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EFFECT OF PLANT DENSITY AND SPRAYING WITH ALUMINUM SILICATE ON FRUIT YIELD AND QUALITY OF PROCESSING TOMATO GROWN IN SUMMER SEASON

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ABSTRACT: *This study was conducted during two successive late summer seasons of 2015and 2016 at a private farm on Cairo-Alex Desert Road-Km73 (Agricultural Almostakbal Association), Giza Governorate. In this study the effects of three plant densities i.e., 14000, 12000 and 10500 plants per fedden along with three levels of aluminum silicate (kaolin), i.e., 1, 2 and 3% added as foliar spray beside the control (tap water) were studied. Data collected were on vegetative growth, flowering characteristics, fruit yield and its quality of processing tomato, hybrid Alissa F_1. Kaolin application started fifteen days after transplanting and repeated at every 8 to 10 days until the beginning of fruits coloring stage. The field soil was sandy in texture and drip irrigation system was used.*

The obtained results showed that using the highest plant density of processing tomato, i.e 14000 plant (30cm spacing between the seedlings) produced the taller plants, high weight of fresh and dry leaves, the highest fruit setting% with high early, total and marketable yield as well as low percentage from sunscald affected fruits. However, such treatment (highest plant density) produced the lowest fruit weight, firmness and fruit contents from vitamin C ,T.S.S as well as pH of juice. The lowest plant density produced low fruit yield with high percentage of unmarketable fruit, but the fruits were bigger, had highest weight, were firmner, and had high concentration from vitamin C, T.S.S and pH of juice, than those harvested from plants grown in higher densities.

Concerning the effect of foliar spray with aluminum silicate kaolin, it is obvious from the results, that the level of 2% significantly increased all traits of vegetative growth, enhanced earliness of flowering and increased fruit setting, total and marketable yield with superior characteristics, i.e, fruit weight, less infection with sunscald fruits, high firmness, high vitamin C, T.S.S as well as pH of juice contents.

For that, it can recommend under the condition of planting the processing tomato in the late summer seasons under sandy soil under drip irrigation system with high density plant per fedden(14000 plant), i.e., 30 cm spacing between plants and foliar spray with 2% aluminum silicate to obtain highest marketable fruit yield and reach to highest productivity.

***Key words**: Tomato, Plant density, Aluminum silicate, Kaolin, sunscald, high temperature, fruit quality and yield.*

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) belongs to the Solanaceae family and self pollinated annual crop. Tomato is a very important vegetable cultivated and consumed in most parts of the world, from home gardens and greenhouses to large commercial farms due to its wider adaptability to various agro-climatic conditions (Agyeman *et al.,* 2014). In Egypt, the total area cultivated by this crop was estimated by 468510 fedden with a total production of 7727217 tons with an average of 16.493* tons/ fedden. Several environmental factors adversely affect plant growth and development as well as final

* Bulletin of the Agricultural Economics and statistics, Ministry of Agriculture and Land Reclamation,A.R.E., Summer&Nili Crops 2014/2015 September, 2016.

yield performance of the crop, and the temperature is among the major environmental constraints affect on crop productivity worldwide (Hamdia and Shaddad, 2010). Under the Egyptian climate conditions, which characterized with high temperature during summer periods, growing tomato plants in sandy soil under several problems i.e., tomato affected with sunscald, low fruit setting% and low fruit quality are normally occur under some growing conditions, particularly when plants directly expose sunlight for extended periods during very hot weather. The excessive sunburn discolors patches appear on ripening or green tomatoes. Tuan and Mao (2015) evaluated different planting density on growth and yield of tomatoes to determine the optimum planting density, they found that plant height, number of leaves per plant, fruit set, number of fruit per plant, fruit weight and fruit yield were enhanced by high plant density: They added that density of 35714 plants per hectar gave the highest plant height, whereas 25974 plants per hectar gave the lowest plant height. Moreover, 25974 plants per hectar gave the best results in fruit set and fruit weight and gave the maximum fruit yield than the other treatments. On the other hand, Abdalbagi *et al.,* (2010) found that the highest plant density (71,428 plant ha-1) gave the highest marketable yield. Lemma *et al.,* (1992) reported that plant spacing greatly influenced fruit yield in both fresh market and processed tomatoes. Law-Ogbomo and Egharevba (2009) reported that the highest total fruit yield of tomato was produced at low plant density than at high plant density. High temperature is a major environmental stress that limits plant growth, metabolism, and productivity worldwide. Plant growth and its development involve numerous biochemical reactions are highly affected by temperature (Hasanuzzaman *et al*., 2013). High temperature causes loss of cell water content and this stress reflect on the cell size and ultimately reduced the growth (Ashraf and Hafeez, 2005 and Rodriguez *et al*., 2005). The high temperature stress is one of the main abiotic stresses that limit plant growth and survival. The morphological symptoms of heat stress include scorching of leaves and twigs, leaf senescence and abscission, shoot and root growth inhibition (Wahid and Shabbir 2005).

In recent years, several investigator discove red that a number of exogenous protectants, such as silicon, selenium, proline, glycinebetaine, nitric oxide, salicylic acid and polyamines have been tested and found to be beneficial in protecting plants against damage from temperature extremes and all other stress conditions (Hasanuzzaman *et al*., 2013). Particle film sprays such as aluminum silicate(kaolin) and silica gel have been recommended to reduce the injury of the high temperature on apple fruit thereby reducing sunburn and improving the development of red coloring of the fruit (Mahmoud *et al*., 2010). Aluminum silicate (kaolin) can also be used to protect the crops from UV radiation (Glenn *et al.*, 2002). Under high temperature and irradiance levels conditions Bedrech and Farag(2015) found that spraying grapes with Kaolin, ($Al_2O_7Si_2$) 5% improved cluster weight of berries. Kaolin-based particle film also provides some physiological benefits to various horticultural crops. For example, kaolin particle has been reported to increase water use efficiency in tomato plants (Rao, 1985), cause a reduction in leaf temperature of peach tree while having no adverse effects on fruit yield and quality (Glenn *et al*., 1999), increase photosynthesis and water use efficiency in grapefruit (Jifon and Syvertsen, 2001), and reduce severity of sunburn damage in pomegranate fruit (Weerakkody *et al.,* 2010). The anti transparent (kaolin) reduce the water losses during vegetable growth period and before or after fruits harvesting in tuberose plant (Al-Moftah and Al-Hamaid, 2005).

The objective of this work is to study effect of planting density and spraying with aluminum silicate (kaolin) on tomato fruit yield and its quality which may help in positive protection against sunscald as one of important physiological disorder effects caused by high temperature and direct sun-light which severely reduced fruit quality of the processing tomatoes.

MATERIALS AND METHODS

This study was carried out at a private farm of Almostakbal Agricultural Association on Cairo-Alex Desert Road-Km73, Giza, Governorate, Egypt, during the two successive summer seasons of 2015 and 2016, to study the effect of planting density and foliar spray with aluminum silicate (kaolin) levels and their combinations on vegetative growth, fruit set% as well as fruit yield of tomato grown under high temperature stress of late summer season. Drip irrigation was used for irrigate the plants with equal amount of water under fertigation system according to fertilizer recommendation program under sandy soil suggested by Minister of Agriculture, Egypt were applied. The soil physical and chemical properties presented in Table1, the farm soil type was sandy soil.

Planting technique:

A split plot design with three replicates was used. Each experimental unit (sub- plot) consisted of 10m long and 1m wide. The treatments were the combination between three planting densities and three levels of aluminum silicate (kaolin) (($Al_2O_7Si_2$,), ($Si_2$48.8ml/g+Al_2O_7 .7%)) It was obtained from Green Way Company, Egypt. The spacing of 30, 35 and 40 cm between plants give the densities of 14000, 12000 and 10500 plants per feddan, respectively which were distributed to the main plots. The foliar spray of aluminum silicate (kaolin) levels were 1, 2and 3 % beside the control (tap water).The foliar application were at 15 days after transplanting and repeated every 8-10 days intervals until beginning fruit coloring stage of tomato fruit, these treatments were arranged randomly in the sub plots. Seeds of tomato.AlissaF_1 hybrid (produced by Nun hems seeds Co. Netherlands) were sown on 17th February in foam trays under the conditions of greenhouse in both seasons and the healthy seedlings of tomato hybrid were transplanted to the open field on April 1th and 2nd in 2015and 2016 seasons, respectively.

Field environmental conditions:

The metrological data for the experimental area obtained from Central Laboratory of Agricultural Climate (CLAC), Agricultural Research Center (ARC), values were calculated and expressed as monthly interval means during the two growing seasons as shown in Table (2).

Table (1): Physical and Chemical properties of the experimental soil during 2015 and 2016 seasons.

	Physical properties					
	Sand %		Clay%		Silt%	Texture
2015	90.0		5.5		4.5	Sandy
2016	88.6		6.1		5.3	Sandy
	Chemical properties					
	Ca	Mg	Na	K	HCO_3	Cl
	meq/l					
2015	10.3	10.8	33.0	0.88	1.42	21.8
2016	10.5	11.2	33.5	1.20	1.46	22.1

Table (2): Maximum air temperature of Cairo-Alex Desert Road-K72 region during the summer seasons 2015 and 2016.

Months	Max. air Temperature [°C]	
	2015	2016
March	36.9	34.8
April	38.5	37.7
May	40.3	39.4
June	40.4	43.3
July	45.6	44.8

***Data recorded*:**

I-Vegetative growth:

After 60 days from transplanting (at the beginning of fruiting stage), plant height (cm), number of branches per plant, fresh and dry leaf weight (g) were determined in 3 plants from each exp. unit then the average per plant was calculated.

II-Flowering characteristics and fruit Yield:

-Flowering date: number of days from transplanting to 50% flower anthesis was calculated as index of flowering date.

-Fruit set percentage: Three plants from each plot were randomly chosen and average fruit set of first three clusters in the main steam were determinate at 60 days after transplanting according to the equation:

$$\text{Fruit set\%} = \frac{\text{No. of setted fruits /cluster}}{\text{No. of total flowers / cluster}} \times 100$$

-Early yield: Weight of all red ripe fruits, picked from each plot during the first 15 days from the beginning of harvesting (three pickings) was considered as early yield.

-Total yield: The weight of all harvested fruits at the red ripe stage from each plot in the whole harvesting season then were modified as ton/ fed.

-Total marketable yield: It was determined after excluding cracked, sunscald and rotted fruits as well as fruits infected with diseases and pests from the total harvest fruits.

-Marketable yield as a percentage: It was calculated according to the formula:

$$\text{Marketable yield\%} = \frac{\text{Marketable yield}}{\text{Total yield}} \times 100$$

-Unmarketable yield: It was determined as the weight of fruits of all unmarketable fruits (cracked, sunscald and infected with diseases) of all pickings in Kg/ plot, then were calculated as ton/ fed.

-Unmarketable yield as a percentage: It was calculated according to the formula:

$$\text{Unmarketable yield\%} = \frac{\text{Unmarketable yield}}{\text{Total yield}} \times 100$$

-Sunscald fruit yield as a percentage: It was determined as the weight of only sunscald fruits and calculated according to the formula:

$$\text{Sunscald fruit yield\%} = \frac{\text{Sunscald affected fruit}}{\text{Total fruit yield}} \times 100$$

III-Fruit quality:

-The physical characteristics of tomato fruits: All physical characters were measured on loved ripe stage fruits at the same stage from the harvesting in mid-season and the averages calculated.

Average fruit fresh weight (g) was determined theoretically by dividing total fruit weight on the total fruit number. A random sample of five fruits per plot was used for measuring fruit length and diameter using a caliper. Fruit firmness was measured using a needle type pocked penetro-meter; one reading was taken for each fruit by pushing the penetro-meter needle slowly at the equatorial plane. Then average fruit firmness was calculated for each experimental plot.

-The chemical characteristics of tomato fruits:

-The percentage of total soluble solids (TSS) A random sample of five fruits per plot was used for measuring T.S.S.in fruit juice was determined by a hand refractor meter according to the methods mentioned in the A.O.A.C.1990.

- **Vitamin C content** was determined by titration with 2.6 dichlorophenol – indophenol method as indicator of A.O.A.C, 1990.

-**The Fruit pH:** It was determined by immersing the glass electrode of a pH meter in juice extracted from 100g of red-ripe fruit sample per experimental plot.

- Tomato fruit dry matter content was determined by dried 100gram fresh tomato fruit from all treatments.

Statistical analysis:

-Data obtained were subjected to the proper analysis of varance (split-plot design as described by Snedecor and Cochran (1982). Averages between treatments were differentiated by using LSD at 5% level using Microsoft office Excel program.

RESULTS AND DISCUSSION

I-Vegetative growth:

i) Effect of Plant density:

The data in Table 3 show that there were significant differences in plant height among plant density treatments. Plant height were tallest between 67.0 and 68.33 cm when grown at highest density (when both seasons are considered), while: the shortest plants were (64.08 and 66.25 cm) when grown at lowest density (10500 plants per fedden) in the 1st and 2nd season, respectively followed by12000 plants per fedden. However, it was noticed that no significant differences were observed between 30 and 35 cm plant spacing in the 2nd season.

Gupta and Shukla 1977 reported the plant height of tomato increased at high plant density (lowest space between tomato plants) than at low plant density (highest space between tomato plants) which is in line with the present result. It seems that plant height increased with higher planting density (lower plant spacing) which is disagreed with the finding of Law-Ogbomo and Egharevba, (2009).

Plant densities had no statistically significant effect on number of branches per plant in both seasons (Table 3).

Regarding to both fresh and dry weight of leaves, results in the same (Table 3) showed that plant density had significant differences effects on both weight. As the maximum values of both traits were achieved in the lower plant space 30cm of 14000 plants per fedden, whereas the lowest values were obtained in the wider spacing 40 cm of 10500 plants per fedden. It seems that low plant spacing gave the heaviest weights for both fresh and dry leaves than the other treatments, although the difference between 30 and 35 cm plant spaces in leaves dry weight of the 1st year was not statistically significant ($p \leq 0.05$).

ii) Effect of foliar spray with aluminum silicate:

Regarding to the effect of foliar spray with aluminum silicate, the results (Table 3) showed that the increase in growth such as plant height, number of branches/plant, leaves fresh and dry weights of processing tomato grown under high temperature conditions was obtained as a result of foliar spray from different treatments i.e.,1 to 3% aluminum silicate in both seasons of the study. However, foliar spray with 2% was more effective than the other treatments, which reflected on producing the highest values on all growth aspects. On the other hand, there were non significant differences among 1% and 3% treatments in the second season on number of branches/plant. Agarie *et al*. (1998) observed that electrolyte leakage caused by high temperature (42.5^{o}C) was less pronounced in the leaves of plants grown with silicon than in those leaves of plants grown without silicon. However, the plant height, number of branches/plant, leaves fresh and dry weight (g) were increased with the increase of aluminum silicate levels from 1 to 2 %, while these items decreased when the aluminum silicate levels increased 2 to 3.0 %. Meanwhile, the effect of aluminum silicate on plant growth may refer to that silicon enhances the growth, improves protection against pathogens (Greger *et al*., 2011) and maintains of photosynthetic activity and that one of the reasons of increasing dry matter production (Agurie *et al.,* 1992). Furthermore, the beneficial effects of silicon are mainly associated with its high deposition in plant tissues, enhancing their strength and rigidity, increased mechanical strength reduces lodging and pest attack, increases the light – receiving posture of the plant and increasing photosynthesis and hence growth (Epstein, 1999 and Crooks and Prentice, 2011).

Table (3): Effect of Plant density and spraying with Aluminum silicate on plant height, number of branches, fresh and dry weight of leaves during 2015 and 2016 seasons.

Treatments		Plant height (cm)		Number of branches/plant		Leaves fresh weight (g)		Leaves dry weight(g)	
Plant density	**Aluminum silicate**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**
14000(30cm)	Control	64.33	65.67	6.17	6.33	146.0	147.0	25.50	26.47
	1%	66.00	67.33	8.17	8.47	165.3	172.1	31.47	34.97
	2%	72.33	72.33	8.87	9.33	213.4	221.0	43.47	43.80
	3%	65.33	68.00	8.21	8.47	171.1	174.1	33.80	34.67
Mean		**67.00**	**68.33**	**7.86**	**8.15**	**174.0**	**175.2**	**33.56**	**34.98**
12000(35cm)	Control	61.67	62.00	7.17	7.17	131.3	131.8	24.40	24.57
	1%	65.00	68.67	7.67	8.33	169.8	169.2	30.23	32.00
	2%	72.67	73.67	8.67	8.83	208.0	203.4	42.60	42.60
	3%	66.33	69.00	7.87	8.00	165.2	167.2	36.33	36.63
Mean		**66.42**	**68.33**	**7.85**	**8.08**	**168.6**	**165.0**	**33.39**	**34.12**
10500(40cm)	Control	59.00	58.33	7.33	8.17	116.0	101.2	21.43	19.93
	1%	62.67	66.33	8.00	8.33	135.3	132.5	23.70	23.53
	2%	69.33	72.67	8.83	9.23	201.3	209.8	41.50	42.30
	3%	65.33	67.67	8.17	8.50	146.3	161.8	26.23	28.20
Mean		**64.08**	**66.25**	**8.08**	**8.56**	**149.7**	**151.3**	**28.22**	**28.49**
Means of aluminum silicate	Control	61.67	62.00	6.89	7.22	131.1	126.7	23.78	23.66
	1%	64.56	67.44	7.94	8.44	156.8	157.9	28.47	30.17
	2%	71.44	72.89	8.72	9.17	193.3	211.4	42.52	43.12
	3%	65.67	68.22	8.06	8.39	175.1	167.7	32.12	33.17
L.S.D.5%	Plant density	0.463	0.378	NS	NS	0.944	0.901	0.748	0.715
	Aluminum silicate	0.939	0.707	0.410	0.513	1.892	1.616	1.062	0.782
	Interaction	1.626	1.224	0.710	0.889	3.277	2.799	1.839	1.355

iii) Effect of the interaction between plant densities and foliar spray with aluminum silicate:

Data in table (3) shows effect of the interaction between plant densities and foliar spray with aluminum silicate on plant height, number of branches/plant, fresh and dry leaves weight/plant of tomato. It is clearly from the data that, the effect of all interaction treatments were significant in the two seasons for these traits. In general, the best interaction was (35 cm space with 2% foliar spray of aluminum silicate) for plant height in the two seasons followed by (30 cm space with 2% foliar spray) in 1st season then (40 cm space with 2% foliar spray) in the 2nd one, respectively without significant differences between them. While, the interaction of 30 cm space with 2% foliar spray gave the highest values of number of branches/plant, fresh and dry weight of leaves /plant. On the other hand, interaction among 40 cm × control produced the lowest values of plant height and both fresh and dry weight of leaves /plant in both seasons.

II-Flowering and Fruit yield:

i) Effect of Plant density:

The effect of tomato plant density on flowering earliness, fruit set%, early and total fruit yield are shown in Table 4. It is obvious from the table that the treatment of the high plant density, i.e 14000 plants (30cm spacing) showed the lowest number of days to T_{50} flowering i.e., 29.67 days with the average of 29.9 days in the two seasons, while the highest number of days tell50% flowering obtained from the plant density of 12000 plants/Fed.31.08 days with the average of (30.87) days of the both two seasons. The same treatment of the high plant density gave the highest fruit set% with the average of 73% of the two seasons.

Concerning to the effect of tomato plants density on early yield, total yield as well as the marketable yield, the data in (Tables 4 and 5) showed that, the high plant density, i.e 14000 plants/ fedden was the favorable treatment for producing the highest early yield (8.21 ton/Fed.) comparing with (5.72 ton/Fed.) from the low plant density as average of the two seasons. The same trend of total yield in Table 4 and the percentage of marketable yield in the (Table 5) was obtained from the same treatment of high plant density, i.e 14000 plants/ Fed was significantly higher than the other plant density treatments, i.e., 12000 or 10500 plants/ Fed. The obtained results are in harmony with those obtained from several investigators, Abdel-Mawgoud, (2007) and, Lemma *et al*., (1992) reported that, plant spacing greatly influenced fruit yield in both fresh market or processed tomatoes. In addition, Godfrey-Sam-Aggrey *et al*., (1985) and Mehla *et al*., (2000) reported that tomato yield parameters have been affected by plant spacing. Moreover Tuan and Mao, (2015) showed that plant density is considered one of the important factor affecting of tomato productivity. On the contrary, Law-Ogbomo and Egharevba, (2009) found that the low plant density produced higher fruit yield than the high plant density grown plants and this due to the plants of low plant density treatment produce bigger fruits, however most of these fruits were unmarketable as they affected by cracking.

ii) Effect of foliar spray with aluminum silicate:

Data illustrated in Table (4) show obviously that, application of different levels of aluminum silicate *i.e*. 0, 1, 2 and 3% significantly affected number of days to flowering (T_{50}), fruit setting% and total yields. The maximum fruit setting (75.93 and 77.44 %) and total yield (36.29 and35.87 t/f) were obtained as a result of foliar spray with aluminum silicate at 2% on tomato plants followed by the treatment which received 3%. The treatment comparing with foliar spray with the level of 2% or 3% but without significant differences between the control and 1% foliar sprays on the earliness in both seasons. The total weights and percentages of marketable and unmarketable fruit yield per fedden for all treatments in this study is presented in Table 5. The maximum desirable effect was obtained with 2% aluminum silicate foliar spray. The effects of aluminum silicate on yield are related to the deposition of the element under the leaf epidermis, which results a physical mechanism of defense, production of phenols, which stimulates phytoalexin production, decreases transpiration losses and increases photosynthesis capacity of crop plants (Korndörfer *et al.,* 2004,Adolfo,2007 and Ahmad *et al*., 2012). Moreover, the kaolin has an important external influence through the reduction of transpiration and reduced the leaf temperature and fruit which led to reflection sun radiation.

Table (4): Effect of plant density and spraying with aluminum silicate on number of days to 50% flowering (T_{50}), fruit setting, early and total yield during 2015 and 2016 seasons.

Treatments		T_{50}		Fruit setting %		Early yield ton/ Fed.		Total yield ton/Fed.	
Plant density	**Aluminum silicate**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**
14000(30cm)	Control	28.33	29.00	67.17	66.20	10.17	10.44	31.56	30.69
	1%	28.33	29.33	73.03	70.27	7.93	7.40	32.06	32.27
	2%	31.33	31.33	79.03	78.67	8.72	7.82	39.70	38.55
	3%	30.67	31.33	74.67	70.67	6.83	6.43	33.46	34.37
Mean		**29.67**	**30.25**	**73.48**	**71.45**	**8.41**	**8.02**	**34.20**	**33.97**
12000(35cm)	Control	29.00	29.67	67.60	67.60	9.03	8.96	27.48	28.42
	1%	30.33	30.67	69.87	70.77	6.27	5.99	30.68	31.24
	2%	31.33	31.67	74.43	77.67	6.68	6.42	38.08	37.27
	3%	32.00	32.33	72.40	71.67	6.26	6.00	31.09	32.05
Mean		**30.67**	**31.08**	**71.08**	**71.93**	**7.06**	**6.84**	**31.83**	**32.24**
10500(40cm)	Control	29.67	29.67	67.17	66.93	7. 91	7.13	25.07	26.14
	1%	28.67	29.33	70.97	71.87	5.25	5.48	25.20	26.30
	2%	30.67	31.00	74.33	76.00	5.55	5.75	31.08	31.79
	3%	31.33	31.67	72.93	72.33	4.56	4.88	26.48	27.56
Mean		**30.08**	**30.42**	**71.35**	**71.78**	**5.64**	**5.81**	**26.96**	**27.95**
Means of aluminum silicate	Control	29.00	29.44	67.31	66.91	8.80	8.84	28.04	28.42
	1%	29.11	29.78	71.29	70.97	6.48	6.29	29.31	29.94
	2%	31.11	31.33	75.93	77.44	6.98	6.66	36.29	35.87
	3%	31.33	31.78	73.33	71.56	5.88	5.77	30.34	31.33
L.S.D.5%	Plant density	0.500	0.517	0.843	NS	0.086	0.109	0.225	0.085
	Aluminum silicate	0.780	0.713	0.921	1.143	0.060	0.133	0.144	0.247
	Interaction	1.351	1.235	1.595	1.980	0.105	0.230	0.249	0.428

Table (5): Effect of plant density and spraying with aluminum silicate on marketable and unmarketable (Sunscald) yield during 2015 and 2016 seasons.

Treatments		Marketable yield				Unmarketable yield			
		Ton/Fed.		percentages%		Ton/Fed		percentages%	
Plant density	**Aluminum silicate**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**
14000(30cm)	Control	25.62	24.79	81.17	80.77	5.95	5.90	18.83	19.23
	1%	27.90	28.25	87.03	87.63	4.16	3.99	12.97	12.37
	2%	36.39	35.37	91.70	91.77	3.33	3.18	8.30	8.23
	3%	30.42	31.32	91.03	91.13	3.04	3.05	8.97	8.87
Mean		**30.08**	**29.93**	**87.73**	**87.83**	**4.12**	**4.03**	**12.27**	**12.18**
12000(35cm)	Control	21.85	22.69	79.50	79.90	5.63	5.73	20.50	20.10
	1%	26.46	27.19	86.23	87.03	4.22	4.05	13.77	12.97
	2%	34.68	33.99	91.07	91.20	3.40	3.28	8.93	8.80
	3%	28.00	29.14	90.03	90.90	3.10	2.92	9.97	9.10
Mean		**27.75**	**28.25**	**86.71**	**87.26**	**4.09**	**3.99**	**13.29**	**12.74**
10500(40cm)	Control	19.46	20.44	77.57	78.20	5.63	5.70	22.43	21.80
	1%	21.93	22.89	86.97	87.10	3.28	3.39	13.03	12.90
	2%	28.28	28.90	91.00	90.90	2.80	2.89	9.00	9.10
	3%	24.11	25.02	91.03	90.77	2.37	2.55	8.97	9.23
Mean		**23.44**	**24.31**	**86.64**	**86.74**	**3.52**	**3.63**	**13.36**	**13.26**
Means of aluminum silicate	Control	22.31	22.64	79.41	79.62	5.73	5.78	20.59	20.38
	1%	25.43	26.11	86.74	87.26	3.89	3.81	13.26	12.74
	2%	33.12	32.75	91.26	91.29	3.18	3.12	8.74	8.71
	3%	27.51	28.49	90.70	90.93	2.84	2.84	9.30	9.07
L.S.D.5%	Plant density	0.173	0.063	0.326	0.118	0.128	0.051	0.326	0.118
	Aluminum silicate	0.180	0.249	0.341	0.174	0.093	0.047	0.341	0.174
	Interaction	0.312	0.432	0.591	0.302	0.161	0.081	0.591	0.302

iii) Effect of the interaction between plant densities and foliar spray with aluminum silicate:

Concerning the early and total yield, the effect of combined interaction between plant density and spraying with aluminum silicate treatments as shown in Tables 4 and 5 exhibited significant differences between such combinations in both seasons. The highest records for both early and total yield were obtained from the control without spraying with aluminum silicate treatment in both seasons. On the other hand, the favorable values for each of fruit setting%, total yield, total marketable yield and percentage of marketable yield were obtained from the interaction between (30 cm apart and 2% aluminum silicate) in both seasons. Generally, plant density is considered an important practice responsible for improving fruit setting, yield as well as quality of fruits, whereas the most important tools to reach more and better fruits in vegetable is the foliar application by some anti transparent which aimed to protect the plants from the no proper climate condition. Whereas, the anti transparent (kaolin) reduce the water losses during vegetable growth period and before or after fruits harvesting in tuberose plant as mentioned by (Al-Moftah and Al-Hamaid, 2005).

-Sunscald fruit yield as a percentage:

On tomatoes, sunscald will appear as a yellow or white-spotted area on the side or upper part of the fruit that has been directly exposed to the sun. As the fruit ripens, the affected area may become blistered before it finally turns thin, wrinkly, and paper-like in appearance. At this stage, the fruit becomes more susceptible to secondary fungal problems. To find cause of sunscald in tomato plants, you should look towards one of the following possibilities:

The fruit exposed to direct sun, the weather dry and hot. These are the most likely causes, but there are other reasons when plants pruned lately or when the vines disturbed while harvesting, or removal of foliage or broken vines can also increase the expose of the fruits to sun damage and the plants loss its foliage with more infection with pests or disease. This too reasons can lead to tomato fruit sunscald, as the fruits become without protection from the sun's blaring heat.

i) Effect of plant density:

Data in Fig.1 show the effect of different plant densities on weight of sunscald affected fruit as a percentage of total fruit weight sunscald it is obvious that all plants of all space treatments (30, 35 and 40 cm space) significantly affected by sunscald with different percentages, but the planting space (30 cm space) recorded the lowest percentage of sunscald yield (favorable value), while the highest were obtained at 35 and 40 cm space without significant differences between them. These results were true in both seasons. In general, tomato (Alissa F_1 seedling planted at 30 cm space) to giving population of 14000 plants/ Fed recorded the lowest values of sunscald yield compared with 35 and 40cm spaces and this due to the narrow spacing with high density induced favorable protection against direct sun shine effect on the fruits and the vegetative growth of the nearer plants induced heavy covering on the fruits.

ii) Effect of foliar spray with aluminum silicate:

The results declare the effect of foliar spray with aluminum silicate on sunscald fruit yield. It is clear in Fig. 2 that all foliar treatments significantly decreased sunscald fruit yield % compared with untreated plants. Sprayed tomato plants with 2% aluminum silicate recorded the lowest percentage of sunscald fruit yield (favorable value) followed by 3% in both seasons. Similar results were recorded by Islam *et al*. (2014) for silicon. Meanwhile, Shetty *et al*., 2012 reported that it enhance activity of chitinases, peroxidases and polyphenyl oxidases and increased formation deposition of callose and hydrogen peroxide and may enhance the indiffusible anion sites, which adsorb Ca, thus imposing an elevated Ca content in the plant tissues (Stamatakis *et al*., 2003). Also, the modification of cell membranes after silicon application that led to reduction of water loss and subsequently reduced sunscald yield %. (Epstein, 2009).

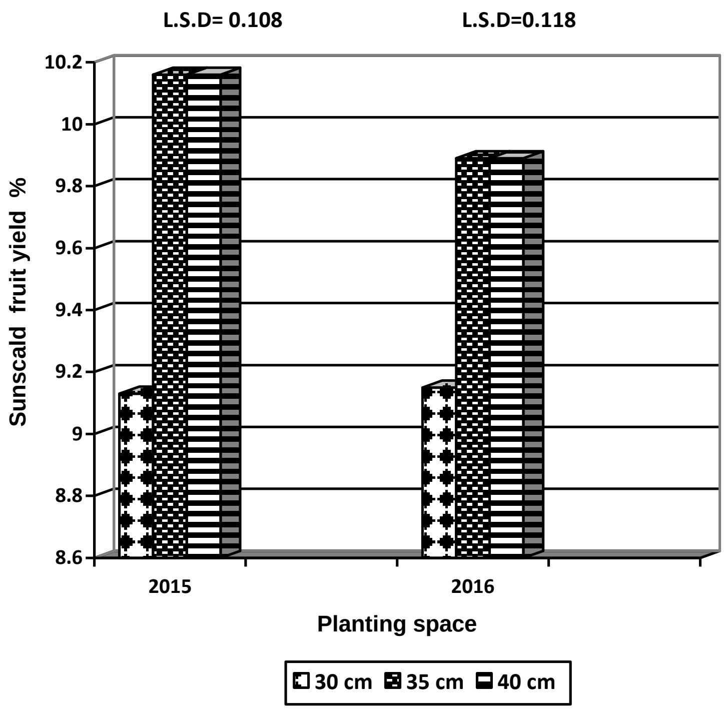

Fig. (1): Effect of Plant density on weight of sunscald affected fruits as a percentage of total fruit weight for tomato plants during 2015 and 2016 seasons.

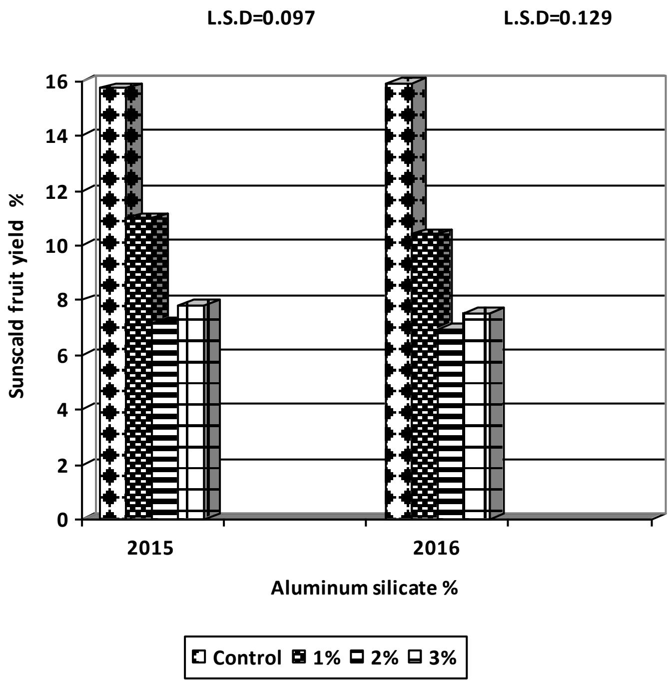

Fig. (2): Effect of praying with aluminum silicate on weight of sunscald affected fruits as a percentage of total fruit weight for tomato plants during 2015 and 2016 seasons.

iii) Effect of the interaction between plant densities and foliar spray with aluminum silicate:

Data presented in Fig. 3 show that the effect of affected all interactions between plant densities and foliar spray with aluminum silicate on sunscald fruits were significant in both seasons. Tomato planted at 30 cm apart and sprayed with 2% aluminum silicate recorded the lowest values, of affected fruits while, the highest one (unfavorable) were recorded when plants planted at 40 cm apart under the control treatments (without spraying).

III-Fruit quality:

-Fruit Physical characteristics

i) Effect of Plant density:

The data presented in Table 6 indicated that treatment of low plant density, i.e 40 cm planting space between the plants had the maximum values for average fruit weight (111.6 and 105.4g) and fruit firmness (2.93 and 3.08 kg/cm^2) in the 1st and 2nd season, respectively without significant differences between 35 cm and 40 cm for fruit firmness and average fruit weight in the 1st and 2nd season respectively as well as the all three treatments among fruit firmness in the 2nd season only. While, the lowest values for the two traits, i.e., fruit weight and firmness were recorded in 30 cm treatment (14000 plants per fedden). It seems that low plant density gave the highest fruit weight and Fruit firmness compared to high plant density. These results are in agreement with those reported by Ali, (1997) and Law-Ogbomo and Egharevba, (2009).

Regarding to both fruit length and diameter, the results in the same Table 6 indicated tha,t treatment with 35 cm planting space, i.e 12000 plants/ Fed had the significant maximum values for both traits without significant differences between 30 cm and 40 cm for fruit length in both seasons and between 35 cm and 40 cm for fruit diameter in the 2nd season.

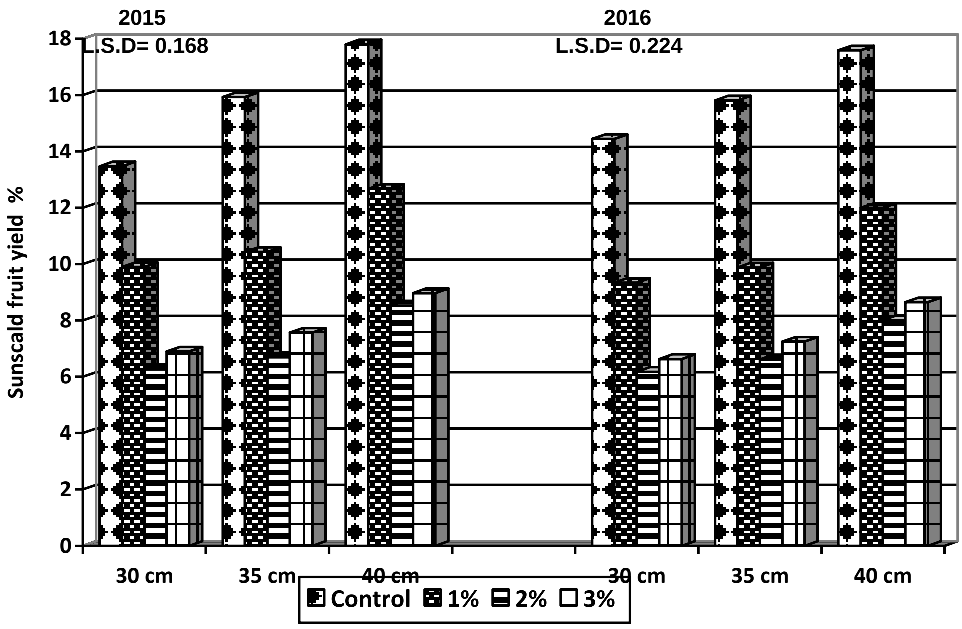

Fig. (3): Effect of Plant density and spraying with aluminum silicate on weight of sunscald affected fruits as a percentage of total fruit weight for tomato plants during 2015 and 2016 seasons.

Table (6): Effect of Plant density and spraying with aluminum silicate on fruit physical characters during 2015 and 2016 seasons.

Treatments		**Average fruit weight (g)**		**Fruit length (cm)**		**Fruit diameter (cm)**		**Fruit firmness (kg /cm^2)**	
Plant density	**Aluminum silicate**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**
14000(30cm)	Control	91.00	83.3	5.53	5.73	5.20	5.40	2.60	2.82
	1%	101.6	96.6	5.83	6.10	5.33	5.57	2.93	3.00
	2%	112.6	103.3	5.50	6.17	5.47	5.67	2.85	3.24
	3%	107.0	100.0	5.77	6.17	5.40	5.50	2.92	3.17
Mean		**103.1**	**95.8**	**5.66**	**6.04**	**5.35**	**5.53**	**2.83**	**3.06**
12000(35cm)	Control	97.6	91.6	5.80	5.73	5.20	5.40	2.68	2.75
	1%	108.3	106.6	6.03	6.23	5.50	5.70	2.89	3.05
	2%	117.3	113.3	5.97	6.20	5.80	6.00	2.97	3.11
	3%	110.0	108.3	6.00	6.27	5.77	5.93	2.89	3.25
Mean		**108.3**	**105.0**	**5.95**	**6.11**	**5.57**	**5.76**	**2.86**	**3.04**
10500(40cm)	Control	101.6	96.6	5.47	6.11	5.30	5.50	2.73	2.82
	1%	111.6	103.3	5.70	5.73	5.47	5.70	2.86	3.00
	2%	118.3	113.3	5.83	6.13	5.47	5.83	3.05	3.17
	3%	115.0	108.3	5.87	6.20	5.57	5.73	3.09	3.33
Mean		**111.6**	**105.4**	**5.72**	**6.04**	**5.45**	**5.69**	**2.93**	**3.08**
Means of aluminum silicate	Control	96.7	90.5	5.60	5.73	5.23	5.43	2.67	2.80
	1%	107.2	102.2	5.86	6.16	5.43	5.66	2.89	3.02
	2%	116.1	110.0	5.77	6.18	5.58	5.83	2.96	3.17
	3%	110.6	105.5	5.88	6.19	5.58	5.72	2.97	3.25
L.S.D.5%	Plant density	2.203	2.313	0.093	0.086	0.117	0.100	0.082	NS
	Aluminum silicate	2.670	2.737	0.086	0.075	0.082	0.077	0.146	0.128
	Interaction	4.625	4.741	0.149	0.130	0.142	0.133	0.252	0.222

ii) Effect of foliar spray with aluminum silicate:

Data illustrated in Table 6 show obviously that, foliar spray with different concentrations i.e. 1, 2 and 3% aluminum silicate affected significantly on average fruit weight, fruit length, fruit diameter and fruit firmness as compared with the control. However, the maximum average fruit weight (116.1 and 110.0 g) and fruit diameter (5.58 and 5.83 cm) were obtained by foliar spray with aluminum silicate at 2% level while, the maximum values of fruit length (5.88 and 6.18 cm) and fruit firmness (2.97 and 3.25

kg/cm^2) were obtained by foliar spray with 3% on tomato plant without significant differences between the three foliar spray levels, i.e., 1%, 2% and 3% on fruit firmness in 1st season and fruit length in 2nd one.

iii) Effect of the interaction between plant densities and foliar spray with aluminum silicate:

Data in Table 6 show the effect of the interaction between plant densities and foliar spray with aluminum silicate on average fruit weight, fruit length, and diameter as well as fruit firmness of tomato. It is obvious from the data that, the effects of all interactions were significant comparing with the control in the two seasons for these traits. In general, the best in terms of interaction was (35 cm × 2% foliar spray) and (40 cm × 2% foliar spray) for average fruit weight in the two seasons without significant differences between them. While, the best in terms of interactions for fruit length were (35 cm × 1% or 2 or 3% foliar spray without significant differences between them) and (35 cm × 1% or 2 % foliar spray for fruit diameter without differences between them). However, (40cm × 3%), (40cm × 2%), (35cm × 2%), (30cm × 1%), (30cm × 2%), showed similar significant effect on fruit firmness.

-Fruit chemical characters:

i) Effect of Plant density:

Data in Table 7 indicated that all chemical traits influenced significantly by the planting density in both seasons except juice pH and TSS in the 1st and 2nd season, respectively. The highest values were found in the treatment of 10500 plants per fedden, i.e 40 cm planting space) for total soluble solids (%), vitamin C content (mg/100g), juice pH and tomato fruit dry matter content (%) with (4.35 and 4.28%), (25.73 and 27.67g), (4.00 and 3.43%) and (4.15 and 4.29%) in 1st and 2nd season, respectively. These results are agreement with those reported by Law-Ogbomo and Egharevba, (2009), Likewise, Godfrey-Sam-Aggrey *et al.,* (1985) and Mehla *et al.,* (2000).

ii) Effect of foliar spray with aluminum silicate:

Data illustrated in Table 7 show obviously that, foliar spray with the different levels *i.e*. 1, 2 and 3% aluminum silicate affected significantly on total soluble solids, vitamin C content, juice pH and tomato fruit dry matter content comparing the control. However, the maximum values of the pervious studied traits were obtained as a result of foliar spray of aluminum silicate at 2% on tomato plant followed by the treatment of foliar spray with 3% in both seasons. In this regard, Jia *et al.* (2011) showed that silicon material increase vitamin C and soluble solids of strawberry and eggplant. Furthermore, Toresano-Sanchez *et al* (2012) reported that silicon application had a positive impact on fruit quality parameters of cherry tomato such as concentration of soluble solids. Recently, Islam *et al*. (2014) on tomato reported that spraying the plants with silicon has the positive effect to advance fruit storability, maintained vitamin C as well as soluble solids, retain firmness and reduced fungal incidence.

iii) Effect of the interaction between plant densities and foliar spray with aluminum silicate:

Concerning total soluble solids, juice pH, vitamin C and fruit dry matter contents as affected by the treatments of interaction between plant density and foliar spray with aluminum silicate, the data at table (7) indicated significant difference regarding to the obvious traits in both seasons. The highest favorable records for total soluble solids and juice acidity traits were obtained from plants spaced with 30 cm apart under spraying with 2% aluminum silicate treatment in 1st and 2nd season, respectively and (40 cm space × 2% aluminum silicate) followed by (30 cm apart × 2% aluminum silicate) without significant differences between both interaction treatments for total soluble solids in the 2nd season as well as (35 cm space × 3% aluminum silicate) followed by (30 cm space × 1% aluminum silicate) without significant differences between both interaction treatments for juice acidity trait in the 1st season. On the other hand, the favorable records for vitamin C content was obtained from the interaction between(40 cm space × 2% aluminum silicate) in 1st season and both (40 cm space × 2% aluminum silicate) and (40 cm space × 2% aluminum silicate) without significant differences between them in 2nd season. The interaction between (40 cm space × 3% aluminum silicate) was the best treatment for the highest values of tomato fruit dry matter content in both seasons**.**

Table (7): Effect of Plant density and spraying with aluminum silicate on fruit chemical characters during 2015 and 2016 seasons.

Treatments		**Total soluble solids (%)**		**Vitamin C content (mg/100g)**		**Juice pH**		**Tomato fruit dry matter content (%)**	
Plant density	**Aluminum silicate**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**
14000(30cm)	Control	4.00	4.01	22.60	23.60	3.99	3.50	3.33	3.57
	1%	4.32	4.21	23.93	24.53	3.93	3.41	3.70	3.93
	2%	<u>4.57</u>	4.40	24.60	25.43	4.00	3.24	4.27	4.07
	3%	4.22	4.30	27.77	29.23	4.02	3.34	4.47	4.47
Mean		**4.28**	**4.23**	**24.73**	**25.70**	**3.99**	**3.37**	**3.94**	**4.01**
12000(35cm)	Control	4.04	4.03	22.67	25.67	4.02	3.42	3.50	3.73
	1%	4.24	4.24	26.07	27.20	3.98	3.41	4.13	4.03
	2%	4.50	4.37	26.73	29.73	4.02	3.35	4.47	4.27
	3%	4.44	4.31	24.20	27.73	3.95	3.33	4.63	4.47
Mean		**4.31**	**4.24**	**24.92**	**27.58**	**3.99**	**3.38**	**4.18**	**4.13**
10500(40cm)	Control	4.21	4.07	23.13	26.70	4.01	3.27	3.53	3.87
	1%	4.40	4.27	26.00	27.70	4.00	3.49	4.03	4.03
	2%	4.40	<u>4.53</u>	29.23	29.70	4.02	3.51	4.33	4.53
	3%	4.38	4.27	24.53	26.57	3.97	3.46	4.70	4.73
Mean		**4.35**	**4.28**	**25.73**	**27.67**	**4.00**	**3.43**	**4.15**	**4.29**
Means of aluminum silicate	Control	4.08	4.04	22.80	25.32	4.01	3.40	3.46	3.72
	1%	4.32	4.24	25.33	26.48	4.02	3.44	3.96	4.00
	2%	4.49	4.43	26.86	28.29	3.97	3.37	4.36	4.29
	3%	4.35	4.29	25.50	27.84	3.98	3.38	4.60	4.56
L.S.D.5%	Plant density	**0.063**	**NS**	**0.823**	**0.837**	**NS**	**0.017**	**0.093**	**0.077**
	Aluminum silicate	**0.086**	**0.076**	**0.890**	**0.980**	**0.016**	**0.013**	**0.121**	**0.092**
	Interaction	**0.148**	**0.132**	**1.542**	**1.697**	**0.028**	**0.023**	**0.209**	**0.160**

CONCLUSION

It could be concluded that, planting tomato, i.e., Alissa F_1 hybrid as a processing tomato in late summer under sandy soil with drip irrigation system using 30 cm space to give plant density of 14000 plants/Fed and foliar spray with 2% aluminum silicate (kaolin) after 15 days from transplanting, and repeated that every 8-10 days intervals until the beginning of coloring stage of tomato fruit to achieve the highest productivity and improving fruit physical and chemical characteristics with lowest percentage from sunscald fruits.

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تأثير الكثافة النباتية والرش بسيليكات الألومنيوم علي محصول وجودة ثمار طماطم التصنيع المنزرعة بالموسم الصيفي

الفونس جريس زاخر

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الملخص العربي

أجريت هذه الدراسة خلال الموسم الصيفي المتأخر لعامي 2015و2016 في مزرعة خاصة بجمعية المستقبل الزراعية بطريق– القاهرة –الاسكندرية الصحراوى الكيلو 73 ، محافظة الجيزة، مصر. لدراسة تأثير ثلاث كثافات نباتية (14000، 12000 و10500 نبات طماطم للفدان) مع الرش الورقي بثلاث تركيزات من مركب سيليكات الألومنيوم (الكاولين) وهي 1 ، 2 و 3٪ بجانب معاملة الكونترول (الرش بماء الصنبور) على النمو الخضري والمواصفات الزهرية ومحصول وجودة ثمار طماطم التصنيع (هجين اليسا) وللحد من اصابة الثمار بلفحة الشمس كاحد الامراض الفسيولوجية الهامة. وبدا الرش بواسطة سيليكات الالومنيوم بعد 15 يوم من الشتل وكرر الرش كل 8–10ايام حتي وصول ثمار الطماطم الي بداية مرحلة التلوين. هذا وكانت الزراعة بالاراضي الرملية تحت نظام الري بالتنقيط.

واظهرت النتائج المتحصل عليها ان اعلا كثافة نباتية من زراعة طماطم التصنيع وهي 14000 نبات بالفدان والناتجة من الزراعة علي مسافات 30 سم بين النباتات اعطت اطول نباتات واعلي الاوزان للأوراق الطازجة والجافة واعلا نسبه عقد للثمار وأعلي محصول مبكر، تسويقي وكلي من ثمار الطماطم واقل نسبة من الثمار المصابة بلفحة الشمس علي العكس من ذلك فكان وزن الثمرة والصلابة ومحتوي الثمار من فيتامين ج والمواد الصلبة الذائبة الكلية والحموضة تأثرت سلبيا بالكثافة النباتية المرتفعة وبالرغم من ان اقل كثافة نباتية وهي 10500 نبات للفدان اعطت اقل محصول من ثمار الطماطم واعلي نسبة اصابة بلفحة الشمس للثمار الا انها اعطت زيادة في وزن الثمار وكبر حجمها وصلابتها وزيادة محتواها من فيتامين ج والحموضة والمواد الصلبة الذائبة الكلية.

اما بالنسبة لتاثير الرش الورقي بمركب سيليكات الالومنيوم (الكاولين) علي نباتات طماطم التصنيع فنجد أن الرش بتركيز 2% اعطى اعلا نسبة معنوية في النمو الخضري–التبكير في التزهير–نسبة العقد واعلي محصول كلي وتسويقي وافضل وزن للثمرة مع نسبه منخفضة جدا من اصابة الثمار بلفحة الشمس كذلك صلابة الثمار وزيادة محتواها من فيتامين ج والحموضة والمواد الصلبة الذائبة الكلية.

وعليه ومن خلال نتائج معاملات التفاعل بين الكثافة النباتية والرش بمركب الكاولين يمكن التوصية عند زراعه طماطم التصنيع في الموسم الصيفي المتاخر تحت ظروف الاراضي الرملية ونظام الري بالتنقيط استخدام الكثافة النباتية المرتفعة وهي14000 نبات للفدان والناتجة من الزراعة علي مسافات 30 سم بين النباتات والرش بمركب سيليكات الالومنيوم (الكاولين) بتركيز 2% للحصول علي اعلي محصول تسويقي واقل نسبه اصابة للثمار بلفحة الشمس وذات مواصفات طبيعية وكيماوية جيدة.