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EFFECT OF SOME ANTIOXIDANT COMPOUNDS ON SOME HORTICULTURAL CHARACTERS OF FOUR NEW F_1 HYBRIDS OF TOMATO

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ABSTRACT

The present investigation was conducted in the fall season of 1997, summer season of 1998 and winter season of 1998, the seeds of four new F_1 hybrids were planted in the Experimental Research Farm, Faculty of Agriculture, Minia university, in a silty clay soil.These hybrids were produced earlier in the present study by crossing Line 16 as a maternal parent with the parental lines of C1943, Ohio 7663, Saladette and Nagcarlang. Seeds of the four new tomato F_1 hybrids and/or their transplants were treated with the antioxidant compounds, e.g. acetylsalicylic acid (ASA), ascorbic acid (AA), salicyclic acid (SA) and thiourea (Thi) at a concentration of 4 mM before planting to show the effect of these compounds on some horticultural characters e.g. mean of total yield (ton/fed), average fruit weight (g), fruit shape index, titratable acidity (%), reducing sugars (%), vitamin"C" (mg/100 g juice), total soluble solids (TSS), and seed germination percentage (%).

The obtained results indicated that hybrid "L x C" (line 16 x C1943) was the best one for average fruit weight and total yield. While, hybrid "LxS" line 16 x Saladette was the best for fruit content of reducing sugars, titratable acidity, vitamin "C" and fruit shape index. Meanwhile, hybrid "LxO" (Line 16 x Ohio 7663) was the best for TSS. Antioxidant types had insignificant effect on tomato seed germination, while hybrids and concentration of the antioxidants differed significantly in their effect on germination percentage. While, fruit weight, total yield, TSS, reducing sugars, vitamin "C" and acidity of fruits were significantly affected by seasonal changes, hybrids and antioxidant treatments. The results of the different combinations indicated that each factor was not acting dependently. Therefore, antioxidants may act differently according to the grown hybrid, and the growing season, so these factors would be considered before using any antioxidant in proper concentration to achieve its maximum effect. Using tomato hybrid and antioxidant treatment in tomato production could be good avenues to improve tomato productivity in the region of Minia, however, further studies should be done.

INTRODUCTION

Tomato is a very popular vegetable for fresh and processing uses. Productivity of tomato is determined by three factors, the grown cultivar, environmental conditions where the cultivar is grown, and the interaction between both factors . Tomato improvement efforts, in the past four decades have been developed cultivars could be grown under a wide range of environments, and could be satisfied some production purposes.

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Unfortunately, most of the tomato cultivars grown in Egypt are from the imported seeds. However, Khalf-Allah and Kassim (1984) stated that F_1 hybrid breeding method should be involved in tomato improvement in Egypt. Hashem (1997) reported that producing hybrid seed in Egypt is increasing rapidly.

Improvement of environments may involve a repeating cost for the growing crop e.g., extra fertilization, fungicide, irrigation, and so on. Recently, husbandry inputs involve the use of antioxidants which may play a role in the regulation of plant development, flowering , and chilling or disease resistance (Elad,1992; Raskin, et al 1989; Walker and Mc Kersie, 1993).

Plants could develope a complex antioxidant system(s) to protect cellular membranes and organelles from the damaging effects of toxic activated oxygen species (Salin, 1987; Foyer *et al.,* 1991). Failure of quench oxygen free radical production or the subsequent propagation chain reactions leads to the extensive degradation of membrane lipids, proteins, and DNA (Elstner, 1982).

Ascorbic acid plays a key central role in detoxification of activated oxygen (Foyer *et al*., 1991). It can react directly by reducing superoxide, hydrogen peroxide, and hydroxyl radical or quenching singlet oxygen. Alternatively, it can react indirectly by regenerating $\alpha\alpha$- tocopherol from α-chromanoxy radical, or in the synthesis of zeaxanthin in the xanthophyll cycle.

Some indications of the mechanisms by which salicylic acid (SA) may increase flower longevity and inhibits ethylene biosynthesis in pear cell suspension culture by blocking the conversion of 1- aminocyclopropane-1-carboxylic acid to ethylene (Leslie and Romani, 1986). In contrast, non-phytotoxic levels of (SA) did not affect ethylene formation in soybean cuttings (Pennazio and Roggero, 1991). Also, (SA) produced in the rhizosphere of some plants functions as an allelopathic chemical (Shettel and Balke, 1983), A subsequent look at plant systems showed that (SA) at 0.05 mM inhibits phosphate uptake by 54% and substantially reduced potassium absorption in barley roots (Glass, 1973 and 1974, respectively).

Singh and Kaur (1980), and Datta and Nanda (1985) reported that SA has other effects on plant development include increasing the pod number and yield in mung beans and increasing the height and grain number of cheena millet (*Panicum miliaceum*). Furthermore, SA at 0.1 mM in combination with indoleacetic acid (IAA) stimulated adventitious root intiation in mung beans (Kling and Meyer, 1983). Pretreatment with cysteine attenulated the reduction of tomato vegetative growth (stem length, number of leaves and fresh and dry weight of leaves and stems). (Reda *et al*.1985). They added that tomato plants treated with systeine showed higher chlorophyll ‘a’ content especially at 150 mg/L.

Gronzalez *et al* (1995) reported that ascorbate free radical stimulated root growth at 15 and 20˚C and also, stimulated root elongation if culture conditions allowed its oxidation.

The objective of the present investigation is to study the effects of four antioxidants, e.g., salicylic acid (SA), acetylsalicylic acid (ASA), ascorbic acid (AA), and thiourea (Thi) on the yield and some other economic characters of four new produced hybrids.

MATERIALS AND METHODS

Five tomato (*Lycopersicon esculentum* Mill.) parental lines were used in this study. The five parents are 'Line16', 'Line C1943', 'Ohio7663', 'Saladette', and 'Nagcarlang'. These parents were kindly obtained from the Tomato Breeding and Genetics Project at the University of California, Davis, USA and from the Agricultural Research Center, Hort.Inst., Mallawy, Res.Sta., El-Minia, Egypt. These parents were planted in the Experimental Farm, Faculty of Agriculture, El-Minia University, El-Minia, Egypt. In this regard, 'Line16' was considered to be a good source for several economic characters (Abdallah, 1995). This line was used as a maternal parent for all the studied hybrids. The chemical and physical properties of the soil are shown in Table (1).

Table (1): Mean of physical and chemical properties of the experimental soil.

Soil constituent	Value	Soil constituent	Value
Exch. K (meq/100g soil)	2.16	C.E.C. [mg/100 g soil]	31.80
pH 1- 2.5 (soil: water ratio)	7.96	E.C. (mmhos/cm)	1.95
Sand (%)	26.09	O.M., %	1.81
Silt (%)	32.80	CaCO3	2.04
Clay (%)	40.40	Total N (%)	0.14
Texture grade	Silty clay	P 'Olson' (ppm)	18

C.E.C. = Cation Exchange Capacity. E.C. = Electric Conductivity. O.M. = Organic Matter.

Tomato seeds of the parental lines were planted in nursery on August 11,1996. Thirty five-day-old transplants were transplanted in the open field and the common cultural practices for tomato production were followed. After good establishment of the growing plants and at the flowering stage, crosses between 'Line16' and the other parents were made under the field conditions. At full maturity of tomato fruits, the seeds were extracted and dried. Then seeds of these new hybrids were treated with the antioxidant compounds under the laboratory conditions as follow:

Laboratory experiments:

Four antioxidant compounds, i.e. Acetyl salicylic acid (ASA), Ascorbic acid (AA), Salicylic acid (SA) and Thiourea (Thi) were used to determine the effectiveness of each concentration. The produced four F_1 hybrid seeds were rinsed three times with distilled water, then air dried. Dried seeds were subjected to antioxidants. Antioxidant treatments were conducted by soaking seeds for 24 h in the tested antioxidant solutions (100 seeds/20 ml test solution) of different concentrations 0.0, 2, 4, 6, 8, 10 and 16 mM of the previous antioxidant compounds (Elad, 1992 and Galal and Abdou, 1996). After 10 days incubation in the dark at 20°C, germinated seeds were counted. A seed was scored as germinated, if the emerged radical was at least 3 times the length of the longest seed axis (Strandberg and White, 1989). Also, shoot length (mm) and root length (mm) characters were recorded. The best concentration was found to be 4 mM. Therefore, it was used in the following experiments under field conditions.

Field experiment:

Field experiments were conducted in three successive growing seasons. Seeds of the four F_1 hybrids were soaked in the antioxidant solutions (ASA, AA, SA and Thi) (4mM concentration) in petri plates for 24 h then planted on July, 5, 1997 for the fall season, on May 10, 1998 for the summer season and on November, 20, 1998 for the winter season. The raised transplants were divided into two groups, the first one was soaked in the aforementioned antioxidants, and the second one was soaked in distilled water (100 transplants/100 ml test solution). Moreover, seeds of the control transplants were soaked in distilled water during the seed germination process as well as their resultant transplants. In Split Plot Design with three replications, the transplants were planted in ridges (three meters long and one meter wide) where transplants were planted on the north side of the ridges at 50cm apart (6 plants/ridge). Antioxidant treatments were arranged in the main plots, while tomato F_1 hybrids were distributed randomly in the sub-plots.

The antioxidant treatments were arranged as follow:

1- Seeds treated with distilled water (control).
2-Seeds treated with salicylic acid (SA).
3-Seeds and transplants treated with salicylic acid.
4-Seeds treated with acetylsalicylic acid (ASA).
5-Seeds and transplants treated with acetylsalicylic acid.
6-Seeds treated with ascorbic acid (AA).
7-Seeds and transplants treated with ascorbic acid.
8-Seeds treated with thiourea (Thi).
9- Seeds and transplants treated with thiorea.

The common cultural practices known in the district for tomato production were followed. Harvesting started approximately after 80 days from planting and fruits were picked at four days intervals till the end of the growing seasons.

Data were recorded for the following characters:

1- Total yield (ton/Fed): Where weight of ripped fruits/plot was converted into total yield/fed.

Ten ripped fruits from the third picking were taken at random to record the following characters:

2- Average fruit weight (g): average weight of 10 ripped fruits.

3- Fruit shape index: this character was determined according to the following equation:

Fruit shape index = Fruit equatorial diameter / Fruit polar diameter x 100

4- Vitamin 'C' (mg/100g juice): was determined using 2,6 dichlorophenol indophenol dye (A.O.A.C., 1950).

5- Titratable acidity (%): was ascertained using 0.1 N NaOH solution and phenolphthalein as indicator (A.O.A.C., 1950).
6- Total soluble solids (TSS) (%): was determined by using a hand Carlizeith refractometer in the juice of ten fully ripped fruits after blending in a waring blender for 30 seconds.
7- Reducing sugars (%): was determined according to Lane and Eynon volumetric method as outlined in (A.O.A.C., 1950).

All recorded data were subjected to the analysis of variance procedure and treatment means were compared using the L.S.D at 0.05 (Gomez and Gomez, 1984).

RESULTS

1-Laboratory Experiment:

Data in Table 2 revealed no significant effect of antioxidant treatment on seed germination. However, there were a significant difference was found among grown hybrids, and among concentrations of antioxidants on seed germination percent. The highest and the lowest values of seed germinate were 65.46 and 51.14% for the hybrids “LxN” and “LxC”, and 75.62 and 2 7.40 % for O and 16 mM concentrations, respectively.

Irrespective of non-treated seed (control), the best concentration was 4mM, where the germination percentage was (67.91%), with insignificant difference between 2 and 4mM concentrations. So that, 4mM was recommended to use in the field experiment.

On the other hand, two way interactions, i.e., antioxidants x hybrids, antioxidants x concentration, and hybrids x concentration did not reflect significant effect on seed germination (Table 2). The interaction of the three factors together was significant and the highest values of seed germination were found with AA x “LxC” or “LxN’ x 4mM.

1-Field Experiment

1.1Yield and fruit characters

1.1.1Average effect of the studied factors:

Results in Table 3 reflected that average fruit shape index was not affected by seasonal changes, but average fruit weight was significantly affected by growing season. Summer season seems to be favorable than winter season for average fruit weight. It also, revealed that the growing hybrids were significantly responded to the growing season, regarding both fruit weight and shape index. The highest value of fruit shape index was obtained by the hybrid “LxS” followed significantly by” LxO”. Moreover, the highest fruit weight was significantly produced by the hybrid ‘LxC’, but the other hybrid were significantly lower than this hybrid. In this respect, antioxidant treatments had insignificant effect on fruit shape index, whereas average fruit weight was significantly affected by the treatment. Ascorbic acid treatments, i.e., seeds, or seeds + transplants treatment, gave higher significant values than control and the two salicylic acid treatments (SA), with

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no significant between AA treatments and Acetylsalicylic acid (ASA) or thiourea (Thi) treatments.

Regarding total yield, data presented in Table 3 revealed that total yield (ton/fed.) was significantly affect by seasonal changes. Total yield favor winter season followed significantly by summer and fall seasons. Hybrids, in this respect, were not significantly differed in their productivity. Antioxidant treatments had significant effect on the produced total yield (ton/fed.). Antioxidant AA treatments gave highest significant values of total yield expressed in ton/fed. compared to other treatments and control.

Table 3: Main effect of antioxidant compounds on fruit shape index, fruit weight and total yield of new tomato hybrids.

Treatment	Fruit shape Index	Fruit weight (gm)	Total yield (ton/fed.)
Season:			
Fall 1997	0.98	51.3	15.77
Summer 1998	0.95	54.4	26.91
Winter 1998	0.94	53.8	29.85
LSD at 0.05	NS	2.1	0.84
Line 16xLine C1943 (LxC)	0.88	63.0	24.71
Line 16x Ohio 7663 (LxO)	0.97	44.5	23.46
Line 16x Saladette (LxS)	1.00	46.3	24.69
Line 16x Nagcarlang (LxN)	0.92	46.8	24.69
LSD at 0.05	0.03	2.4	NS
Control	0.98	49.4	19.69
SA[1]	0.93	49.4	23.50
SA[2]	0.97	47.0	22.05
ASA[1]	0.93	50.3	24.34
ASA[2]	0.92	50.5	25.16
AA[1]	0.90	52.9	26.06
AA[2]	0.94	52.7	26.86
Thi[1]	0.94	51.9	24.98
Thi[2]	0.95	51.2	24.93
LSD at 0.05	NS	3.6	1.64

[1,2] denotes seeds, and seeds + transplants treated, respectively.

2.1.2 Combined effect of the studied factors:

Results presented in Table 4 and 5, regarding the combined effect of two factor together, showed a significant effect of all two way combinations on fruit shape index and fruit weight, except that of fruit shape index which was not affected by the interaction of season x antioxidant treatments. The interactions of summer or winter x “LxS” hybrid (Table 3), and control x “LxO” hybrid (Table 4) seemed to increase fruit equatorial diameter relative to polar diameter compared with other interactions. Regarding fruit weight, the highest values of fruit weight were obtained with the combination treatment of fall x “LxC” followed significantly by winter x “LxC” or “LxN” hybrids and

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winter x ASA_2 (seeds + transplants treatment) (Table 4), and 'LxC' x ASA_2 or AA_2 (Table 5) compared with other interactions.

Regarding total yield, combined effect of any two factors had significant effect on total productivity tomato plants (Table 3 and 4) the results indicated that total yield favuored the interactions of winter x "LxC", "LxO", or "LxS" hybrids and summer or winter x AA (seeds + transplants treatment) and winter x ASA_2, AA_1 and $Thi_{1,2}$ (Table 4). On the other hand, the combined effect of hybrids x antioxidant treatments had no significant effect on the productivity of tomato plants.

Regarding three way interactions, the combined effect of the studied three factors together had significant effect on fruit both traits (fruits weight and shape) and total yield (Table 6). The interaction of control x fall x "LxO" or LxS, control x summer x LxS, and control x winter x LxO gave highest values of fruit shape index. Fruit weight was highest with combined effect of fall x LxC x SA_1 or Thi_2. Moreover, total yield favored the combined effect of winter x LxO x ASA_1 followed by summer x "LxC'x Thi_2, summer x "LxN" Thi_2 or ASA_2 and winter or summer x "LxC" or "LxN" x ASA_2 or Thi_2 (Table 5).

2.2 Fruit chemical composition

2.2.1 Average effect of the studied factors:

Results in Table 7 indicated that, each of growing season, studied hybrid, and antioxidant treatments had significant effect on fruit chemical composition, i.e. TSS, reducing sugar, vitamin C, and Acidity. Regarding seasonal changes, obtained data showed that fruit TSS and reducing sugar scored highest significant values when tomato plant grown at fall season, whereas vitamin C and acidity of the fruit were significantly high at winter, and at fall and winter seasons, respectively. The best hybrids produced fruits contained highest values of TSS was LxO, and of reducing sugars, vitamin C and acidity was LxS.

Regarding average effect of antioxidant treatments, data in Table 7 showed that the effective antioxidant treatments in inducing highest significant values of TSS were Thi_2, Thi_1, SA_1 and control, with no significance among them. Data also, reflected that fruit reducing sugars was significantly high in plants treated with SA_1 and AA_1, with no significance between them. For vitamin C, highest significant values were obtained with SA_2, ASA_1, SA_1 and control compared with other treatments. The treatments gave high fruit acidity were SA_2, ASA_2, control and AA_2. By and large, it could be conclude that TSS favour Thi, reducing sugars favour SA_1, vitamin C favour SA_2 and ASA_1, and acidity favour SA_2 and ASA_2.

2.2.2 Combined effect of the studied factor

Two way combinations (Table 8, 9) reflected significant effect on fruit composition of TSS, reducing sugars, vitamin C, and acidity. Regarding the combined effect of season x Hybrids (Table 8), the highest and the lowest values of TSS were obtained from the interaction of fall x "LxO" and winter x "LxC", of reducing sugars were from the interaction of winter x "LxS" and winter x "LxN", of vitamin C were obtained from the interaction of winter x "LxS" and winter x "LxO", and of acidity were obtained from the interaction of winter x "LxS" and summer x "LxC", respectively.

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Table (7). Main effect of seasons, antioxidant compounds and hybrids on TSS, Reducing sugars, vitamin C and acidity of tomato.

Treatment	TSS(%)	Reducing Sugars(%)	Vitamin C	Acidity (%)
Season				
Fall 1997	6.34	2.06	18.67	0.68
Summer 1998	3.90	1.85	13.98	0.23
Winter 1998	3.75	1.96	21.47	0.69
LSD at 0.05	0.09	0.07	1.37	0.02
Hybrids				
Line16 x lineC1943(LxC)	4.43	1.97	20.29	0.52
Line16 x Ohio7663(LxO)	4.75	1.97	17.51	0.52
Line16 x Saladette (LxS)	4.55	2.13	20.32	0.61
Line16 x Nagcalang(LxN)	4.52	1.76	14.04	0.48
LSD at 0.05	0.11	0.08	1.58	0.02
Antioxidants				
Control	4.65	2.02	19.26	0.55
SA[1]	4.65	2.16	19.31	0.53
SA[2]	4.53	1.92	20.70	0.57
ASA[1]	4.23	1.86	20.22	0.47
ASA[2]	4.55	1.79	15.87	0.57
AA[1]	4.25	2.09	16.96	0.53
AA[2]	4.69	1.93	18.30	0.54
Thi[1]	4.71	1.88	16.19	0.51
Thi[2]	4.81	1.97	15.53	0.53
LSD at 0.05	0.16	0.13	2.37	0.04

[1,2] denote seeds, and seeds + transplants treated, respectively.

Regarding season x antioxidants interaction (Table 8), the highest and the lowest values of TSS were obtained from the interaction of fall x Thi[1],[2] and winter into ASA[1], of reducing sugars were obtained from the interaction of fall x SA[1] and summer x Thi[1], of vitamin C were obtained with the interaction of winter x AA[2] and summer x AA[2], and of acidity were obtained with the interaction of winter x ASA[2] and summer x Thi[2], respectively.

Concerning hybrids x antioxidants interaction (Table 9), the highest and the lowest values of TSS were obtained from the interaction of “LxS” x Thi[7] and “LxN” x ASA[1], of reducing sugars were obtained from the interaction of “LxS” x SA[1] and “LxN” x Thi[1], of vitamin C were obtained from the interaction of “LxC” x ASA[1] and “LxN” x ASA[2], and of acidity were obtained from the interaction of “LxS” x ASA[2] and “LxN” x AA[1], respectively.

Regarding the combined effect of the studied three factors (Table 10, 11), the results presented in the tables showed that all mentioned fruit chemical compositions were significantly responded to the interaction of the three factors. Data in Table 10 revealed that the highest and the lowest values of TSS were obtained with the interaction of fall x “LxN” x AA[2] and winter x “LxC” x ASA[1], and of reducing sugars were obtained from the interaction of fall x “LxS” x SA[2] and fall x “LxS” x ASA[2], respectively. Results in Table 11 showed that the highest and the lowest values of vitamin C were

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obtained from the interaction of winter x “LxS” x ASA^2 and summer x “LxN” x ASA^2, and of acidity were obtained from the interaction of winter x “LxS” x Thi^2, and summer x “LxC” x Thi^2, respectively.

DISSCUSSION

Response of tomatoes to growth regulators have been studied conclusively (Owen and Aung, 1990). Recently, plant growth hormone was defined as a natural compound in plants with an ability to affect physiological processes at concentrations for below those where either nutrients or vitamins would affect these processes (Davies, 1988). However, the use of antioxidants in plant production appears to be very promising and economic, and should be given more attention. However, some of antioxidants compounds are from divers group of plant phenolics (Raskin, 1992), that play an important role in regulation of the plant growth, and development (Harborne, 1980).

The effect of antioxidant types in the present study had insignificant effect on tomato seed germination, while genotypes (hybrids) and concentration of the antioxidants differed significantly in their effect on tomato seed germination (Table 2). But, when two factors combined each other had no effect on seed germination, however the effect of the three factors together on seed germination was significant. It suggested that the three factors not acting independently, so that, selection of a promising treatment to improve tomato seed germination depends of genotype specificity to react with specific antioxidant of suitable concentration. In this regard, the results indicated that the best combinations of the three factor were LxN or LxC hybrids when treated by ascorbic acid at 4mM gave the highest values of seed germination and considered as promising treatment. The stimulating effect of ascorbic on plant growth has been attributed to different mechanisms such as cell division (Arrigoni, 1994), and also (phenolic compounds) could regulate plant growth and development (Harborne, 1980).

Regarding fruit shape index, fruit weight and total yield (ton/fed.), results of the present study indicated that fruit shape was not affected by seasonal changes or antioxidant treatments, while it was differed among genotypes, which could be attributed to their genetic archetecture.

Whereas, fruit weight and total yield were significantly affected by seasonal changes, hybrids and antioxidants treatments. Moreover, these traits were significantly affected by the combination treatments, each two factors or even the three factors together. These results suggest that each factor, beside its own effect, was not act independently on the other factors, except total yield which was not reflect significant response to the interaction of hybrids x antioxidant treatments. In other words, to grow and choice a hybrid would depend on growing season, on antioxidant treatment suitable for this hybrid, and its concentration. Accordingly, the promising combination for fall season is to grow “LxS” hybrid and treat this hybrid by AA_1, for summer season is to grow “LxN” hybrid treat this hybrid either by ASA_2 or

Thi_2, and for winter season is to grow “LxO” and treat this hybrid by ASA, to obtain high yield. In general, the use of antioxidants can vary in its aims and effects according to its type and the time of application.

Regarding fruit chemical composition, present data (Table 8-11) indicate that TSS, reducing sugars, vitamin C, and acidity of tomato fruits were significantly affected by growing season, genotype (hybrid), and antioxidant treatment. It suggested that although each of the studied factors was independently affecting fruit chemical composition, their combinations (dependent effect) had relevant effect in this respect. So that, the maximum value of TSS, reducing sugar, vitaminC, and acidity was obtained when “LxC” (hybrid) grown in fall season and treated with Thi^1 and ^{2}, “LxS” (hybrid) grown in fall season and treated with SA^1, “LxO” (hybrid) grown in winter and treated with ASA^1, and “LxO” (hybrid) grown in winter and treated with Thi^2, respectively. Therefore, antioxidants may play differently according to growing hybrid and season, so these factors would be considered before using any antioxidant in proper concentration to achieve its maximum effect.

Raskin *et al.* (1989),in this respect, reported that SA is an important endogenous messenger in thermogenic plants. Also the main role of antioxidants is to protect the plant against hazardes of oxygen free radical produced under stresses or adverse conditions (Salin, 1987; foyer *et al*., 1991). Moreover, antioxidants could prevent the extensive degradation of membrane lipids, proteins, and DNA from the risk of oxygen free radicals and their capacity to quench it Elstner, 1982. So that, antioxidants may improve plant deployment, productivity and other plant traits (Elad, 1992; Raskin *et al*., 1989); walker and Mc-kersie, 1993. Therefor in this study, improvement of tomato productivity and its fruit chemical constituents could be attributed to the effective roles of antioxidants involved which beneficially affect tomato plant physiology.

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تأثير بعض مركبات مضادات الأكسدة على بعض الصفات لأربعة هجن جديدة "جيل أول" من الطماطم .

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أجريت هذه الدراسة في خريف 1997 وصيف 1998 وشتاء 1998 تم زراعة بذور أربعة هجن جديدة"جيل أول" في المزرعة البحثية بكلية الزراعة جامعة المنيا . وكانت التربة طمييه سلتيه .
عوملت بذور الجيل الاول لاربعة هجن من الطماطم وشتلاتها بواسطة مركبات مضادات الاكسدة acetylsalicylic acid (ASA),ascorbic acid (AA), salicylic acid (SA) and thiourea (Thi).بتركيز 4 ملليمول لبيان تا"ثير هذة المركبات على الصفات التالية، المحصول الكلى (طن/الفدان)، متوسط وزن الثمرة (جم)، معامل شكل الثمرة، الحموضة المعايرة، السكريات المختزلة، فيتامين ج ، المواد الصلبة الكلية، نسبة انبات البذور.
وكانت النتائج المتحصل عليها تشير إلى أن الهجين LxCكان أحسن الهجن من حيث متوسط وزن الثمره والمحصول الكلى بينما الهجين L x S كان أحسن الهجن من حيث محتوى الثمرة من السكريات المختزله والحموضه وفيتامين ج وكذلك معامل شكل الثمرة وكان الهجين L x O أحسن الهجين من حيث محتوى الثمرة من المواد الصلبه الكليه.
ليس للانواع المجتلفة لمضادات الاكسدة تاثير معنوى على انبات البذور، بينما تاثرت هذه الصفة معنويا" بالتركيزات المختلفة للنوع الواحد، وكذلك بالتركيب الوراثى المنزرع. بينما تاثرت معنويا" صفات وزن الثمرة والمحصول الكلى ونسبة المواد الصلبة الكلية والسكريات المختزلة ومحتوى الثمار من فيتامين ج والحموضة بموسم الزراعة و الهجين المستخدم وبمعاملات مضادات الاكسدة واوضحت الدراسة ان تاثير هذه المعاملات لم يكن منفردا"، ولكن كان هناك تفاعل معنوى بين العوامل تحت الدراسة فى معظم الصفات. وعلى ذلك يجب ان يؤخذ فى الاعتبار التركيب الوراثى ونوع المضاد المستخدم وكذلك موسم الزراعة للحصول على اعلى تاثير منها.

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Table 4. Combined effect of antioxidant compounds on fruit shape index, fruit weight and total yield of new tomato hybrids.

Treatment	Fruit shape index			Fruit weight (gm)			Total yield (ton/fed.)		
	Fall 1997	Summer 1998	Winter 1998	Fall 1997	Summer 1998	Winter 1998	Fall 1997	Summer 1998	Winter 1998
Season x Hybrids:									
Line 16x line C 1943	0.86	0.92	0.86	74.9	53.7	60.5	14.51	29.24	30.37
Line 16 x Ohio 7663	0.98	0.96	0.89	40.3	46.6	46.6	15.61	24.75	30.55
Line 16x Saladette	0.95	1.03	1.01	47.8	43.2	48.0	17.12	24.18	29.69
Line 16x Nagcarlang	0.92	0.88	0.91	42.4	37.9	60.1	15.84	29.46	28.78
LSD at 0.05		**0.06**			**4.13**			**1.69**	
Season x Treatments:									
Control	1.00	0.95	1.00	52.2	43.5	54.9	13.87	17.38	27.81
SA_1	0.88	0.92	0.95	49.7	47.0	51.6	16.98	26.50	27.03
SA_2	0.97	0.99	0.96	44.9	47.1	48.9	16.27	23.52	26.49
ASA_1	0.94	0.95	0.90	49.6	44.2	57.0	14.94	27.44	30.63
ASA_2	0.95	0.94	0.88	48.4	42.0	61.2	14.52	29.30	31.67
AA_1	0.81	0.94	0.95	52.7	53.4	52.6	18.28	28.51	31.42
AA_2	0.89	0.97	0.96	55.8	44.5	57.9	16.01	32.42	32.14
Thi_1	0.92	0.97	0.94	54.1	45.5	56.3	16.73	26.76	31.38
Thi_2	0.99	0.93	0.93	54.7	40.0	59.7	14.45	30.26	30.08
LSD at 0.05		**NS**			**6.19**			**2.53**	

[1,2] denotes seeds, and seeds + transplants treated, respectively.

Table 5. Interaction effect of antioxidant compounds on fruit shape index, fruit weight and total yield of new tomato hybrids.

Treat.	Fruit shape Index				Fruit weight (gm)				Total yield (ton/fed.)			
	L[3]XC[4]	L[3]XO[5]	L[3]XS[6]	L[3]XN[7]	L[3]XC[4]	L[3]XO[5]	L[3]XS[6]	L[3]XN[7]	L[3]XC[4]	L[3]XO[5]	L[3]XS[6]	L[3]XN[7]
Control	0.89	1.12	1.09	0.81	61.8	47.5	44.0	44.2	21.36	18.66	19.01	19.72
SA [1]	0.90	0.95	0.95	0.86	67.9	41.8	46.2	41.8	25.24	21.45	22.51	24.75
SA [2]	0.92	0.97	0.97	1.00	55.7	41.9	45.6	44.6	21.70	22.24	21.54	22.75
ASA[1]	0.88	0.97	0.89	0.98	67.0	44.5	44.0	45.6	22.30	25.76	24.99	24.14
ASA [2]	0.85	0.91	1.00	0.93	73.5	42.1	42.3	44.2	25.89	24.68	25.06	25.02
AA [1]	0.86	0.94	0.91	0.89	71.2	41.2	47.7	51.4	25.63	24.51	25.14	29.00
AA [2]	0.88	0.94	1.06	0.86	62.5	49.3	49.4	49.8	28.37	26.92	26.09	26.04
Thi [1]	0.85	0.99	1.02	0.90	62.7	44.2	51.3	49.7	23.86	24.70	26.11	25.14
Thi [2]	0.92	0.94	1.08	0.87	60.2	48.0	43.8	53.9	27.96	23.66	22.41	25.69
LSD at 0.05	0.1				7.15				NS			

[1, 2] denote seeds, and seeds + transplant treated, respectively
[3]L=line 16. [4]C=line C1943. [5]O=Ohio 7663 CV. [6]S=Saladette CV. [7]N=Nagcatlang CV.

Table (10). Combined effect of antioxidant compounds and seasons and hybrids on TSS, Reducing sugars, vitamin"C" and acidity of tomato.

Treatments	Fall				Summer				Winter			
	L[3]XC[4]	L[3]XO[5]	L[3]XS[6]	L[3]XN[7]	L[3]XC[4]	L[3]XO[5]	L[3]XS[6]	L[3]XN[7]	L[3]XC[4]	L[3]XO[5]	L[3]XS[6]	L[3]XN[7]
TSS (%)[8]												
Control	6.23	6.10	5.77	6.10	3.83	3.10	4.47	4.60	3.03	4.20	3.67	4.70
SA[1]	6.13	7.33	6.13	5.90	3.50	4.57	2.80	4.70	3.10	3.00	3.90	4.70
SA[2]	5.97	7.17	5.23	5.13	4.33	4.10	3.37	4.67	3.33	3.00	4.23	3.83
ASA[1]	5.10	5.73	6.63	5.72	3.03	3.83	3.60	4.10	2.73	3.40	3.90	3.43
ASA[2]	6.77	6.50	6.37	4.90	3.97	3.40	3.70	4.03	3.07	4.00	4.23	3.63
AA[1]	5.30	5.73	5.57	4.90	3.10	3.87	3.37	3.80	3.77	4.27	4.00	3.33
AA[2]	6.20	7.47	5.80	5.37	3.77	3.57	3.63	4.67	4.37	4.07	3.83	3.57
Thi[1]	6.83	6.43	6.37	5.33	3.30	4.10	3.97	4.30	4.37	3.87	4.63	3.00
Thi[2]	7.17	7.37	5.57	5.50	3.97	4.47	4.33	4.33	3.33	3.73	3.83	4.17
Reducing Sugars (%)[9]												
Control	2.78	2.10	2.12	1.41	1.93	2.05	2.09	1.63	1.62	2.41	2.29	1.81
SA[1]	2.42	2.21	3.32	2.79	1.42	1.41	2.16	2.11	1.96	1.93	2.39	1.91
SA[2]	2.29	1.53	1.75	1.85	1.74	1.99	1.87	1.87	1.79	1.92	2.59	1.63
ASA[1]	2.35	2.42	1.66	2.24	1.83	1.48	1.84	1.52	1.29	1.45	2.62	1.65
ASA[2]	1.43	2.17	1.19	1.69	1.65	1.90	2.11	2.01	1.43	2.19	1.83	1.92
AA[1]	2.29	2.60	2.09	1.96	2.11	2.03	2.06	2.18	1.67	2.15	2.45	1.43
AA[2]	2.32	1.25	2.55	1.29	1.74	1.96	2.25	1.99	1.86	1.96	2.25	1.76
Thi[1]	2.18	2.36	2.39	1.21	1.52	1.98	1.36	1.34	2.62	2.10	2.01	1.49
Thi[2]	2.77	1.56	1.99	1.68	2.19	2.29	1.69	1.43	1.72	1.82	2.53	1.92

[1,2]denote seeds and seeds + transplants treated, respectively.
[3]L=line 16. [4]C=line C1943. [5]O=Ohio 7663 cv.[6]S=Saladette cv. [7]N=Nagcatlangcv [8]LSD at 0.05 [9]LSD at 0.05 = 0.44

Table (11). Combined effect of antioxidant compounds on TSS, Reducing sugars, vitamin C and Acidity of new tomato hybrids.

	Fall				Summer				Winter			
	L[3]XC[4]	L[3]XO[5]	L[3]XS[6]	L[3]XN[7]	L[3]XC[4]	L[3]XO[5]	L[3]XS[6]	L[3]XN[7]	L[3]XC[4]	L[3]XO[5]	L[3]XS[6]	L[3]XN[7]
Vitamin C[8]												
control	17.02	26.05	15.34	17.60	13.17	20.00	4.14	22.84	17.57	25.34	30.63	21.42
SA[1]	20.49	17.73	17.33	17.97	20.29	5.03	20.63	15.07	24.03	23.53	32.25	17.37
SA[2]	27.75	16.73	17.38	15.70	23.05	15.77	15.90	23.80	27.00	21.10	30.87	13.38
ASA[1]	17.20	14.45	18.27	14.80	36.92	24.64	14.00	5.88	30.28	21.73	32.08	12.43
ASA[2]	14.63	20.94	17.40	18.07	18.69	6.83	22.16	3.19	19.93	23.71	16.05	8.85
AA[2]	18.36	19.33	17.95	20.47	21.68	5.68	17.25	4.40	14.60	24.69	26.01	13.11
AA[2]	18.44	19.06	16.17	20.24	14.97	7.33	19.27	2.69	15.95	30.08	40.36	15.02
Thi[1]	32.39	11.70	17.46	16.97	5.32	8.63	9.04	4.35	20.03	22.93	31.35	14.10
Thi[2]	27.06	16.77	17.57	19.28	11.87	15.59	18.50	4.69	19.01	7.41	13.29	15.28
Acidity (%)[9]												
control	0.57	0.69	0.72	0.66	0.18	0.27	0.24	0.27	0.67	0.89	0.87	0.54
SA[1]	0.75	0.80	0.57	0.59	0.18	0.20	0.22	0.25	0.62	0.56	0.72	0.90
SA[2]	0.65	0.62	0.76	0.69	0.23	0.20	0.23	0.43	0.61	0.54	1.05	0.85
ASA[1]	0.71	0.59	0.74	0.65	0.27	0.18	0.21	0.19	0.56	0.57	0.78	0.22
ASA[2]	0.71	0.66	0.60	0.71	0.24	0.19	0.43	0.22	0.79	0.82	1.03	0.44
AA[1]	0.70	0.72	0.62	0.63	0.20	0.21	0.20	0.21	0.64	0.80	1.07	0.37
AA[2]	0.64	0.74	0.75	0.74	0.16	0.38	0.25	0.19	0.74	0.79	0.60	0.50
Thi[1]	0.76	0.57	0.70	0.72	0.17	0.23	0.23	0.13	0.72	0.47	0.99	0.39
Thi[2]	0.77	0.69	0.61	0.80	0.10	0.24	0.21	0.17	0.60	0.51	1.10	0.56

[1,2]denote seeds and seeds + transplants treated, respectively.
[3]L=line 16. [4]C=line C1943 [5]O=Ohio 7663 cv. [6]S=Saladette [7]N=Nagcatlang cv. [8]LSD at 0.05 = 8.2 [9]LSD at 0.05 = 0.12

Table 6 Interaction effect of antioxidant compounds on fruit shape index, fruit weight and total yield of new tomato hybrids.

Treatments	Fall 1997				Summer 1998				Winter 1998			
	L[3]XC[4]	L[3]XO[5]	L[3]XS[6]	L[3]XN[7]	L[3]XC[4]	L[3]XO[5]	L[3]XS[6]	L[3]XN[7]	L[3]XC[4]	L[3]XO[5]	L[3]XS[6]	L[3]XN[7]
Fruit shape Index [8]												
Control	0.92	1.29	1.16	0.61	0.91	0.87	1.12	0.88	0.84	1.20	1.00	0.95
SA[1]	0.77	1.02	0.94	0.8	0.88	0.89	0.94	0.98	1.06	0.95	0.96	0.81
SA[2]	0.79	0.96	1.07	1.04	0.98	1.00	0.99	1.00	0.98	0.95	0.93	0.97
ASA[1]	0.97	1.01	0.67	1.10	0.90	0.96	1.00	0.93	0.77	0.94	1.00	0.90
ASA[2]	0.87	0.85	1.04	1.05	0.91	0.98	1.02	0.83	0.76	0.90	0.96	0.91
AA[1]	0.81	0.83	0.71	0.90	0.92	0.96	1.05	0.83	0.84	1.02	0.97	0.95
AA[2]	0.84	0.84	1.01	0.85	0.95	1.01	1.07	0.84	0.86	0.98	1.10	0.90
Thi[1]	0.82	1.06	0.88	0.90	0.96	0.97	1.09	0.84	0.77	0.95	1.08	0.97
Thi[2]	0.95	0.95	1.07	1.00	0.91	0.94	1.07	0.80	0.89	0.93	1.10	0.81
Fruit weight[9] (g)												
Control	82.7	41.0	42.8	42.4	43.5	50.7	42.0	37.7	59.3	50.7	47.2	52.5
SA[1]	82.8	42.0	48.0	25.9	57.5	41.6	44.4	44.5	63.5	41.8	46.2	55.0
SA[2]	62.0	32.5	45.2	39.7	57.7	49.3	44.0	37.5	47.5	43.8	47.7	56.7
ASA[1]	69.0	38.2	47.2	44.0	56.2	49.0	37.9	33.6	75.7	46.3	46.8	59.3
ASA[2]	69.2	39.0	43.4	42.0	52.6	40.4	40.1	34.9	98.7	46.8	43.5	55.7
AA[1]	76.1	36.5	50.4	47.9	64.8	50.7	45.6	52.4	72.7	36.5	47.0	54.0
AA[2]	77.2	43.2	48.7	54.0	46.2	51.8	43.4	36.6	64.0	53.0	56.0	58.7
Thi[1]	71.8	42.0	57.7	44.8	58.2	40.7	51.2	31.9	58.0	49.8	45.0	72.3
Thi[2]	83.1	48.0	46.4	41.4	39.6	45.0	32.0	43.5	58.0	51.0	53.0	76.7
Total yield (ton/fed.)[10]												
Control	13.75	13.67	13.44	14.62	23.11	13.51	14.76	18.13	27.23	28.79	28.82	26.41
SA[1]	17.80	17.12	15.83	17.18	31.43	21.66	23.06	29.83	26.63	25.58	28.65	27.25
SA[2]	11.37	16.08	19.82	17.32	26.35	21.83	22.83	23.07	27.37	28.81	21.97	27.80
ASA[1]	11.39	15.61	16.27	16.49	25.47	26.13	28.70	29.47	30.05	36.00	30.00	26.45
ASA[2]	13.76	14.05	16.75	13.53	29.80	26.63	26.74	34.03	34.11	33.35	31.70	27.50
AA[1]	1s4.24	14.05	21.71	23.12	32.22	26.47	22.27	33.07	30.44	33.01	31.43	30.81
AA[2]	18.82	16.20	13.23	15.78	33.20	31.72	32.59	32.17	33.08	32.84	32.45	30.17
Thi[1]	13.84	17.57	23.19	12.30	25.83	26.91	23.57	30.74	31.92	29.63	31.57	32.39
Thi[2]	15.63	16.10	13.84	12.23	35.74	27.91	22.78	34.62	32.50	26.97	30.61	30.23

[1,2]denote seeds and seeds + transplants treated, respectively.
[3]L=line 16. [4]C=line C 1943. [5]O=Ohio 7663 CV. [6]S=Saladette CV. [7]N=Nagcatlang CV. [8]LSD=0.17 [9]LSD=12.39 [10]LSD=5.09

Table (8). Combined effect of antioxidant compounds and season or hybrids on TSS, Reducing sugars, vitamin C and acidity of tomato.

Treat.	TSS(%)			Reducing Sugars(%)			Vitamin C			Acidity (%)		
	Fall 1997	Summer 1998	Winter 1998	Fall 1997	Summer 1998	Winter 1998	Fall 1997	Summer 1998	Winter 1998	Fall 1997	Summer 1998	Winter 1998
Season X Hybrids												
L[3]XC[4]	6.16	3.64	3.46	2.32	1.79	1.79	21.48	18.44	20.94	0.70	0.19	0.66
L[3]XO[5]	6.65	3.89	3.73	2.03	1.90	2.00	18.08	12.17	22.28	0.68	0.23	0.66
L[3]XS[6]	5.94	3.70	4.03	2.12	1.94	2.33	17.21	15.65	28.10	0.67	0.25	0.91
L[3]XN[7]	5.38	4.36	3.82	1.78	1.79	1.73	17.90	9.66	14.55	0.69	0.23	0.53
LSD at 0.05	0.18			0.15			3.74			0.04		
Season x Treatments												
Control	6.05	4.00	3.90	2.10	1.93	2.03	19.00	15.04	23.74	0.66	0.24	0.74
SA[1]	6.37	3.89	3.78	2.69	1.78	2.05	18.38	15.26	24.30	0.68	0.21	0.70
SA[2]	5.88	4.12	3.60	1.86	1.87	1.98	19.39	19.63	23.09	0.68	0.27	0.76
ASA[1]	5.80	3.64	3.37	2.17	1.67	1.75	16.18	20.36	24.13	0.67	0.21	0.53
ASA[2]	6.14	3.78	3.73	1.62	1.92	1.84	17.65	12.72	17.14	0.67	0.27	0.77
AA[1]	5.38	3.54	3.84	2.24	2.10	1.84	19.03	12.25	19.60	0.67	0.21	0.72
AA[2]	6.21	3.91	3.96	1.85	1.99	1.96	18.48	11.07	25.35	0.72	0.25	0.66
Thi[1]	6.24	3.92	3.97	2.04	1.55	2.06	19.63	6.84	22.10	0.69	0.19	0.64
Thi[2]	6.40	4.28	3.77	2.00	1.90	2.00	20.17	12.66	13.75	0.72	0.18	0.69
LSD at 0.05	0.28			0.22			4.10			0.06		

[1,2]denote seeds and seeds + transplants treated, respectively.
[3]L=line16. [4]C=line C1943 [5]O=Ohio 7663 cv. [6]S=Saladette cv. [7]N=Nagcalang.

Table 2. Effect of different concentrations of antioxidant compounds on germination percentage of tomato hybrids seeds.

Mean of Hybrids	Av. Effect of Antioxidants	Concentrations "mM"							Hybrids	Antioxidant
LxC= 51.14	52.107	16	10	8	6	4	2	0.0		
		12.50	27.33	36.67	45.00	67.76	69.17	75.00	LxC	SA
		37.67	40.00	47.50	53.77	60.00	67.50	78.70	LxO	
		17.50	41.27	47.50	54.27	62.13	63.77	72.50	LxS	
		22.67	42.50	53.77	58.77	61.27	66.27	76.27	LxN	
LxO= 56.03	56.625	21.27	35.00	40.00	51.27	55.00	61.27	75.00	LxC	ASA
		21.27	27.50	38.77	48.77	60.00	65.00	78.70	LxO	
		22.67	32.67	38.77	55.00	60.00	66.27	72.50	LxS	
		26.17	36.20	42.50	53.77	55.17	68.77	76.27	LxN	
LxS= 54.15	63.133	27.50	40.00	52.50	50.83	81.33	67.50	75.00	LxC	AA
		51.27	52.50	60.00	76.33	76.27	55.00	78.70	LxO	
		36.67	48.77	51.27	61.26	76.27	77.50	72.50	LxS	
		47.50	67.50	70.00	78.67	86.33	72.50	76.27	LxN	
LxN= 65.46	54.920	20.00	47.50	51.27	56.27	60.00	55.00	75.00	LxC	Thi
		28.67	40.00	50.00	58.77	78.77	58.77	78.70	LxO	
		26.33	42.50	48.77	57.50	71.33	66.33	72.50	LxS	
		18.77	36.03	50.00	67.50	75.00	70.00	76.27	LxN	
		27.40	41.09	48.70	57.98	67.91	65.66	75.62	Av. Effect of concentration	

L.S.D. at $_{0.05}$ for antioxidants = N.S antioxidant x Hybrids = N.S. Hybrids x concentrations = NS Hybrids = 9.7 antioxidant x Conc. = N.S. antioxidant x Hybrids x concentrations=51.53 Concentrations = 19.48

Table 9. Combined effect of antioxidant compounds, hybrids on TSS, Reducing sugars, vitamin C and acidity of tomato.

Treatment	TSS (%)				Reducing sugars (%)				Vitamin C				Acidity			
	L[3]XC[4]	L[3]XO[5]	L[3]XS[6]	L[3]XN[7]	L[3]XC[4]	L[3]XO[5]	L[3]XS[6]	L[3]XN[7]	L[3]XC[4]	L[3]XO[5]	L[3]XS[6]	L[3]XN[7]	L[3]XC[4]	L[3]XO[5]	L[3]XS[6]	L[3]XN[7]
Control	4.36	4.47	4.64	5.13	2.11	2.19	2.17	1.62	15.92	23.80	16.61	20.62	0.47	0.62	0.61	0.49
SA[1]	4.24	4.97	4.28	5.10	1.93	1.85	2.62	2.26	21.60	15.43	23.50	16.80	0.52	0.52	0.50	0.58
SA[2]	4.54	4.76	4.28	4.54	1.94	1.81	2.07	1.78	25.93	17.07	21.38	17.63	0.50	0.45	0.68	0.66
ASA[1]	3.62	4.32	4.71	4.42	1.82	1.78	2.04	1.78	28.13	20.27	21.45	11.04	0.51	0.45	0.58	0.35
ASA[2]	4.60	4.63	4.77	4.19	1.50	2.09	1.71	1.87	17.75	17.16	18.54	10.04	0.58	0.56	0.69	0.46
AA[1]	4.06	4.62	4.31	4.01	2.02	2.26	2.20	1.86	18.21	16.57	20.40	12.66	0.51	0.57	0.63	0.40
AA[2]	4.78	5.04	4.42	4.54	1.97	1.72	2.35	1.68	16.45	18.82	25.27	12.65	0.51	0.64	0.53	0.48
Thi[1]	4.83	4.80	4.99	4.21	2.11	2.15	1.92	1.35	19.25	14.42	19.28	11.81	0.55	0.42	0.64	0.41
Thi[2]	4.82	5.26	4.58	4.67	2.23	1.89	2.07	1.68	19.31	13.26	16.45	13.08	0.49	0.48	0.64	0.51
LSD at 0.05	0.32				0.25				4.74				0.12			

[1,2]denote seeds, and seeds + transplants treated, respectively.
[3]L=line 16. [4]C=line C1943. [5]O=Ohio 7663 cv. [6]S=Saladette cv. [7]N=Nagcatlang cv.