths, respectively in the first season and were from 0.48 to 0.72 and 0.46 to 0.69 cm/hr^{-1} at the same depths, respectively in the second season. These results may be attributed to the higher levels of water stable aggregates and more macro pores fraction, leading to greater hydraulic conductivity.

Statistical analysis in Table (6) showed that soil hydraulic conductivity (Kh) values increased with all treatments at (0–20 and 20–40 cm) at the end of the two growing seasons compared with the sole planting of maize or tomato. The (kh) values varied from layer to another and from season to season where the highest (kh) values were 0.76 and 0.70 cm hr^{-1} at the two soil layers, respectively in the first season, while in the second season were 0.79 and 0.73 cm hr^{-1} at the two soil depths, respectively, it can be observed that, (kh) values in the second season were greater than the first season, this may be due to compost decomposition in the second season was greater than the first season. These result are in line with those reported by Seidel *et al.*(2017), Udom *et al.* (2019) and Sutoyo *et al.* (2020).

Soil moisture characteristics.

Generally, soil moisture content are influenced by the particle size, soil structure and organic matter content. As concerned, the effect of plant density (D1, D2 and D3) on soil moisture characters shown in Table (5) were not significant, while soil moisture characters (SP, FC, WP, AW and θW%) were significantly increased by the application of compost and sulfur to soil, where there are significant variations from soil layer to another and from season to season. FC values ranged from 38.40 to 42.97% and from 37.43 to 41.44% at the two soil depths, respectively in the first season and were from 39.74 to 45.86% and from 38.58 to 43.59% at the same depths, respectively in the second season, however the increasing in (AW) values ranged from 18.28 to 21.06% and from 17.88 to 20.02% at the two soil depths, respectively in the first season, while in the second season increases were from 18.67 to 22.68 and from 17.86 to 20.89% at the same depths, respectively. Similar findings were found by Matusso *et al.* (2014) and Yeshpal *et al.* (2017)

Results recorded in Table (6) cleared that soil moisture characters (SP, FC, WP, AW and θW% just before harvesting) increased at (0- 20 and 20- 40cm) soil depths at the end of the two growing season as a result to the effect of interaction treatments compared with the sole planting of maize or tomato. The highest FC values were 43.98 and 43.17% at the two soil layers, respectively in the first season and were 46.96 and 45.18% at the same depths, respectively in the second one, meanwhile the highest AW values were 21.76 and 20.96% at (0-20 and 20- 40cm) soil depths, respectively in the first season, while in the second season were 23.35 and 22.11% at the two soil layer, respectively. Also the highest SP, WP, and θW% values took the same trend. From the results in Table (6) it can be noticed that, the highest soil moisture characters values (SP, WP, AW and θW%) were recorded due to interaction effect of the treatment compost + sulfur and plant density (D3). These results attributed to the improvement of soil physical properties, which lead to occurs improvement in soil moisture characters as a result to compost decomposition which added to soil. These results are in harmony with those recorded by Zhang *et al.* (2012) and El-Nady, Manal (2015)

Table 5. Effect of maize plant density and soil conditioners on some soil hydro physical properties during 2019 and 2020 seasons.

Characters		Hydraulic conductivity (Kh, cm/hr))				Saturation percentage (SP.%)				Field capacity (FC.%)				Wilting point (WP.%)				Available water (AW.%)				Soil moisture content Just before harvesting (Θw, %)				Water consumption (CU, m.m)		Water use efficiency (WUE, Kg fed^{-1} $m.m^{-1}$)	
		2019		2020		2019		2020		2019		2020		2019		2020		2019		2020		2019		2020					
Factors		0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 Cm	20-40 cm	0-20 Cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	2019	2020	2019	2020
Intercropping patterns	D1-(100% tomato + 50% maize)	0.53	0.50	0.56	0.54	74.58	73.20	75.99	74.66	39.88	38.25	41.71	40.26	20.69	19.89	21.80	21.41	19.19	18.36	19.92	18.85	16.94	18.32	17.46	19.31	938.13	929.40	24.14	24.28
	D2-(100% tomato + 60% maize)	0.55	0.52	0.58	0.56	75.56	73.80	76.78	75.45	40.35	38.91	42.35	40.74	20.87	20.22	21.94	21.42	19.48	18.69	20.42	19.32	17.51	18.85	18.38	21.27	944.53	935.90	25.70	26.04
	D3-(100% tomato +70%maize)	0.59	0.56	0.62	0.59	76.19	74.57	78.11	76.67	41.13	39.74	43.22	41.63	21.25	20.68	22.38	21.76	19.88	19.06	20.84	19.88	17.82	19.44	19.40	20.91	950.60	941.13	27.91	28.70
	F-test	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	**	**	**	**
	L.S.D 0.05	0.09	0.14	0.09	0.06	3.27	2.00	1.61	1.99	1.74	4.95	5.76	2.88	0.90	0.86	0.96	1.56	0.83	0.80	1.98	0.79	1.27	2.14	2.99	5.41	0.05	0.04	0.02	0.02
Soil conditioners	Recommended of (NPK)	0.46	0.45	0.48	0.46	72.52	71.73	72.87	72.40	38.40	37.43	39.74	38.58	20.12	19.55	21.07	20.71	18.28	17.88	18.67	17.86	15.55	16.04	16.22	18.07	965.03	954.90	21.71	21.88
	Compost	0.57	0.54	0.61	0.57	76.20	74.10	78.14	76.12	40.98	39.28	42.96	41.62	21.21	20.49	22.26	21.90	19.77	18.79	20.70	19.72	18.00	20.30	19.75	21.37	939.70	929.73	27.37	27.40
	sulfur	0.50	0.48	0.53	0.51	73.77	72.85	74.84	73.89	39.45	37.71	41.15	39.71	20.51	19.59	21.64	20.80	18.95	18.12	19.51	18.91	16.97	17.93	17.35	19.37	951.33	945.90	24.23	24.93
	Compost + Sulfur	0.66	0.65	0.72	0.69	79.28	76.76	81.99	79.96	42.97	41.44	45.86	43.59	21.91	21.42	23.18	22.70	21.06	20.02	22.68	20.89	19.16	21.20	20.33	23.18	921.60	911.37	30.35	31.15
F-test		**	**	**	**	**	**	**	**	**	*	*	*	**	**	**	*	**	**	**	**	**	**	**	**	**	**	**	**
L.S.D 0.05		0.07	0.04	0.08	0.06	3.26	2.27	1.75	3.15	1.73	2.89	5.77	3.35	0.91	0.87	0.95	1.92	0.83	0.80	1.56	0.82	1.66	2.18	1.44	1.46	1.13	1.12	0.02	0.02

Table 6. Effect of the interaction between maize plant density and soil conditioners on some soil hydro physical properties during 2019 and 2020 seasons.

Treatments		Hydraulic conductivity (Kh, cm hr^{-1})				Saturation percentage (SP,%)				Field capacity (FC,%)				Wilting point (WP,%)				Available water (AW,%)				Soil moisture content Just before harvesting (Θw, %)				Water consumption (CU, m.m)		Water use efficiency (WUE, Kg fed^{-1} $m.m^{-1}$)	
		2019		2020		2019		2020		2019		2020		2019		2020		2019		2020		2019		2020					
Intercropping patterns	Soil conditioners	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 cm	20-40 cm	0-20 Cm	20-40 cm	0-20 cm	20-40 cm	2019	2020	2019	2020
D1- (100% tomato +50% maize)	Recommended of(NPK)	0.45	0.44	0.47	0.45	72.13	71.34	72.55	72.13	38.13	37.05	39.27	38.23	20.02	19.24	20.85	20.60	18.11	17.81	18.42	17.63	15.19	15.63	15.93	16.13	959.50	952.40	19.75	19.79
	Compost	0.55	0.52	0.58	0.55	75.11	73.18	76.92	74.95	40.15	38.55	42.11	40.83	20.82	20.22	21.96	21.76	19.33	18.33	20.15	19.07	17.73	19.52	18.25	20.32	933.40	921.20	26.53	25.65
	sulfur	0.49	0.47	0.51	0.49	73.13	72.53	73.96	72.93	39.11	37.15	40.59	39.13	20.32	19.12	21.46	20.46	18.79	18.03	19.13	18.67	16.35	17.39	16.46	18.23	947.20	942.10	22.39	22.37
	Compost + Sulfur	0.63	0.57	0.67	0.65	77.96	75.76	80.53	78.63	42.11	40.23	44.88	42.83	21.59	20.97	22.92	22.80	20.52	19.26	21.96	20.03	18.48	20.73	19.18	22.56	912.40	901.90	27.87	29.29
D2- (100% tomato +60% maize)	Recommended of (NPK)	0.46	0.45	0.48	0.46	72.58	71.73	72.96	72.46	38.32	37.52	39.71	38.54	20.11	19.65	21.07	20.63	18.21	17.87	18.64	17.91	15.51	15.92	16.11	20.82	966.20	954.80	21.55	21.52
	Compost	0.57	0.54	0.60	0.57	75.93	73.92	77.63	75.78	40.92	39.36	42.86	41.78	21.05	20.43	22.04	21.92	19.87	18.93	20.82	19.86	18.15	20.42	19.83	21.15	939.50	928.60	26.58	26.77
	sulfur	0.50	0.48	0.52	0.51	73.96	72.86	74.83	73.83	39.32	37.83	41.09	39.87	20.40	19.72	21.62	20.91	18.92	18.11	19.47	18.96	16.93	17.82	17.24	19.96	949.20	945.90	24.11	25.07
	Compost + Sulfur	0.66	0.61	0.71	0.68	79.76	76.69	81.69	79.73	42.83	40.92	45.74	42.75	21.93	21.09	23.01	22.22	20.90	19.83	22.73	20.53	19.46	21.23	20.35	23.15	923.20	914.30	30.55	30.79
D3- (100% tomato +70% maize)	Recommended of (NPK)	0.48	0.46	0.50	0.48	72.86	72.11	73.11	72.62	38.76	37.72	40.25	38.96	20.23	19.75	21.29	20.91	18.53	17.97	18.96	18.05	15.96	16.56	16.63	17.25	969.40	957.50	23.84	24.32
	Compost	0.60	0.57	0.64	0.60	77.57	75.19	79.86	77.63	41.86	39.92	43.92	42.25	21.75	20.81	22.79	22.02	20.11	19.11	21.13	20.23	18.13	20.96	21.16	22.63	946.20	939.40	29.01	29.77
	sulfur	0.52	0.50	0.55	0.53	74.22	73.15	75.72	74.91	39.93	38.15	41.76	40.13	20.80	19.94	21.83	21.02	19.13	18.21	19.93	19.11	17.63	18.58	18.35	19.93	957.60	949.70	26.18	27.34
	Compost + Sulfur	0.76	0.70	0.79	0.73	80.12	77.83	83.76	81.53	43.98	43.17	46.96	45.18	22.22	22.21	23.61	23.07	21.76	20.96	23.35	22.11	19.54	21.65	21.46	23.82	929.20	917.90	32.62	33.38
F–test		N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	**	**	**	**
L.S.D 0.05		0.13	0.07	0.13	0.11	5.65	3.93	3.02	5.45	3.00	5.00	9.99	5.80	1.57	1.52	1.64	3.33	1.43	1.39	2.71	1.41	2.87	3.77	2.50	2.53	1.96	1.94	0.04	0.04
Soled maize		0.43	0.42	0.44	0.43	71.33	70.96	71.29	71.11	37.18	36.12	38.18	37.18	19.45	18.59	20.21	19.96	17.73	17.53	17.97	17.22	15.05	15.11	15.09	15.21	692.30	688.90	4.95	5.08
Soled tomato		0.44	0.43	0.45	0.44	71.85	71.15	71.92	71.63	37.82	36.92	38.76	37.85	19.77	19.14	20.55	20.20	18.05	17.78	18.21	17.65	15.11	15.46	15.13	15.92	658.70	653.20	41.67	42.30

Water consumption (CU) and water use efficiency (WUE)

Data in Table (5) cleared that water consumption was significantly decreased, while water use efficiency was significantly increased by using plant density, where (CU) values decreased from 950.60 to 938.13 m.m in the first season and from 941.13 to 929.40 m.m in the second season, whereas (WUE) values increased from 24.14 to 27.91 in the first season and from 24.28 to 28.70 kg fed^{-1} $m.m^{-1}$ in the second season. Also the results in Table (5) cleared the effect of soil conditioners on water consumption and water use efficiency, where (CU) values were significantly decreased from 965.03 to 921.60 m.m in the first season and from 954.90 to 911.37 m.m in the second season, while (WUE) were significantly increased from 21.71 to 30.35 kg fed^{-1} $m.m^{-1}$ in the first season and 21.88 to 31.15 kg $fed^{-1}$$m.m^{-1}$ in the second season. These results may be due to the compost applied to soil reduced the applied amounts of irrigation water supplied and increased irritation water productivity.

The results in Table (6) obtained the effect of the interaction between plant density and soil conditioners on water consumption (CU) and water use efficiency (WUE). The lowest (CU) values were 912.40 and 901.90 m.m in the first and second seasons, respectively, while the highest (WUE) values were 32.62 and 33.38 kg fed^{-1} m.m^{-1} in the first and second seasons, respectively. These results showed that the lowest (CU) was recorded by the treatment consist of low plant density (D1) with (compost + sulfur) while the highest WUE values were achieved by the treatment consist of high plant density (D3) with compost + sulfur. These results agree with those obtained by Qiao *et al.* (2017), Udom *et al.* (2019) and Sutoyo *et al.* (2020).

Generally, the results of this research suggest that plant density with the application of compost and sulfur to soil have played a positive role in improving soil physical and hydro physical properties under these soil conditions, which reflect on the yield of tomato and maize.

Maize growth, yield and its attributes:

Plant density effect:

The obtained results presented in Table (7) showed that plant density of maize intercropped with tomato exhibited significant effects on maize growth, yield and its attributes *i.e.* plant height, number of leaves/plant, ear leaf area (cm^2), ear length and ear diameter, number of rows ear $^{-1}$, number of grains row^{-1}, weight of 100 grains and grain yield fed^{-1}, in both seasons. Planting maize on one side of terraces of plant density 14 thousand plant/fed., and leaving two plants/hill (D3), attained the highest values of the all traits . On the other hand the lowest values were recorded on planting maize on one side of terraces of plant density 10 thousand plant/fed., and leaving two plants/hill (D1) on maize during 2019 and 2020 summer growing seasons. These results are in harmony with those reported by Doerge *et al.* (2002), Chim *et al.* (2014) , Silva *et al.* (2015) and Hamdany and Darwish (2017).

Results in Table 7 show that the plant density effect on 100-kernel weight was significant in 2019 and 2020 growing seasons. Increasing the distance between planting in terraces from 10, 12 to 14 thousand plant/fed., and leaving two plants/hill., significantly increased 100-kernel weight (28.48 , 30.58, 34.18 and 28.73, 31.56 , 34.00 g. in the first and second seasons, respectively). Generally, planting maize in densities of 12 and 14 thousand plant/fed., and leaving two plants/hill recorded the highest values of 100-kernel weight in 2019 and 2020 growing seasons, respectively. These results may be due to better interception of solar radiations by plant canopy which enhanced grain filling and yield of maize plants. Similar results were obtained by Shaheen *et al.* (2001) and Zamanian and Najafi (2002).

Also, the results are shown in Table 7 show that the plant density effect on grain yield fed^{-1} was significant in both growing season. Increasing plant density from 10 to 12 and 14 thousand plant/fed., and leaving two plants/hill lead to a significant increase in grain yield fed^{-1} (11.44 , 16.36 and 19.71 in 2019, and 13.28 , 16.45 and 20.09 ardb fed^{-1} in 2020 growing seasons, respectively). These results may be due to better interception and utilization of solar radiations and the increase in photosynthetic processes in case of high plant density (D3), which led to an increase in all growth attributes and all yield components. These results are in agreement with those obtained by Yadav and Singh (2000), Zamanian and Najafi (2002) , Leite *et al.* (2003) and Valentinuz *et al.* (2003) .

Effect of soil conditioners

The results in Table (7) demonstrated that the effect of soil conditioners on maize growth, yield and its attributes (plant height, number of leaves/plant, ear leaf area (cm^2), ear length and ear diameter, number of rows ear^{-1}, number of grains of row^{-1}, 100 kernel weight and grain yield fed^{-1}). The highest values of the all traits were recorded by treatment fertilizer (compost + sulfur), while low values were recorded by treatment (recommended doses of NPK) during the two planting seasons.

It was also found that there was a significant increase in ear leaf area by adding fertilizer (compost + sulfur), it gave the highest average leaf area (757.6, 755.5 cm^2)while the lowest rate was when using recommended doses of NPK which reached 530.5, 531.22 cm^2 during the 2019 and 2020 planting seasons, respectively.

Results in Table (7) showed that the addition of compost fertilizer and sulfur had a significant effect on the grain yield (ard./fed.) compared with the recommended doses of (NPK), where the treatment (compost + sulfur) was superior by giving the highest grain yield (ard./fed.) 18 30, 19,14 ard./ fed. compared with recommended doses of (NPK), which gave the lowest values of 14.57 and 14.56 ard./fed. during the two seasons respectively. It was evident from the results shown in Table (7) the superiority of fertilization treatment (compost with sulfur), perhaps due to the positive effect of these fertilizers on plant growth, as it was found that they play an important role in improvement yield and its components. Comparable results were in coincided with those stated by John *et al* . (2002), Saleh and Nawar (2003) and Astier *et al* . (2005).

Table 7. Effect of maize plant density and soil conditioners on maize growth and yield characters during 2019 and 2020 seasons.

Characters		Plant height (cm)		Number of leaves /plant		Ear leaf area (cm^2)		Ear length (cm)		Ear diameter (cm)		Number of rows/ ear		Number of kernels/ row		100 kernel weight (g)		grain yield (ard./fed.)	
factors		2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Intercropping	D1-(100% tomato + 50% maize)	249.2	253.1	9.25	10.25	564.9	574.2	16.40	17.03	3.54	3.48	10.41	10.37	28.86	29.55	28.48	28.73	11.44	13.28
	D2-(100% tomato + 60% maize)	260.0	266.9	11.69	12.55	627.7	637.4	17.96	19.11	3.99	4.19	12.52	12.20	30.85	32.10	30.58	31.56	16.36	16.45
	D3-(100% tomato +70%maize)	272.1	280.9	15.78	16.85	710.0	714.2	19.28	20.14	4.64	4.60	13.58	13.56	34.49	33.95	34.18	34.00	19.71	20.09
	F-test	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
	L.S.D 0.05	0.64	0.69	0.32	0.46	33.14	16.95	0.32	0.44	0.14	0.25	0.33	0.21	0.53	0.28	0.58	0.72	0.47	0.23
Soil conditioners	Recommended of (NPK)	246.9	253.3	10.03	11.10	530.5	531.2	16.62	17.83	3.52	3.56	9.06	10.42	29.21	29.64	28.48	27.60	14.57	14.56
	Compost	262.2	267.5	12.94	13.80	655.6	585.7	18.31	18.96	4.06	4.32	12.8	12.46	31.84	31.66	31.66	32.90	15.75	16.96
	sulfur	262.1	268.9	10.48	11.56	593.2	595.3	17.21	18.22	3.84	3.93	12.90	11.55	30.31	31.58	29.88	30.44	14.73	15.77
	Compost + Sulfur	272.4	278.2	15.49	16.41	757.6	755.5	19.38	20.04	4.81	4.54	13.92	13.74	34.23	34.59	34.31	34.77	18.30	19.14
	F-test	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
	L.S.D 0.05	0.79	1.30	0.31	0.54	21.5	15.9	0.44	0.29	0.17	0.21	0.22	0.17	0.44	1.66	0.29	0.49	0.41	0.22
Soled maize		266.13	270.29	14.76	14.81	785.6	792.8	20.63	21.02	4.60	4.87	14.37	14.75	34.93	36.43	34.77	35.45	24.5	25.00

Table 8. Effect of the interaction between maize plant density and soil conditioners on maize growth and yield characters during 2019 and 2020 seasons.

Treatments		Plant height (cm)		Number of leaves /plant		Ear leaf area (cm^2)		Ear length (cm)		Ear diameter (cm)		Number of kernels/ row		Number of rows / ear		100 seed weight (g)		Grain yield (ard./fed)	
Intercropping patterns	**Soil conditioners**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**
D1-(100% tomato + 50% maize)	Recommended of (NPK)	235.7	242.0	7.23	8.80	479.8	473.7	15.17	15.79	3.23	3.05	27.30	27.47	7.47	9.20	25.93	26.67	9.87	11.27
	Compost	249.3	253.0	10.43	11.20	593.0	627.9	17.33	17.29	3.23	3.80	29.63	30.33	10.57	10.68	29.57	29.77	11.36	14.12
	sulfur	251.9	256.2	7.80	8.43	532.2	507.7	15.60	16.68	3.50	3.45	27.93	28.83	11.33	9.65	27.67	27.73	10.27	12.11
	Compost + Sulfur	259.7	261.1	11.53	12.57	654.7	687.6	17.50	18.37	4.20	3.61	30.57	31.57	12.27	11.95	30.73	30.73	14.27	15.63
D2-(100% tomato + 60% maize)	Recommended of (NPK)	246.6	253.9	8.10	8.80	519.8	530.2	16.57	18.79	3.13	3.74	28.83	29.07	9.33	10.42	28.47	28.83	15.67	13.93
	Compost	261.9	268.1	11.67	12.57	636.1	679.6	18.40	19.12	4.33	4.25	31.40	33.27	13.30	12.86	31.50	33.20	16.00	16.80
	sulfur	261.8	267.8	11.34	12.47	572.3	605.2	17.53	18.49	3.80	3.90	29.67	31.70	13.10	11.65	29.40	30.47	15.37	15.90
	Compost + Sulfur	269.7	277.8	15.63	12.37	782.7	734.4	19.33	20.04	4.70	4.85	33.50	34.37	14.33	13.85	32.97	33.73	18.40	19.17
D3-(100% tomato + 70% maize)	Recommended of (NPK)	258.4	264.0	14.77	15.70	591.8	589.8	18.13	18.89	4.20	3.88	31.50	32.40	10.37	11.65	31.03	27.30	18.17	18.48
	Compost	272.2	281.4	16.73	17.63	737.8	749.4	19.20	20.49	4.60	4.91	34.50	31.37	14.53	13.84	33.90	35.73	19.88	19.96
	sulfur	269.7	282.6	12.30	13.77	675.0	673.1	18.50	19.50	4.23	4.45	33.33	34.20	14.27	13.35	32.57	33.13	18.57	19.31
	Compost + Sulfur	287.9	295.6	19.30	20.30	835.4	844.6	21.30	21.70	5.53	5.17	38.63	37.83	15.17	15.40	39.23	39.83	22.23	22.62
F-test		**	**	**	**	*	*	*	**	**	*	**	*	**	**	**	**	**	**
L.S.D 0.05		1.37	2.25	0.54	0.94	37.3	27.61	0.76	0.50	0.29	0.35	0.76	2.87	0.38	0.30	0.50	0.85	0.71	0.39
Soled maize		266.13	270.29	14.76	14.81	785.6	792.8	20.63	21.02	4.60	4.87	34.93	36.43	14.37	14.75	34.77	35.45	24.5	25.00

Effect of interaction:

The interaction effect between plant density (10, 12 and 14 thousand plant/fed., and leaving two plants/hill) and soil conditioners (compost, sulfur and compost + sulfur), was significant on maize growth, yield and its attributes (plant height, number of leaves/plant, ear leaf area (cm^2), ear length and ear diameter, number of kernels rows^{-1}, number of rows ear^{-1}, 100 kernel weight and grain yield fed^{-1}) in both seasons (Table 8). The maximum values of the all traits in both seasons. were obtained from planting maize on one side of terraces of plant density 14 thousand plant/fed., and leaving two plants/hill (D3) with fertilizations treatment (compost + sulfur), in both seasons. Nevertheless, the lowest values of the all traits were resulted from planting maize on plant density 10 thousand plants/fed., and leaving two plants/hill (D1) with recommended doses of (NPK) in both seasons.

Tomato growth, yield and its attributes:

Plant density effect:

The studied plant density of maize intercropped with tomato excreted significant effects on tomato growth, yield and its attributes, *i.e*., Plant height (cm), number of branches/plant, fruit diameter (m.m.), number of fruits/ plant, fruit weight (g), fruit weight / plant (kg) and fruit yield ton fed^{1}., in both seasons. Planting maize on one side of terraces of plant density 14 thousand plants/fed., and leaving two plants/hill (D3) and planting tomato on the other side of the terraces attained the highest values of the all traits at the same time the lowest values were recorded when Planting maize on one side of terraces of plant density 10 thousand plants/fed., and leaving two plants/hill (D1) and planting tomato on the other side of the terraces during 2019 and 2020 summer growing seasons. These increments in growth, yield and its attributes of tomato with D3 plant density may be ascribed to that plant density have great importance in the interception and efficiency of conversion of the photosynthetically active radiation intercepted by the canopy into Increase fruit yield (Ogundari and Ojo, 2005). Also, this plant density can be reduce the use efficiency of water, light and nutrients by plants (Moyin-Jesu, 2012).

Results in Table 9 revealed that the plant density effect on number of branches/plant was significant in both growing seasons. Increased planting maize of from 10 to 12 and 14 thousand plants/fed., and leaving two plants/hill and planting tomato on the other side of the terraces increased number of branches/plant. Clearly that maize plant density 14 thousand plant/fed., and leaving two plants/hill (D3) and planting tomato on the other side of the terraces, enhanced plant growth and hence increased number of branches/plant at harvest. Similar findings were found by Martine (2011) and Ijoyah and Dzer (2012).

The obtained results in Table 9 revealed that tomato fruit weight / plant (kg), was significantly affected by plant density in both growing seasons. The highest fruit weight / plant (kg) (3.59 and 4.04 kg) were resulted of planting maize plants on one side of terraces of plant density 14 thousand plants/fed., and leaving two plants/hill (D3) and planting tomato on the other side of the terraces, in both seasons. Similar findings were found by Degri and Samaila (2014) and El–Sadany and El-Shamy (2016).

Also, the results shown in Table 9 cleared that the plant density effect on fruit yield ton fed^{-1} was significant in both growing seasons. Increasing maize plant density from 10 to 12 and 14 thousand plants /fed., and leaving two plants/hill and planting tomato on the other side of the terraces, lead to a significant increase in fruit yield per fed. (21.03, 21.93 and 23.73 in 2019, and 20.63, 22.02 and 24.15 ton fed^{-1} in 2020 growing seasons, respectively). These results may be due to better interception and utilization of solar radiations and the increase in photosynthetic processes, which led to an increase in all growth attributes and all yield components. These results are in agreement with those obtained by Upadhyay *et al* (2010), Mohammed, Wafaa *et al* (2013) and Hamdany and Darwish (2017).

Effect of soil conditioners:

Significant variations were observed between soil conditioners (compost, sulfur and compost + sulfur) tested as for tomato characters (Plant height (cm), number of branches/plant, fruit diameter (m.m.), number of fruits/ plant, fruit weight (g),fruit weight / plant (kg) and fruit yield ton fed ^{1}.) studied in both seasons (Table 9). the application of (compost + sulfur) brought marked increases in most tomato attributes and yield compared with both (recommended, NPK, compost or sulfur). In other meaning, application of (compost + sulfur), gave a favorable effect on tomato yield components, reflecting, therefore better yields per unit land area. The promoted effect of land fertilization to a limited level and on tomato as for yield and it's related parameters was documented by some research workers, such as El–Nady, Manal (2015) and Rashid *et al.* (2016).

Results in Table (9) showed the response of tomato fruit yield to (compost + sulfur fertilizer). Use of (compost + sulfur fertilizer) increased fruit yield ton/fed. significantly than compost in both seasons. They had 25.48, 20.99 and 23.52 ton/fed (in 2019 season) and 25.72, 21.38 and 23.11 ton/fed (in 2020 season) compared with recommended doses of NPK (18.92 ton/fed and 18.86 ton/fed) in both seasons, respectively. This effect of treatment (compost + sulfur fertilizer) refer to improving of the soil physicals which play an important role in uptake nutrients and gave good active root system, where founding nutrient elements available, this active promote photosynthese and accumulation of dry matter. These results are in harmony with those obtained by Bharose *et al.* (2014), Seidel *et al.* (2017), Suman *et al.* (2018) and Sutoyo *et al.* (2020).

Effect of interaction:

Regarding plant height (cm), number of branches/plant, fruit diameter (m.m.), number of fruits/ plant, fruit weight (g), fruit weight / plant (kg) and fruit yield ton/ fed.)

The results in Table (10) show that, tomato plants was significantly affected by the interaction between planting maize on one side of terraces of plant density from 10 to 12 and 14 thousand plant/fed., and leaving two plants/hill and planting tomato on the other side of the terraces and soil conditioners (compost, sulfur and compost + sulfur). Plant density 14 thousand plant/fed., and leaving two plants/hill (D3) and planting tomato on the other side of the terraces, attained the highest values of the all traits when applying compost and sulfur ,while, the lowest values were obtained with plant density 10 thousand plant/fed., and leaving two plants/hill (D1) and planting tomato on the other side of the terrace with recommended doses of NPK during 2019 and 2020 summer growing seasons.

Land equivalent ratio (LER)

Result in Table (11) indicate that intercropping maize with tomato as average of the two seasons. Results indicated that LER values were greater with intercropping system than sole crop of them. The values of land equivalent ratio for intercropping treatments were significantly greater than monoculture. It was the same (1.0) for all pure stands of main crop and intercrops. maize with tomato and using plant density (D3) and application of (compost + sulfur), recorded the highest values for (LER) which were (1.898 and 1.899) in both seasons. Intercropping maize with tomato with using plant density (D1) and application of recommended doses of NPK recorded the lowest values for (LER) which was 1.043 and 1.076 in both seasons. Similar results were observed by Mohammed, Wafaa *et al* (2013) , Abd El-Hady *et al* (2013), El–Sadany and El-Shamy (2016) and El-Mehy, Amira and Mohamed (2018).

Table 9. Effect of maize plant density and soil conditioners on tomato growth and yield characters during 2019 and 2020.

Characters		plant height (cm)		Number of branches /plant		Fruit diameter (m.m)		Number of fruit / plant		Fruit weight (g)		Fruit weight / plant (kg)		Fruit yield (Ton /fed)	
Factors		2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Intercropping patterns	D1-(100% tomato + 50% maize)	61.85	62.29	3.54	3.79	43.38	44.56	21.83	23.13	95.67	100.17	2.13	2.35	21.03	20.63
	D2-(100% tomato + 60% maize)	63.23	66.22	5.03	5.78	48.36	49.22	25.55	26.08	109.00	106.91	2.76	2.98	21.93	22.02
	D3-(100% tomato +70%maize)	69.60	70.89	7.46	8.00	53.08	53.38	29.81	31.58	121.97	125.60	3.59	4.04	23.73	24.15
	F-test	**	**	**	**	**	**	**	**	**	*	**	**	**	**
	L.S.D 0.05	2.08	0.81	0.55	0.49	1.83	0.27	0.55	0.26	1.14	12.55	0.21	0.36	0.43	0.34
Soil conditioners	Recommended of (NPK)	59.67	57.44	3.54	3.64	44.23	44.68	21.48	22.04	96.59	100.03	2.10	2.23	18.92	18.86
	Compost	66.21	68.56	5.81	6.35	49.02	49.32	26.76	28.08	111.68	108.07	2.95	3.30	23.52	23.11
	Sulfur	63.51	63.90	4.78	5.04	45.57	47.24	23.98	24.44	106.19	109.14	2.46	2.69	20.99	21.38
	Compost + Sulfur	70.19	75.97	7.24	8.38	54.27	54.97	30.71	33.14	121.06	126.32	3.79	4.26	25.48	25.72
	F-test	**	**	**	**	**	**	**	**	**	**	**	**	**	**
	L.S.D 0.05	1.69	0.81	0.37	0.22	1.35	0.25	0.50	0.40	0.87	11.68	0.18	0.04	0.29	0.22
	Soled tomato	77.29	78.44	7.59	7.66	58.65	58.83	36.15	36.32	135.18	136.25	4.89	4.97	27.45	27.63

Table 10. Effect of the interaction between mazie plant density and soil conditioners on tomato growth and yield characters during 2019 and 2020 seasons.

Treatments		Plant height (cm)		Number of branches /plant		Fruit diameter (m.m)		Number of fruit / plant		Fruit weight (g)		Fruit weight / plant (kg)		Fruit yield (Ton /fed)	
Intercropping patterns	Soil conditioners	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
D1-(100% tomato + 50% maize)	Recommended of (NPK)	58.27	50.40	1.90	2.11	39.87	40.87	17.77	18.67	83.33	87.70	1.48	1.63	17.57	17.27
	Compost	62.80	64.73	4.00	3.87	45.67	45.80	22.53	23.80	99.44	102.27	2.24	2.43	23.17	21.65
	sulfur	60.93	61.27	2.70	2.72	39.50	43.73	20.90	20.93	93.47	98.40	1.95	2.06	19.77	19.38
	Compost + Sulfur	65.40	72.77	5,57	6.44	48.47	47.83	26.13	29.10	106.43	112.30	2.85	3.26	23.60	24.23
D2-(100% tomato + 60% maize)	Recommended of (NPK)	56.27	57.87	3.33	3.27	44.13	44.37	21.80	21.70	96.40	99.23	2.10	2.15	18.63	18.60
	Compost	65.97	67.17	5.70	6.33	48.77	48.60	26.47	26.57	111.43	92.37	2.72	3.07	22.73	22.51
	sulfur	60.53	64.13	4.57	5.20	46.77	47.43	23.90	23.53	106.67	108.60	2.55	2.55	20.73	21.49
	Compost + Sulfur	70.17	75.70	6.53	8.33	53.77	56.47	30.03	32.53	121.50	127.43	3.65	4.14	25.63	25.47
D3-(100% tomato + 70% maize)	Recommended of (NPK)	64.47	64.07	5.40	5.54	48.70	48.80	24.87	25.77	110.03	113.17	2.74	2.91	20.57	20.70
	Compost	69.87	73.77	7.73	8.87	52.63	53.57	31.27	33.87	124.17	129.57	3.88	4.39	24.67	25.17
	sulfur	69.07	66.30	7.07	7.21	50.43	50.57	27.13	28.87	118.43	120.43	2.88	3.47	22.47	23.27
	Compost + Sulfur	75.00	79.43	9.63	10.37	60.57	60.60	35.97	37.80	135.23	139.23	4.87	5.39	27.20	27.47
F-test		*	**	NS	**	*	**	**	**	*	NS	**	**	**	**
L.S.D 0.05		2.92	1.40	NS	0.38	2.34	0.44	0.87	0.70	1.5	NS	0.31	0.07	0.51	0.38
Soled tomato		77.29	78.44	7.59	7.66	58.65	58.83	36.15	36.32	135.18	136.25	4.89	4.97	27.45	27.63

Area time equivalent ratio (ATER):

High area time equivalent ratio (1.8 and 1.81) was obtained when intercropping maize with tomato and using plant density (D3) and application of (compost + sulfur) as average of two seasons. These values indicated that the intercropping system was highly efficient in utilizing the growth resources than sole cropping of both crops, (Table 7). Whereas, intercropping maize with tomato with using planting in plant density (D1) and application of recommended doses of NPK recorded the lowest values of ATER (0.99 and 1.027) was obtained as an average of the two successive seasons. These results are in agreement with those obtained by Verma *et al* (2005) , Mohammed, Wafaa *et al* (2013) and El-Mehy, Amira and Mohamed (2018).

Land Equivalent Co-efficient (LEC):

When the values of LEC were increased than 25%, the treatments were positive; this means that all treatments had LEC values above 0.25 suggesting yield advantages and showed efficient utilization of land resource by growing both crops together and *vice versa*. So, all treatments as a combination between factors under study were increased than 25% in both seasons. Results revealed that the best yield advantage as the interaction between factors under study was shown under plant density (D3) and with compost and sulfur (0.899 and 0.900) in both season. These results are in accordance with those obtained by Nassef, Dalia and EL-Gaid (2012) and Mohammed, Wafaa *et al*., (2013)

Total income:

Results in Table (12) clearly revealed the total income of intercropping when intercropping maize with tomato and using plant density (D3) with, application of (compost + sulfur). According to the objective, intercropping maize with tomato gave the highest total income was L.E. 24806 flowed by L.E. 24678.5 when maize with tomato, while the lowest total income was L.E.3279.5 and 3044.5 intercropping maize with tomato with using maize planting in plant density (D1) with application of recommended doses of NPK in both seasons. The total income showed that intercropping with tomato more profitable for farmers than sole maize.

Table 11. Effect of the interaction between maize plant density and soil conditioners on land equivalent ratio (LER), area time equivalent ratio (ATER) and land equivalent coefficient (LEC) during the two summer seasons 2019 and 2020.

Treatments		Land equivalent ratio (LER)		ATER		Land equivalent coefficient (LEC)	
Intercropping patterns	Soil conditioners	2019 RYm +RYt	2020 RYm + RYt	2019	2020	2019 RYm x RYt	2020 RYm x RYt
D1-(100% tomato + 50% maize)	Recommended of (NPK)	0.403 + 0.640 = 1.043	0.451 + 0.625 = 1.076	0.999	1.027	0.403 x 0.640 = 0.258	0.451 x 0.625 = 0.282
	compost	0.479 + 0.844 = 1.323	0.565 +0.784 = 1.348	1.271	1.287	0.479 x 0.844 = 0.404	0.565 x 0.784 = 0.443
	sulfur	0.419 + 0.720 = 1.139	0.484 + 0.701 = 1.186	1.094	1.133	0.419 x 0.720 = 0.302	0.484 x 0.701 0.340
	Compost+ sulfur	0.582 + 0.860 = 1.442	0.625 + 0.877 = 1.502	1.379	1.435	0.582 x 0.860 = 0.501	0.625 x 0.877 = 0.548
D2-(100% tomato + 60% maize)	Recommended of (NPK)	0.640 + 0.679 = 1.318	0.557 + 0.673 = 1.230	1.249	1.170	0.640 x 0.679 = 0.434	0.557 x 0.673 = 0.375
	compost	0.653 + 0.828 = 1.481	0.672 + 0.815 = 1.487	1.411	1.414	0.653 x 0.828 = 0.541	0.672 x 0.815 = 0.547
	sulfur	0.627 + 0.755 = 1.383	0.636 + 0.778 = 1.414	1.315	1.345	0.627 x 0.755 = 0.474	0.636 x 0.778 = 0.495
	Compost+ sulfur	0.751 + 0.934 = 1.685	0.767 + 0.922 = 1.689	1.604	1.606	0.751 x 0.934 = 0.701	0.767 x 0.922 = 0.707
D3-(100% tomato + 70% maize)	Recommended of (NPK)	0.742 + 0.749 = 1.491	0.739 + 0.749 = 1.488	1.411	1.408	0.742 x0.749 = 0.556	0.739 x 0.749 = 0.554
	compost	0.811 + 0.899 = 1.710	0.798 + 0.911 = 1.709	1.622	1.623	0.811 x 0.899 = 0.729	0.798 x 0.911 = 0.727
	sulfur	0.758 + 0.819 = 1.577	0.772 + 0.842 = 1.615	1.495	1.531	0.758 x 0.819 = 0.620	0.772 x 0.842 = 0.651
	Compost+ sulfur	0.907 + 0.991 = 1.898	0.905 + 0.994 = 1.899	1.800	1.801	0.907 x 0.991 = 0.899	0.905 x 0.994 = 0.900

RYm Relative yield maize **RYt Relative yield Tomato**

Table 12. Effect of the interaction between maize plant density and soil conditioners on economic evaluation and monetary advantage index (MAI), during the two summer seasons 2019 and 2020.

Treatments		Yield/ fed				Economic evaluation/fed										Monetary advantage index (MAI),	
		2019		2020		2019					2020						
Intercropping patterns	Soil conditioners	grain yield (ard./ fed)	Fruit yield (Ton /fed)	grain yield (ard./ fed)	Fruit yield (Ton /fed)	Actual yield L.E Maize	Actual yield L.E Tomato	Total income L.E/ fed	Total cost L.E/ fed	Economic return L.E/ fed	Actual yield L.E Maize	Actual yield L.E Tomato	Total income L.E/ fed	Total cost L.E/ fed	Economic return L.E	2019	2020
D1-(100% tomato + 50% maize)	Recommended of (NPK)	9.87	17.57	11.27	17.27	3948	30747.5	34695.5	31686	3279.5	4508	30222.5	34730.5	31686	3044.5	1428.17	2448.44
	compost	11.73	23.17	14.12	21.65	4692	40547.5	45239.5	32462	12777.5	5648	37887.5	43535.5	32462	11073.5	11041.14	11247.96
	sulfur	10.27	19.77	12.11	19.38	4108	34597.5	38705.5	31966	6739.5	4844	33915	38759	31966	6793	4735.50	6073.37
	Compost+ sulfur	14.27	23.60	15.63	24.23	5708	41300	47008	32742	14266	6252	42402.5	48654.5	32742	15912.5	14413.22	16264.49
D2-(100% tomato + 60% maize)	Recommended of (NPK)	15.67	18.63	13.93	18.60	6268	32602.5	38870.5	31686	7184.5	5572	32550	38122	31686	6436	9384.74	7138.11
	compost	16.00	22.73	16.80	22.51	6400	39777.5	46177.5	32462	14715.5	6720	39392.5	46112.5	32462	13650.5	14999.92	15095.70
	sulfur	15.37	20.73	15.90	21.49	6148	36277.5	42425.5	31966	10459.5	6360	37607.5	43967.5	31966	12001.5	11738.83	12868.20
	Compost+ sulfur	18.40	25.63	19.17	25.47	7360	44852.5	52212.5	32742	19470.5	7668	44572.5	52240.5	32742	19798.5	21220.67	21303.77
D3-(100% tomato + 70% maize)	Recommended of (NPK)	18.17	20.57	18.48	20.70	7268	35997.5	43265.5	31686	11579.5	7392	36225	43617	31686	11931	14247.63	14312.10
	compost	19.87	24.67	19.96	25.17	7948	43172.5	51120.5	32462	18658.5	7984	44047.5	52031.5	32462	19569.5	21221.02	21592.44
	sulfur	18.57	22.47	19.31	23.27	7428	39322.5	46750.5	31966	14784.5	7724	40722.5	48446.5	31966	16480.5	17096.61	18441.24
	Compost+ sulfur	22.23	27.20	22.62	27.47	8892	47600	56492	32742	24806	9048	48072.5	57120.5	32742	24378.5	26731.79	27041.39
Soled maize		24.5		25.00	–	9800	–	9800	6300	3500	10000	–	10000	6300	3700	–	
Soled tomato		–	27.45		27.63–	–	48037.5	48037.5	30300	17737.5	–	48352.5	48352.5	30300	18052.5	–	

Ton (tomato) 1750LE ardab maize 400LE

Monetary advantage index (MAI)

The MAI values were positive in all cases. The highest MAI value (26731.79 and 27041.39) was observed in Monetary advantage index (MAI) when intercropping maize with tomato and using plant maize density (D3) and application of (compost + sulfur), while the lowest value (1428.17 and 2448.44) was observed with intercropping maize with tomato with using maize planting in plant density (D1) and application of recommended doses of NPK in both seasons.

These positive MAI values were observed in the other intercropping systems which had LER, ATER, LEC, and K values greater . Similar observations were reported by Upadhyay *et al* (2010), Ijoyah and Dzer (2012), Mohammed, Wafaa *et al* (2013) and El-Mehy, Amira and Mohamed (2018).

CONCLUSION

It can be recommended that planting maize on 43 cm between hills and leaving two plants/hill and planting tomato on the other side of the terrace and planting maize in plant density (D3) and applying soil conditioners (compost + sulfur) obtained the maximum values growth, yield and its attributes of maize, tomato and competitive relationships and yield advantages of both crops and improvement of soil physical and hydro physical properties under the environmental conditions of El-Gharbia Governorate, Egypt.

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تأثير الكثافة النباتية للذرة والكمبوست والكبريت على انتاجية الذرة والطماطم المحملين وبعض خواص التربة

أحمد محمد شيحه[1] ، يسري أحمد محمود عبد الله[2] و هيثم مصطفى الشاهد[3]

[1] قسم بحوث التكثيف المحصولي – معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية، الجيزة – مصر

[2] معهد بحوث الأراضي والمياه والبيئة، مركز البحوث الزراعية، الجيزة – مصر

[3] قسم بحوث الذرة الشامية – معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية، الجيزة – مصر

تم إجراء تجربتين حقليتين بالمزرعة التجريبية لمحطة البحوث الزراعية بالجميزة ، مركز البحوث الزراعية ، خلال موسمى 2019 و 2020 لدراسة تأثير استخدام ثلاث كثافات نباتية من الذرة (10 ، 12 ، 14 ألف نبات/ فدان) ومحسنات التربة (كمبوست ، كبريت) على إنتاجية الذرة الشامية الصفراء و الطماطم المحملين و بعض الخواص الطبيعية والهيدروفيزيائية للتربة وصافى العائد الإقتصادى للفدان. وكان تصميم التجارب قطع منشقة مرة واحدة فى ثلاثة مكررات. تم تخصيص القطع الرئيسية للكثافات النباتية (100% طاطم + 50% ذرة ، 100% طماطم + 60% ذره ، 100% طماطم + 70% ذره) تحت نظم تحميل مختلفة. بينما تم تخصيص القطع الشقية لمحسنات التربة (كمبوست، كبريت، كمبوست + كبريت بالإضافة إلى الموصى به من الـ NPK). أظهرت النتائج أن الكثافة النباتية العالية 100% طماطم + 70% ذره أعطت أعلى القيم لجميع الصفات المدروسة للذرة والطماطم فى كلا الموسمين. سجلت الكثافة النباتية العالية مع الكمبوست + الكبريت أقل قيم للكثافة الظاهرية ونسب التحبب وأعلى قيم للمسامية الكلية ونسبة المسام والتوزيع الحجمي للمسام في موسمي النمو. زادت قيم التوصيل الهيدروليكي والصفات الرطوبية للتربة في كل المعاملات في العمقين وموسمي النمو مقارنة مع الزراعة المنفردة من الذرة أو الطماطم. أعطت الكثافة النباتية العالية 100% طماطم + 70% ذرة مع الكمبوست + الكبريت أعلى القيم من كفاءة استخدام المياه ,معدل استغلال الارض ,المكافىءالزمنى لاستغلال الارض ,معامل المكافىء الارضى ,الميزة المحصولية للعائد النقدى وصافى العائد الاقتصادى في موسمي النمو.