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Improving Tomato Plant Growth, Health, Earliness, Productivity and Fruit Quality by Chemically Induced Systematic Resistance

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Abstract: This study came out as results of many preceding primary studies from 1995 to 2003 years on chemical induced resistance, this experiment was conducted For two summer season from 2003- 2004, in newly reclaimed sandy soil. Seeds of four tomato commercial F1 hybrids were sown in foam try on May 1st in the two season. On June 15th seedling were transplanted into field. On the day of transplanting, three chemical resistance inducer treatments were foliar applied and repeated 15 days intervals for four. Complete randomized blocks design with three replicates was adapted. Data of Plant growth, Disease incidence earliness, yield and fruit quality were recorded. All recorded data were subject to statistical analysis by SAS computer program. The results showed that all recorded data were improved significantly by chemical induction of resistance in all four cultivars through both growing season. Meanwhile, the response rate was differed up on cultivars and its base resistance level. Up on the results, it could be concluded that, the application of chemical induction of t resistance not only reduce the viruses diseases infection, development and effects in tomato but also improve plant growth, productivity, earliness and fruit quality. So it could be the ideal solution to control insect born viruses such as Tobacco mosaic virus (TMV) and cucumber mosaic virus (CMV) in summer tomato.

Key words: Induce resistance, Tomatoes, Plant growth, Disease incidence Productivity, Earliness and Fruit quality, Insect born viruses diseases

INTRODUCTION

Tomato is one of the most important vegetable crop in Egypt. It's grown all year round in Egypt. However, production faces some problems in summer season due to high temperature and insect born viruses diseases prevailing in these months. The main effect of adverse weather conditions was found on flowering and fruit set. So cultivation of heat tolerant cultivars could come over the problem of flowering and fruit set depression[23,1,8,19]. But heat tolerant hybrids are almost sensitive to insect born viruses such as Tobacco mosaic virus (TMV) and cucumber mosaic virus (CMV). which resulted in an estimated at least 25% yield loss. Also insect born viruses is a particularly difficult to manage, due in part to its extensive host range and ability to be transmitted by more than 65 insects species. Moreover, there is a lack of genetically resistant fresh-market tomato varieties to CMV infection, so management options are limited[37]. Thus, most of summer tomato growers consume a huge amount of insecticide to prevent viruses transmitted by aphids or whit fly specially in the first 40 days after transplanting (up to fruit set). the huge amount of insecticide affected significantly both earliness and total yield and may also influence the consumer health.

Zehnder *et al*[37], Anfoka[2] and Salem[26] reported that insect born viruses such as Tobacco mosaic virus (TMV) and cucumber mosaic virus (CMV) could be well controlled by applying induced resistance (IR) even by biological or chemical inducer.

Hammerschmidt and Kuf[14] found that, Systemic acquired resistance (SAR) is an inducible defense mechanism that plays a central role in disease resistance. Moreover, Lawton *et al*[18] showed that chemically induction of systemic acquired resistance treatment induced both PR protein accumulation and resistance to viruses bacterium' and the fungus in Arabidopsis plants. Recently, it has been demonstrated that chemically induction of Systemic acquired resistance treatment of tomato plants protected plants against the root rot disease[5]. In addition Langcake and Wickins[17], Kato *et al*[15], Ward[33], Salt *et al*[27], Doubrava *et al*[11], Gottstein and Kuf[12], Brederod *et al*[6], Cohen *et al*[7], Kessmann *et al*[16] Reuveni *et al*[24], Siegrist *et al*[28], Anfoka[2] and Salem[26] studied the possibility of chemical induction of systematic aquare resistance (SAR) by various chemical

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substances. Malamy *et al*[20] and Stout *et al*[29] indicated that, salicylic scid (SA) is the endogenous signal in the resistance response to viruses infection in plant. White[34],Uknes *et al*[31] and Vernooij *et al*[32] found that the exogenous application of salicylic scid (SA) or its salt can induce expression of SAR genes. Ryals *et al*[25] were the first to suggest the possibility of utilization of chemical inducers, which cause plants to generate immunity signal, may be useful for plant protection. Ye *et al*[36] agreed with them and added that chemical inducers could be applied with the techniques and equipment of mechanized agriculture to minimizing labor and expense involved in resistance induction. Moreover Ye *et al*[36] mentioned that chemically induced resistance is nonspecific. Being effective against a wide spectrum of fungal, bacterial and viral diseases.

Ye *et al*[36] also discussed phytotoxicity as an important issues associated with routine chemical application of SAR inducers in agriculture. Many chemicals inducers can incite a gradual development of chlorosis and / or necrosis. They illustrated that this phytotoxicity appears to be a function of the chemical, its concentration and mode of application, crop species and environmental conditions. In our primary study using salicylic acid (SA) for inducing systemic resistance we meet the previous phenomenon mentioned by Ye *et al*[36]. To overcome this problem citric acid was added to the solution of SA before foliar application.

Therefore, this study, aims to screen the response of some tomato commercial heat tolerance hybrids to chemically induced resistance under open field conditions in the summer season, as approach of applying the phenomena (SAR) in vegetable production in order to reduce using pesticide and its side effect in the consumer health. Thus, summer tomato growers could found an alternative management strategies, environmentally sound and easily implemented.

MATERIALS AND METHODS

This study came out as results of some preceding primary studies from 1995 to 2003 years on chemical induced resistance, it was conducted For two summer season from 2003- 2004, in newly reclaimed sandy soil, Berqash- El-Giza Governorate. Seeds of the most popular four tomato commercial F1 hybrids (GS12, Alisa, VT737 and SS33) in summer season were sown "in foam try filed with growing media of 1 peat : 1Vermeculite" on May 1st in the two season. On June 15th seedling were transplanted into field. On the day three chemical solution (0.01 % of SA, CA and their mixture) treatments were foliar applied and repeated 15 days intervals for four time up to 45 days after transplanting in comparison with clear water as control treatment. Every chemical treatments was replicated three time and received the same solution four time a season.

Complete randomized blocks design with three replicates was adapted. Each plot consisted of two row of 1.5 m in wide and 5 m long (15 m2 /plot), plant spacing was 50 cm, every replicates included 20 plants. The recommended cultivation practices for summer season were applied through the growing season.

Plant length, plant height, number of leaves, branch, flower clusters and fruits/ plant recorded in five plants/plot after 50 days after transplanting (at fruit set stage). Moreover, The level of the resistance induced in tomato plants against the viruses disease was recorded after 50 days after transplanting as plant height/plant length (%) and the percentage of plants that developed chlorosis and mosaic symptoms (Disease incidence)[37,2,26]. Moreover, the yield of the first three pickings (25 % of pickings number) was calculated as the early yield. At the end of harvesting total yield and marketable yield were calculated. In addition average fruit weight, dry matter percent, total soluble solids (TSS %), total acidity and ascorbic acid (V.C), was determined as described in A.O.A.C[4], as indictors for fruit quality.

Data were subject to statistical analysis of ANOVA, and the entries means were compared according to Duncan multiple comparative methods, as reported by[13]. All statistical process were processed by SAS computer program.

RESULTS AND DISCUSSIONS

1- Vegetative growth:

1.1- Effect of cultivars: Data in Table(1) showed that, cultivars differed significantly in all three traits of vegetative growth in both two seasons except leaves number trait in the second season. Alisa plants were the longest in both investigated seasons. Also, they produced the highest leave numbering in the first season. Regarding branches number, VT737 plants were the superior in both two seasons. They recorded the second value of plant length leaves number and in second season and both seasons respectively. Although, plants of GS12 hybrids recorded the lowest value of all investigated traits in both seasons, they got the highest value of leaves number in the second season without any significant between cultivars.

1.2- Effect of treatments: Foliar application treatments were affected all recorded traits in both seasons with very high significant level absolutely. The treatment of salicylic

Table 1: Response of vegetative growth of some tomato cultivars to chemical induction of systematic resistance, at fruit set stage.

Cultivars	Treatments	First Season 2003			Second Season 2004		
		Plant length (cm)	Branches number	Leaves number	Plant length (cm)	Branches number	Leaves number
GS12	SA	47.33 G	7.00 GH	51.67 DEF	48.47 J	8.67 DEFG	59.73 BC
	CA	48.33 FG	7.33 FGH	55.00 BC	56.00 F	7.67 FGHI	57.57 DE
	SA+CA	53.00 DE	8.33 DEF	52.67 CDE	58.53 DE	9.33 BCDE	58.40 CD
	Control	43.67 H	7.00 GH	42.00 I	52.70 G	6.67 I	53.57 G
Cultivar mean		48.08 C	7.42 C	50.33 C	53.93 B	8.08 B	57.32
Alisa	SA	55.66 CD	7.67 EFGH	53.17 BCD	59.57 CD	8.00EFGHI	52.47 GH
	CA	60.33 AB	7.33F GH	60.33 A	57.13 EF	7.33 GHI	60.73 B
	SA+CA	61.67 A	10.33 B	60.00 A	61.00 BC	10.33 BC	65.40 A
	Control	50.66 EF	6.67 H	46.67 H	49.50 IJ	7.00 HI	42.10 J
Cultivar mean		57.08 A	8.00 B	55.04 A	56.80 A	8.17 B	55.18
VT737	SA	50.00 EFG	11.67 A	56.00 B	52.17 GH	10.67 B	55.37 F
	CA	52.00 E	9.67 BC	50.00 EFG	57.07 EF	9.33 BCDE	55.20 F
	SA+CA	57.67 BC	8.67 CDE	60.00 A	63.70 A	12.00 A	56.70 EF
	Control	51.00 EF	8.00 EFG	48.67 FGH	53.63 G	9.00 CD	53.67 G
Cultivar mean		52.67 B	9.50 A	53.67 A	56.64 A	10.25 A	55.23
SS33	SA	50.33 EFG	9.67 BC	53.33 BCD	48.47 J	8.33 EFGH	51.97 H
	CA	62.33 A	9.33 BCD	53.67 BCD	61.40 B	9.33 BCDE	56.53 EF
	SA+CA	52.67 E	10.33 B	54.00 BCD	57.27 EF	10.00 BCD	60.40 B
	Control	48.33 FG	6.67 H	47.00 GH	50.63 HI	7.33 GHI	50.27 I
mean		53.42 B	9.00A	52.00 B	54.44 AB	8.75 B	Cultivar 54.8
Treatments Means	SA	50.83 B	9.00 A	53.54 B	52.17 B	8.92 B	54.88 B
	CA	55.75 A	8.42 B	54.75 B	57.90 A	8.42 B	57.51AB
	SA+CA	56.25 A	9.42 A	56.67 A	60.13 A	10.42 A	60.23 A
	Control	48.42 C	7.08 C	46.08 C	51.62 B	7.50 C	49.90 C
Significant levels	Cultivar	***	**	***	*	***	NS
	Treatments	***	***	***	***	***	***
	Interaction	***	***	***	***	***	***

NS= Non Significant ***** = Significant at 5 % ******= Significant at 1 % *******= Significant at<0.1 %

Table 2: Response of diseases index of some tomato cultivars to chemical induction of systematic resistance, at fruit set stage.

Cultivars	Treatments	First Season 2003			Second Season 2004		
		Plant height (cm)	Plant height/ Plant length (%)	Virus Infection (%)	Plant height (cm)	Plant height/ Plant length (%)	Virus Infection (%)
GS12	SA	40.90 H	86.43 F	36.73 CD	42.80 I	88.31 DE	35.33 EF
	CA	47.20 E	97.67 AB	40.30 C	52.27 DE	93.34 C	39.40 DE
	SA + CA	52.53 C	99.10 A	29.93 E	56.20 C	96.03 ABC	22.97 I
	Control	39.23 H	89.87 E	63.17 A	45.17 GH	85.64 E	58.27 B
Cultivar mean		44.97 C	93.27 A	42.53 A	49.11 B	90.83 B	38.99B
Alisa	SA	45.23 EF	81.30 G	39.83 C	56.00 C	94.01 BC	41.40 D
	CA	55.13 B	91.37 DE	49.83 B	54.03 CD	94.59 BC	45.83 C
	SA + CA	57.93 A	93.97 CD	24.17 FG	60.30AB	98.85 A	21.37 IJ
	Control	40.23 H	79.50 H	58.87 A	43.30 HI	87.50 DE	65.10 A
Cultivar mean		49.63 A	86.53 C	43.18 A	53.41 A	93.74 A	43.43 A
VT737	SA	45.13 EF	90.27 E	27.73 EF	50.23 EF	96.31 ABC	21.77 IJ
	CA	50.33 CD	96.80 ABC	29.53 E	55.40 C	97.09 AB	24.77 HI
	SA + CA	56.30 AB	97.63 AB	20.03 G	61.30 A	90.23 ABC	17.43 J
	Control	43.43 FG	85.27 F	32.30 DE	48.23 F	89.94 D	31.87 FG

Table 2: Continued.

Cultivar mean		48.80AB	92.49 A	27.40 C	53.79 A	94.89 A	23.96 C
SS33	SA	41.20 GH	81.93 G	31.00 E	45.90 G	94.72 BC	25.27 GH
	CA	58.03 A	93.67 DE	38.50 C	58.43 B	95.16 BC	28.67 GH
	SA + CA	49.83 D	94.60 BCD	21.23 G	55.50 C	96.92 ABC	18.23 J
	Control	41.70 GH	86.21 F	37.57 C	45.63 G	90.12 D	39.47 DE
Cultivar mean		47.69 B	88.97 B	32.08 B	51.37 AB	94.23 A	27.91 C
Treatments Means	SA	43.12 C	84.98 B	33.83 C	48.73 C	93.34 B	30.94 B
	CA	52.68 B	94.73 A	39.54 B	55.03 A	95.05 B	34.67 B
	SA + CA	54.15 A	96.33 A	23.89 D	58.33 A	97.01 A	20.00 C
	Control	41.15 D	85.23 B	47.98 A	45.58 D	88.30 C	48.67 A
Significant levels	Cultivar	***	***	***	**	***	***
	Treatments	***	***	***	***	***	***
	Interaction	***	**	***	***	***	***

NS= Non Significant, * = Significant at 5 %, **= Significant at 1 %, ***= Significant at < 0.1 %

acid, citric acid mixture (SA + CA) recorded the highest value in all traits in both two seasons, followed by citric acid (CA) treatment in plant length and leaves number for two seasons. Meanwhile, salicylic acid (SA) treatments recoded the second value of branch number in both two seasons, it was the third regarding to other traits for two seasons. Control treatment was absolutely the least regarding all investigated traits in both two seasons,

1.3- Effect of Interaction: Vegetative growth of tomato plants expressed as plant length and number of branches and leaves was very high significantly affected by the interaction between the four cultivars with the four treatments, in both two seasons (Table1). The data revealed the superiority of the plants of VT737 and Alisa treated with salicylic acid, citric acid mixture (SA + CA), in the most recorded traits for the two seasons, followed by the plant of Alisa treated with citric acid (CA), VT737 plants treated with salicylic acid (SA) and SS33 plants treated with citric acid (CA) respectively. Some exception of this trend was found with leaves number trait in the second season.

These results going well with those trend mentioned by Mohamedien *et al*[23], Abdel-Baki[1], Dane[8], Mahasen *et al*[19], Zehnder *et al*[37] and Anfoka[2] .

2- Diseases index:

2.1- Effect of cultivars: As shown in Table (2), data of plant height, plant length to plant height percent and the percentage of plants that developed chlorosis and mosaic symptoms (Disease incidence), reflected that, cultivars differed significantly regarding their reaction to viruses diseases, and resistance induction where Vt737 showed the highest resistance ability followed by SS33, GS12 and then Alisa F1 hybrids. In contrary GS12 showed the greatest response to chemical induction of resistance followed by Alisa, SS33 and then VT737 F1 hybrid. These trend was true in both two seasons with high significant differences.

2.2- Effect of Treatments: From the abovementioned data, SA plus CA treatment resulted in higher values for plant height and plant length/plant height percent in the two experimental seasons. Moreover, this treatment gave the lowest percentage of plants that developed chlorosis and mosaic symptoms (disease incidence). An opposite trend was recorded for control. The difference among treatmement were very high significant in all cases for two seasons.

2.3-Effect of Interaction: Plant height, plant length to plant height percent and the percentage of plants that developed chlorosis and mosaic symptoms (Disease incidence) were recorded as indicator of the level of the resistance induced in tomato plants against the viruses disease, and presented in Table (2).

All recorded data in Table(2) were greatly affected by the different interaction of cultivars with treatments in both seasons, where the differences were very high significant in most cases. plant height value was increases due to applying (SA +CA) treatment with Alisa cultivar and CA treatment with SS33 cultivar than those resulting by other treatments in the first season. On the other hand, the highest value of plant height were recorded with VT 737 plants treated with salicylic acid, citric acid mixture (SA + CA) in the second season. In addition, application

Table 3: Response of some earliness component of some tomato cultivars to chemical induction of systematic resistance, after 50 days from transplanting.

Cultivars	Treatments	First Season 2003			Second Season 2004		
		Flower cluster number	Fruits number	Early yield (kg/ M^2)	Flower cluster number	Fruits number	Early yield (kg/ M^2)
GS12	SA	9.33 FGH	12.33 BC	1.26 DE	12.00 GH	13.33 ABC	2.48 D
	CA	13.33 CD	13.33 AB	1.25 DE	17.00 BC	14.00 ABC	1.53 FG
	SA + CA	16.33 AB	13.67 AB	2.60 A	18.67 AB	14.67 AB	2.95 A
	Control	8.33 H	9.00 E	0.98 FG	12.00 GH	11.00 E	1.02 J
Cultivar mean		11.83 B	12.08 A	1.53 A	14.92 A	13.25	1.81 A
Alisa	SA	10.67 EFG	10.33 DE	1.35 D	13.33 EF	13.33 ABC	1.61 DEF
	CA	11.00 EF	14.67 A	1.35 D	13.00 FG	14.00 ABC	1.59 EF
	SA + CA	13.33 CD	14.00 AB	2.19 B	14.33 E	15.00 A	2.50 B
	Control	9.33 FGH	6.33 F	0.69 H	12.67 FG	6.67 F	0.89 K
Cultivar mean		11.08 B	11.33 AB	1.39 B	13.33 B	12.92	1.65 AB
VT737	SA	11.67 DE	11.33 CD	0.92 FG	12.33 FGH	13.00 BC	1.40 GHI
	CA	15.33 BC	10.67 CDE	0.88 GH	17.33 B	13.00 BC	1.29 I
	SA + CA	17.33 A	11.33 CD	1.79 C	19.67 A	14.33 ABC	2.24 C
	Control	10.33 EFGH	9.00 E	0.91 FG	11.33 HI	11.33 DE	1.38 HI
Cultivar mean		13.67 A	10.58 B	1.13 D	15.17 A	12.92	1.58 B
SS33	SA	10.33 EFGH	10.67 CDE	1.14 DEF	11.33 HI	12.67 CD	1.64 DE
	CA	13.00 D	11.33 CD	1.13 DEF	15.67 D	13.33 ABC	1.50 FGH
	SA + CA	13.67 CD	12.33 BC	1.75 C	16.00 CD	14.67 AB	2.28 C
	Control	8.67 GH	9.33 E	1.09 EFG	10.33 I	11.00 E	1.27 I
Cultivar mean		11.42 B	10.92 B	1.28 C	13.33 B	12.25	1.67 AB
Treatments Means	SA	10.50 C	11.17 B	1.17 B	12.25 C	13.08 B	1.60 B
	CA	13.17 B	12.50 A	1.15 B	15.75 B	13.58 B	1.48 B
	SA + CA	15.17 A	12.83 A	2.09 A	17.17 A	14.67 A	2.49 A
	Control	9.17 D	8.42 C	0.92 C	11.58 C	10.00 C	1.14 C
Significant levels	Cultivar	***	*	***	**	NS	*
	Treatments	***	***	***	***	**	***
	Interaction	*	***	***	***	***	***

NS= Non Significant, ***** = Significant at 5 %, ******= Significant at 1 %, *******= Significant at < 0.1 %

of CA treatment with Alisa or SS33 cultivar came to the second order for plant height. Data indicated that the superiority of GS12 cultivar with (SA + CA) treatment over those other interactions for plant height/ plant length percent in the first season and Alisa cultivar with (SA + CA) treatment in the second one.GS12 cultivar with CA treatment and VT 737 cultivar with (SA + CA) treatment recorded the second order in the first season and VT 737 cultivar with CA treatment in the second one.

As regard to disease incidence (percent of plants that developed chlorosis and mosaic symptoms), it is clear from data of Table (2) that the lowest values were recorded with VT 737 or SS33 cultivar with (SA + CA) treatment in both seasons. The highest disease infection percent was obtained by the interaction effect of Alisa cultivar with control in both seasons and GS12 with control in the first season.

Regarding the improvement of plant health (disease incidence), its clear to notice that the treatment salicylic acid, citric acid mixture (SA + CA) was the most effective in this regard followed by salicylic acid (SA) then, citric acid (CA) treatment respectively. On other hand GS12 and Alisa F1 hybrids responded to foliar treatment greater than VT 737 and SS33. these trends agree with those reported by Salt *et al*[27], Doubrava *et al*[11] Gottstein *et al*[12], Metaux *et al*[21], Ward *et al*[33], Uknes *et al*[31], Cohen *et al*[7], Kessmann *et al*[16], Reuveni *et al*[24], Vernooij *et al*[32], Ye *et al*[36], Ryals *et al*[25], Zehnder *et al*[37], Anfoka[2] and Salem[26].

3- Earliness:

3.1- Effect of cultivars: The obtained data indicated that, cultivars differed significantly in all traits of earliness in the two seasons except fruits number in the second season (Table 3). The highest flower clusters number

Table 4: Response of some yield components of some tomato cultivars too chemical induction of systematic resistance.

Cultivars	Treatments	First Season 2003			Second Season 2004		
		Marketable yield (kg/m^2)	Total yield (kg/m^2)	Marketable yield (%)	Marketable yield (kg/m^2)	Total yield (kg/m^2)	Marketable yield (%)
GS12	SA	3.97 DE	4.77 D	83.36 CD	4.83 EF	5.38 DE	89.91 CD
	CA	4.35 C	5.11 BC	85.20 C	5.05 CD	5.56 D	90.74 BC
	SA + CA	5.26 A	5.73 A	91.90 A	6.03 A	6.49 AB	93.00 A
	Control	2.67 G	3.47 F	77.12 E	3.15 I	4.12 F	76.54 J
Cultivar mean		4.06 A	4.76 B	84.39 A	4.77 AB	5.39	87.55 A
Alisa	SA	4.14 CD	4.99 CD	82.92 CD	4.79 F	5.54 D	86.43 F
	CA	4.33 C	5.27 B	82.15 D	5.13 C	5.81 C	88.33 E
	SA + CA	5.17 AB	5.87 A	88.02 B	6.06 A	6.66 A	91.07 B
	Control	3.02 F	3.53 F	85.43 C	3.17 I	3.97 G	79.99 J
Cultivar mean		4.15 A	4.91 A	84.63 A	4.79 AB	5.49	86.96 A
VT737	SA	4.02 DE	5.20 BC	77.35 E	4.79 F	5.83 C	82.17 H
	CA	3.87 E	4.72 D	81.88 D	4.35 G	5.24 E	83.12 G
	SA + CA	4.97 B	5.63 A	88.23 B	5.81 B	6.46 AB	89.83 D
	Control	2.85 FG	3.94 E	75.94 E	3.56 H	4.59 F	77.50 K
Cultivar mean		3.92 B	4.87 AB	79.94 B	4.63 B	5.53	83.16
SS33	SA	4.25 C	4.73 D	89.85 AB	4.81 F	5.47 D	88.00 E
	CA	4.24 C	5.04 BC	84.13 CD	4.96 DE	5.56 D	89.29 D
	SA + CA	5.05 B	5.70 A	88.58 B	5.93 AB	6.40 B	92.62 A
	Control	2.96 F	3.90 E	72.28 F	3.62 H	4.40 F	81.23 I
Cultivar mean		4.12 A	4.84 AB	84.63 A	4.83 A	5.47	87.79 A
Treatments Means	SA	4.10 C	4.92 B	83.37 B	4.81 B	5.55 B	86.63 B
	CA	4.20 B	5.04 B	83.34 B	4.87 B	5.54 B	87.87 B
	SA + CA	5.11 A	5.73 A	89.18 A	5.96 A	6.50 A	91.63 A
	Control	2.87 D	3.70 C	77.70 C	3.38 C	4.29 C	78.82 C
Significant levels	Cultivar	***	NS	***	*	NS	***
	Treatments	***	***	***	***	***	***
	Interaction	***	***	***	***	***	***

NS= Non Significant, ***** = Significant at 5 %, ******= Significant at 1 %, *******= Significant at < 0.1 %

associated with VT737 plants. On the other side, GS12 cultivar was higher regarding to fruits number and early yield compared with other cultivars in both seasons, followed by Alisa Hybrid. Meanwhile plants of SS33 hybrid recorded th lowest value of early yield. These results were similar in both experimental seasons.

3.2-Effect of Treatments: Data also revealed that, all traits "number of flower clusters, fruits and early yield were higher when the treatment of (SA + CA) was applied in both seasons, followed by those which received CA treatment. The lowest values of flower clusters number, fruits number and early yield of tomato were recorded with the control treatment in both seasons

3.3-Effect of Interaction: Data presented in Table (3) showed clearly that number of flower clusters, fruits and early yield of tomato were greatly affected by the interaction of cultivars with treatments. Plants of VT737 and GS12 Cultivar treated with(SA + CA) gave the highest flower clusters number as compared with the other interactions in both seasons respectively.

Increasing of fruits number due to treating Alisa plants with CA and (SA + CA) Treatments over all those resulted from the other interaction in the first and second seasons respectively. The lowest records were obtained in case of control treatment with Alisa cultivar. Concerning early yield, plants of GS12 cultivar treated with (SA + CA) treatment were the superior in the two Seasons. In addition, the same treatment(SA + CA) with plants of Alisa and VT737 cultivars came to the second order in both seasons respectively. The lowest values were recorded in case of Alisa cultivar with control treatment in both seasons.

Its clear to notice that, earliness characters improvement by treatments took almost the similar trends of plant growth and health (disease incidence), where the treatment salicylic acid, citric acid mixture (SA + CA) was the most effective.

Table 5: Response of fruit physical characters of some tomato cultivars to chemical induction of systematic resistance.

Cultivars	Treatments	First Season 2003			Second Season 2004		
		Mean fruit weight (g)	Dry matter (%)	T.S.S (%)	Mean fruit weight (g)	Dry matter (%)	T.S.S (%)
GS12	SA	63.03 H	4.82 BCD	3.94 FG	79.27 G	5.65 CD	4.83 D
	CA	70.43 FG	4.92 BC	4.07 B	78.63 G	5.70 C	5.04 C
	SA + CA	82.27 BC	5.33 A	4.97 A	91.47 BC	6.25 A	5.81 A
	Control	62.87 H	4.50 EFG	4.02 EFG	59.53 J	5.48 EF	4.03 K
Cultivar mean	70.88 C	4.89 A	4.39 A	77.23 C	5.77 A	4.93 A	
Alisa	SA	70.13 FG	4.40 FGH	4.17 DEF	82.77 F	5.29 HI	4.69 EF
	CA	79.93 DE	4.62 DEF	4.25 CDE	87.70 DE	5.38 FGH	4.77 DE
	SA + CA	88.50 A	5.08 AB	4.66 B	92.37 B	5.97 B	5.29 B
	Control	63.03 H	4.32 GH	3.94 FG	66.30 I	5.19 I	4.25 J
Cultivar mean		74.65 B	4.60 B	4.26 BC	82.29 B	5.46 B	4.75 AB
VT737	SA	72.97 EF	4.76 CDE	4.18 DEF	86.37 E	4.92 JK	4.53 GH
	CA	85.73 AB	4.74 CDE	4.16 DEFG	88.97 CD	4.99 J	4.49 H
	SA + CA	89.03 A	5.09 AB	4.45 BC	95.53 A	5.28 HI	4.66 F
	Control	69.63 FG	4.51 EFG	3.89 G	72.37 H	4.85 K	4.39 I
Cultivar mean		79.34 A	4.77 A	4.17 C	85.81 A	5.01 D	4.52 C
SS33	SA	80.60 CD	4.20 H	4.17 DEF	90.50 BC	5.33 GH	4.62 FG
	CA	82.33 BC	4.38 FGH	4.31 CD	92.10 B	5.44 FG	4.64 F
	SA + CA	85.73 AB	4.98 BC	4.63 B	95.77 A	5.55 DE	4.95 C
	Control	69.70 FG	4.17 H	4.14 DEFG	70.83 H	4.97 J	4.38 I
Cultivar mean	79.59 A	4.43 C	4.34 AB	87.30 A	5.32 C	4.65 BC	
Treatments Means	SA	72.91 C	4.54 B	4.14 C	84.73 C	5.30 B	4.67 C
	CA	78.86 B	4.67 B	4.35 B	86.89 B	5.39 B	4.74 B
	SA + CA	86.38 A	5.12 A	4.68 A	93.78 A	5.76 A	5.18 A
	Control	66.31 D	4.38 C	4.00 D	67.27 D	5.12 C	4.26 C
Significant levels	Cultivar	***	***	**	***	***	***
	Treatments	***	***	***	***	***	***
	Interaction	***	NS	***	***	***	***

NS= Non Significant, * = Significant at 5 %, **= Significant at 1 %, ***= Significant at < 0.1 %

4- Yield components:

4.1- Effect of cultivars: Data of two grooving seasons of 2003 and 2004 were presented in Table (4) and showed clearly that, Alisa plants. was higher yielded of tomato planets in the first season and VT737 in the Second one. On the contrary, the lowest yield of tomato plants was recorded by GS12 in the two seasons of study. Concerning marketable yield in Table (4) its clearly to notice that, Alisa gave the highest marketable yield of tomato plants compared with other varieties. On the other hand, VT737. gave the lowest marketable yield. The data presented in Table (4) indicate that, the highest marketable yield % was recorded by using SS33 and the Lowest % was found with VT737. These results held good in the tow seasons of 2003 and 2004.

4.2- Effect of treatments: Results in Table (4) show that, the highest yield of tomato plant recorded when used (SA + CA) treatment in 2003 and 2004 seasons, respectively. This results were true in the two seasons of study. On the other hand, the lowest yield of tomato plant recorded by control treatment in the two seasons of study. Data in Table (5), illustrated that, treatment of (SA + CA) gave the highest marketable yield of tomato plants. On the contrary, control treatment recorded lowest marketable yield in the two experimental seasons. Concerning the effect of different foliar spray CA, SA, SA + CA and control treatment on tomato plants the data presented in Table (4) show that, the highest value of marketable yield % was recorded by (SA + CA) Treatment on the contrary, the lowest was recoded by control treatment. These results held good in the two experimental seasons.

4.3- Effect of the interaction: The results in Table (4), showed that, the varieties of tomato plants and foliar spray of CA and SA act in Co-operating pattern in both experimental seasons. The data presented in Table (4) Show that, the highest total yield of tomato plants was

recorded when the plants of GS12 were treated with (SA + CA). On the contrary, the lowest total yield was found by GS12 and control treatment.). Also The obtained data revealed that, the interaction treatments significantly affect of marketable yield of tomato plants. The highest marketable yield of was recorded by using GS12 sprayed with (SA + CA) in the first season and by using Alisa and sprayed with (SA + CA) in 2004 season. On the contrary, the lowest marketable yield was found by using GS12 with Control treatments. These results were completely similar in both two experiments.

5- Physical properties of fruits:

5.1- Effect of cultivars: The data of Table (5) indicated that, the MFW of tomato was significantly affected by the cultivars. The highest MFW was recorded by SS33. On the other hand, the lowest MFW was recorded by GS12. these results held good in the two seasons of 2003 and 2004. Data of fruit dry matter revealed that, GS12 fruits recorded the highest values among all cultivars. On the contrary, SS33 fruits got the lowest fruit dry matter content in the first season and VT737 in the second one. The results in Table (5) demonstrated that, the tomato cultivar affected significantly the T.S.S content. the highest value of T.S.S. in tomato fruits was produced by GS12. On the contrary, the lowest T.S.S. value recoded by VT737 fruits these results held good in the two seasons of study.

5.2- Effect of treatments: Data presented in Table (5) show clearly that, the MFW was significantly affected by treatment in the two seasons of study. The highest MFW was recorded by plants treated by (SA + CA) Treatment. On the other side, the lowest MFW was obtained on the plants received control treatment. These results held good in the two seasons of 2003 and 2004. the effect of chemical treatments on dry matter of tomato fruits, data are shown in Table (5). Dry matter was significantly increased by using SA, CA and SA + CA treatments as foliar spray and the highest dry matter content in tomato fruits was recorded when (SA + CA) treatment was applied. On the other side, the lowest value obtained by using Control treatment. These results were true in the two experimental seasons. Also, foliar spraying of chemical treatments effects on TSS took the same trend of their effects on dry matter contents, in both seasons.

5.3-Effect of the interaction: The results of the effect of the interaction between the cultivars and foliar spray of SA ,CA, SA + CA and control treatment on physical properties of tomato fruits presented in Table (5). The results indicated that, the highest mean fruit weight (MFW) of tomato plants was found by treating VT737 by (SA + CA) in the first season and SS33 sprayed with (SA + CA) in the second one. On the other hand, the lowest MFW was recorded by treatment of GS12 with Control. These results were true in the 2003 and 2004 seasons. These results show clearly that the two factors of the varieties and foliar application act in Co-Operating pattern. The interaction between varieties and foliar application had no significant effect on the dry matter of tomato fruits in the first season, this means that each factor plays as independent role. But in the second season. The obtained data reveals that, the interaction treatments significantly affected of dry matter of tomato fruits. The obtained data reveals that, the interaction treatments significantly affected T.S.S. of tomato fruits. These results held good in the two experimental seasons. Generally, it could be summarized that, the highest amount of T.S.S. was recorded by GS12 fruits treated with (SA + CA). on the contrary, the lowest value of T.S.S. was found in VT737 fruits treated with control treatment.

These results agreed those mentioned by Mohamedien *et al*[23], Abdel-Baki[1], Dane[8] and Mahasen *et al*[19]

6- Chemical properties of fruits:

6.1- Effect of cultivars: Data in Table(6) showed that, cultivars differed significantly in all three traits of fruits chemical quality in both two seasons except vitamin C content in the second season. GS12 fruits were superior in both vitamin C and taste index and recorded the lowest acidity contents among all cultivars in both investigated seasons. Meanwhile Alisa fruits recorded the lowest vitamin C contents, they got the second order after GS12 fruits in regard of taste index. On contrary VT737 fruits recorded the highest acidity contents and the lowest taste index value in both seasons.

1.2- Effect of treatments: Foliar application treatments were affected all recorded traits in both seasons with very high significant level absolutely. The treatment of salicylic acid, citric acid mixture (SA + CA) recorded the highest value in regard to vitamin C both two seasons, but citric acid (CA) treatment combined it in the second season with no significant differences and preceded all treatments concerning acidity contents for two seasons. Meanwhile, citric acid (CA) treatment recorded the lowest taste index value in both seasos. On the other hand, control treatment recoded the lowest value of vitamin C and acidity contents, it got the first order, regarding to taste index in both two seasons,

1.3- Effect of Interaction: Chemical quality of tomato fruits expressed as vitamin C, acidity contents and taste

Table 6: Response of fruit chemical characters of some tomato cultivars to chemical induction of systematic resistance.

Cultivars	Treatments	First Season 2003			Second Season 2004		
		Vitamin C (mg/kg)	Total acidity (%)	T.S.S/ Total acidity	Vitamin C (mg/kg)	Total acidity (%)	T.S.S/ Total acidity
GS12	SA	17.96 G	0.53 I	7.45 B	19.92 G	0.52 EF	9.33 B
	CA	22.05 C	0.64 DE	7.36 BC	25.63 B	0.61 BCD	8.24 CDE
	SA + CA	23.93 A	0.59 G	8.39 A	26.80 A	0.55 DE	10.49 A
	Control	15.01 J	0.48 J	8.32 A	15.88 I	0.38 G	10.55 A
Cultivar mean		19.76 B	0.56 D	7.88 A	22.06	0.52 C	9.65 A
Alisa	SA	19.95 F	0.61 FG	6.87 CD	21.87 F	0.59 CDE	7.98 CDE
	CA	21.94 C	0.68 C	6.29 EF	24.32 C	0.65 BC	7.37 EFG
	SA + CA	21.97 C	0.62 EF	7.56 B	24.73 C	0.61 BCD	8.73 BC
	Control	12.05 K	0.51 I	7.67 B	14.92 J	0.45 FG	9.36 B
Cultivar mean		18.98 D	0.60 C	7.09 B	21.46	0.57 B	8.36 B
VT737	SA	19.99 F	0.69 B	6.01 FG	21.60 F	0.69 AB	6.59 GH
	CA	20.18 E	0.74 A	5.65 G	22.17 EF	0.74 A	6.11 H
	SA + CA	20.97 D	0.70 B	6.40 DEF	22.86 DE	0.67 AB	6.91 FGH
	Control	16.83 H	0.57 H	6.89 CD	18.39 H	0.54 DE	8.12 CDE
Cultivar mean		19.49 C	0.67 A	6.24 C	21.26	0.66 A	6.93 D
SS33	SA	20.98 D	0.63 EF	6.83 CD	22.18 EF	0.60 BCDE	7.73 DEF
	CA	21.04 D	0.65 D	6.63 DE	23.03 D	0.62 BCD	7.50 EFG
	SA + CA	23.13 B	0.61 FG	7.61 B	24.12 C	0.69 AB	7.48 EFG
	Control	15.90 I	0.57 H	7.25 BC	18.00 H	0.51 EF	8.51 BCD
Cultivar mean		20.26 A	0.61 B	7.08 B	21.83	0.61 B	7.81 C
Treatments Means	SA	19.72 C	0.61 C	6.79 B	21.39 B	0.60 C	7.91 C
	CA	21.30 B	0.68 A	6.48 C	23.79 A	0.65 A	7.30 D
	SA + CA	22.50 A	0.63 B	7.49 A	24.63 A	0.63 AB	8.40 B
	Control	14.97 D	0.53 D	7.53 A	16.80 C	0.47 C	9.13 A
Significant levels	Cultivar	***	***	***	NS	***	***
	Treatments	***	***	***	***	***	***
	Interaction	***	***	*	***	***	***

NS= Non Significant, * = Significant at 5 , ** = Significant at 1 % , *** = Significant at < 0.1 %

index(Ratio of TSS/ Total acidity) was very high significantly affected by the interaction between the four cultivars with the four treatments, in both two seasons (Table 6). The data revealed the superiority of the fruits of GS12 treated with salicylic acid, citric acid mixture (SA + CA), in vitamin C and taste index for the two seasons.

On contrary VT737 fruits treated with citric acid (CA) recoded the lowest value of taste index, and the highest value of acidity contents in both to seasons. The lowest vitamin C content was obtained in Alisa fruits treated with control treatments in the two seasons

These results going well with those trend mentioned by Mohamedien *et al*[23], Abdel-Baki [1], Dane [8] and Mahasen *et al*[19].

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