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# THE EFFECT OF BIO-FERTILIZERS AND AMINO ACIDS ON TOMATO PRODUCTION AND WATER PRODUCTIVITY UNDER NET-HOUSE CONDITIONS

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## ABSTRACT

The present study was carried out during two successive seasons, 2011/2012 and 2012/2013, at the Agricultural Research Station; El-Otouria, Sheehaniya, Doha, Qatar; to investigate the response of two tomato cultivars (Isabella and Milas) to biofertilizers and amino acids. Two biofertilizer treatments, rizobacterien at a rate of 2 and 4 liter per feddan and one of amino acid (Delfan) at a rate of 200 ppm, were used. Chicken manure, at a rate of 10 tons/ feddan, was the control treatment. Results showed the superiority of Isabella compared to Milas in terms of vegetative growth and fruit yield. Using Rizobacterien at a rate of 4 liter/feddan plus Delfan (amino acids) at a rate of 200 ppm increased growth and fruit chemical characters, earliness and total yield. The average fruit weight per plant was significantly high under Rizobacteria at a rate of 4 liter/feddan plus Delfan (amino acids) at a rate of 200 ppm. The lowest vegetative growth, fruit and yield characters were obtained from Rizobacteria at a rate of 2 liter/feddan. The water productivity results showed that all treatments led to the increase of fruit yield. Isabella cultivar had higher water productivity than Milas cultivar. Using of Rizobacterien at a rate of four liter/feddan also increased the water productivity. The same trend was obtained by using Delfan at a rate of 200 ppm. Concerning water productivity, Isabella cultivar had higher water productivity 16.7 and 17.2 kg of tomato fruits per cubic meter of irrigation water ($m^3$) compared with Milas cultivar which produced15.9 and 16.5 kg tomato fruits per cubic meter of irrigation water for first and second seasons, respectively. Isabella cultivar plus amino acid (Delfan) gave the highest water productivity 19.1 and 19.7 kg of tomato fruits per $m^3$ water for first and second seasons, respectively compared the other treatments.

## INTRODUCTION

Microorganisms, which are used as biofertilizers, induce simulative effect on plant growth and production by atmospheric nitrogen in a free living state e.g. Azotobacter (**Saber, 1996; Awad., 1998).** Numerous investigations stated that biofertilizations with different strains of bacteria induced significant increase in plant growth expressed as fresh and dry weight of different plant organs as well as number of leaves and branches and chemical compositions (**Radwan 1983, on tomato; Kabesh *et al* 1987, on Soybean and Abdel Ati 1996**, **on potato**.

The production of high yield vegetable crops requires that the soil must have favourable physical, chemical, nutritional and biological conditions. It is worth to mention that the good effect of biofertilizer inoculation improve root and plant growth parameters. In addition, adding biofertilizers increased population of soil microorganisms, especially in the surface layer at root rhizosphere, which stimulate plant growth (**Awad, *et al* 1993**). Many investigators emphasized the beneficial role of organic manures incorporated with biofertilizers to stimulate plant growth and vegetable crop yield, among them i.e., **Abdalla, *et al* (2001) on pepper, Abou-Hussein (2002) on potatoes, Adam, *et al* (2002) on cantaloupe and Rizk, *et al* (2003) on**

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**squash**. Many studies proved that foliar application of amino acid can improve the vegetative growth, physical parameters and fruit quality of chilli pepper **(Maheswari *et al* 2004**).

Tomato fruit yield and its composition responded significantly to biofertilizer applications. **Kumaraswany and Madalageri (1990)** mentioned that highest physical parameters and tomato fruit yield were gained by inoculating tomato plants with biofertilizers. Moreover, **Shahaby (1993)**, **Valpin & Kapulink (1994), Terry *et al* (1995) and Awad *et al* (1998)** obtained highest tomato fruit yield and chemical compositions with best fruit quality using various bacterial fertilizers. **Hewedy, (1999)** indicated that adding biofertilizer (Azotobacter) at a rate of 3 liters per feddan gave higher plant heights, physical parameters and fruit quality. **Hasanein and Kabeel (2006)** reported that using Rizobacterien, at a rate of 2 liters per feddan, significantly increases vegetative growth, chemical and physical parameters and total yield of potato crop. Proline amino acid was greatly synthesized within plant tissues more than other amino acids in grown plants and fruit for the protection against stresses (**Batets *et al* 1999, Verranjaneyulu and Kumari, 2003**). However, **El-Shaabasi *et al* (2005)** reported that the concentration of total amino acids increased plant height, leaf area and total yield of tomato plants. The same trend was reported by **Ahmed *et al* (2006)** who indicated that foliar proline amino acid at 100 ppm, on sweet pepper plants, gave the highest values of plant height, number of leaves, fruit length, average leaf area and total yield per plant. **Hasanein and Gaafer, (2006)** indicated that spraying free amino acids (Glutamic) at a rate of 200 ppm increased plant height, chemical and physical parameters and total yield of watermelon crop.

The Food and Agriculture Organization (**FAO, 1988**) estimated that almost two-third of the increase in crop production needed in the next decades must come from higher yields per unit of land. The relationship between crop production and water received is called the crop–water production function. Moreover, good agriculture practices such as greenhouse cover, the use of microbial fertilizer, the use of amino acids can improve irrigation productivity via better plant growth and yield per water unit (**Batets *et al* 1999; Verranjaneyulu and Kumari, 2003; Abdrabbo *et al* 2009**). **Abdrabbo *et al* (2007)** mentioned that the use of good potato variety led to the increase in water productivity for water unit

The aim of the present study is to investigate the interaction effect, between the bio-fertilizer (Rizobacterien) and foliar application with amino acid (Delfan), on the vegetative growth, crop yield and quality of two tomato cultivars (Isabella and Milas).

## MATERIALS AND METHODS

### Experimental Layout

This study was conducted, at the Agricultural Research Station in El-Otouria, Sheehaniya, Doha, Qatar, during two successive seasons, 2011 and 2012. The experimental design was split plot with four replicates, having the cultivars at random in the main plot and biofertilizer treatments were randomly distributed in the sub plot. Each experimental plot consisted of raised bed, ten meters long and one meter width (two rows in each bed), and contained 40 tomato plants. The space between plants in each row was 0.5 m. Tomato seeds were sown in the nursery on September 21th and 26th in 2011 and 2012, respectively. Seedling transplanting took place on October 19th and 23th in 2011 and 2012, respectively, under net-house conditions.

1- **Treatments**

The treatments were as follows:
A- Main plot:
a- Cultivar Isabella ( I )
b- Cultivar Milas (M)
B**-** Sub main plot**:**
a- Rizobacterien at a rate of 2 liter /feddan + Delfan (amino acids) at a rate of 200 ppm (R1+D).
b- Rizobacterien at a rate of 4 liter /feddan + Delfan (amino acids) at a rate of 200ppm (R2+D.(
c- Rizobacterien at a rate of 2 liter /feddan (R1).
d- Rizobacterien at a rate of 4 liter /feddan (R2).
e- Control Chicken manure at a rate of 10 tons per feddans (C).
One Feddan = 4200 $m^2$.

DELFAN is a brown liquid with pH of 5-5.5 and specific gravity of 1.12 g/ml. It contains 18.4% w/w organic matter content, 10% w/w free amino acids, 3% w/w total nitrogen and 3% w/w organic nitrogen.

### C- Soil treatments

Chicken manure and Rizobacteria were applied 20 days before transplanting date in the middle of

the row at 20 cm depth from the soil surface. All experimental plots received the same water volume from transplanting till harvest using drip irrigation system. The flow rate of drippers was 4 L/h, the distance between the lateral irrigation lines was 150 cm, and the distance between plants was about 35 cm. All treated plants received 3 amino acid sprayings. The first was 30 days after planting, the second and third were performed after 21 days intervals with equal amount for each application. The amino acid treatments were carried out at early morning. Data of the physical and chemical properties of the soil are presented in **Table (1).**

**2- Measurements**

**A- Vegetative growth**

The vegetative growth parameters, plant height (cm) and leaf area (cm2), were measured from the 5th true leaf from the top (by Li 300 using laser leaf area meter produced by Li-Cor, Pinclivania). Total number of leaves per plant and the plant fresh weight (gm) were also recorded. Plant samples were dried in the oven, at 70°C., to measure the plant dry weight (gm).

**a- Yield and its components**

The recorded yield parameters were early and total yield (kg\plant), number of fruits per plant and average fruit weight.

b- **Chemical composition**

The Chemical composition parameters were measured as follow:-

**i-. Ascorbic acid (mg\100g fresh weight):**

It was measured by using 2, 6, dichloro-phenol indophenols according to **A.O.A.C. (1990)**.

**ii- Total Titratable Acidity**

A random sample of 100g fruit from each experimental plot at full ripe stage was taken to determine the total titratable acidity of juice by titration with 0.2 NaOH (sodium hydroxide) solution using phenol phthalein indicator according to the method described in **A.O.A.C. (1990).**

**iii- Total soluble solids (TSS)**

It was determined using refract meter **A.O.A.C. (1990).**

**iv- Total chlorophyll content**

It was determined in sample taken randomly from the fourth upper leaf according to the **A.O.A.C. (1990)**.

**3. Estimation of water requirements**

Potential evapotranspiration were measured by automatic weather station, allocated in the farm site. The water requirements was estimated based on FAO-56 method (**Allen, *et al* 1998).** Water requirement under net-house **(Table 2)** was calculated according to **Hashem (2007)**. Leaching requirements of 25% were added to modify different water requirements.
Water productivity: It was calculated as follows:
WP = Yield (Kg/plant) ⁄ Amount of water applied (m3/plant), according to **Michael (1978).**

**4. Statistical analysis**

Data were statistically analyzed using split plot design with four replicates. Each replicate consisted of 30 plants each seasons. The mean of different treatment were compared using the Least Significant Difference test (L.S.D.) at 5% level of probability **(Gomez and Gomez, 1984)**.

## RESULTS AND DISCUSSION

**A. Vegetative growth of tomato plants grown under net-house conditions**

Cultivar Isabella gave significantly higher plant height, leaf area, number of leaves, fresh and dry weight than cultivar Milas with significant effect during the two seasons **(Table 3). Table (3)** also showed that applying Rizobacterien at a rate of 4 liter/feddan + Delfan (amino acids) at a rate of 200 ppm increased plant height, leaf area, number of leaves, fresh and dry weight than the other treatments with significant differences. The second treatment that increased the vegetative growth parameters was rizobacterien at a rate of 4 liter/feddan. Similar results were found by **Radwan (1983), Kabesh *et al* (1987), Awad *et al* (1993) and Abdel Ati (1996), Hewedy (1999), Verranjaneyulu and Kumari (2003), Maheswari *et al* (2004)** and **El- Shaabasi *et al* (2005**).

**Table 1**. Physical and chemical properties of the investigated soil.

| 2011/2012 season | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| particle size distribution % | | | Texture | pH | EC | C/N | Ca CO3 | macro nutrients | | | micro nutrients in (ppm) | | | |
| sand | Salt | Clay | | | dS/m | Ratio | % | N% | P ppm | K ppm | Fe | Mn | Zn | Cu |
| 69.28 | 6.00 | 24.7 | salty clay loam | 7.89 | 3.68 | 21: 1 | 24.9 | 0.18 | 168 | 230 | 10.9 | 11.9 | 13.2 | 3.30 |
| 2012/2013 season | | | | | | | | | | | | | | |
| 67.3 | 4.00 | 28.7 | salty clay loam | 7.73 | 3.87 | 20: 1 | 23.2 | 0.19 | 160 | 277 | 8.5 | 12.2 | 11.3 | 3.61 |

**Table 2.** Average daily water requirements (every 15 days) of tomato under green-house during 2011 /2012 and 2012/2013 seasons

| | 2011 /2012 | | | | | | 2012/2013 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | ETo Open Field | ET green-house | Kc | ETc | ETc Plus leaching fraction | Water Req. liter/ plant / day | ETo Open Field | ET green-house | Kc | ETc | ETc Plus leaching fraction | Water Req. liter/plant /day |
| October | 4.43 | 3.10 | 0.45 | 1.40 | 1.74 | 0.94 | 4.30 | 3.01 | 0.45 | 1.35 | 2.42 | 1.31 |
| | 3.89 | 2.72 | 0.50 | 1.36 | 1.70 | 0.92 | 3.79 | 2.66 | 0.50 | 1.33 | 2.37 | 1.28 |
| November | 3.35 | 2.35 | 0.60 | 1.41 | 1.76 | 0.95 | 3.29 | 2.30 | 0.60 | 1.38 | 2.47 | 1.33 |
| | 3.08 | 2.16 | 0.75 | 1.62 | 2.02 | 1.09 | 2.91 | 2.04 | 0.75 | 1.53 | 2.73 | 1.48 |
| December | 2.81 | 1.96 | 0.90 | 1.77 | 2.21 | 1.19 | 2.54 | 1.78 | 0.90 | 1.60 | 2.85 | 1.54 |
| | 2.65 | 1.86 | 0.95 | 1.76 | 2.20 | 1.19 | 2.64 | 1.85 | 0.95 | 1.76 | 3.14 | 1.69 |
| January | 2.49 | 1.75 | 1.10 | 1.92 | 2.40 | 1.30 | 2.75 | 1.93 | 1.10 | 2.12 | 3.78 | 2.04 |
| | 2.95 | 2.06 | 1.15 | 2.37 | 2.96 | 1.60 | 3.14 | 2.20 | 1.15 | 2.53 | 4.52 | 2.44 |
| February | 3.40 | 2.38 | 1.20 | 2.85 | 3.57 | 1.92 | 3.53 | 2.47 | 1.20 | 2.97 | 5.30 | 2.87 |
| | 4.01 | 2.80 | 1.10 | 3.09 | 3.86 | 2.09 | 4.08 | 2.85 | 1.10 | 3.14 | 5.60 | 3.02 |
| March | 4.62 | 3.23 | 1.05 | 3.39 | 4.24 | 2.29 | 4.62 | 3.23 | 1.05 | 3.39 | 6.06 | 3.28 |
| | 5.15 | 3.61 | 1.00 | 3.61 | 4.51 | 2.44 | 5.00 | 3.50 | 1.00 | 3.50 | 6.24 | 3.37 |
| April | 5.69 | 3.98 | 0.95 | 3.78 | 4.73 | 2.56 | 5.38 | 3.76 | 0.95 | 3.57 | 6.38 | 3.44 |
| | 6.32 | 4.43 | 0.85 | 3.76 | 4.70 | 2.54 | 6.03 | 4.22 | 0.85 | 3.59 | 6.41 | 3.46 |
| May | 6.95 | 4.87 | 0.65 | 3.16 | 3.95 | 2.14 | 6.69 | 4.68 | 0.65 | 3.04 | 5.44 | 2.94 |
| | 7.10 | 4.97 | 0.50 | 2.49 | 3.11 | 1.68 | 3.35 | 2.34 | 0.60 | 1.17 | 2.09 | 1.32 |
| Total | | | | | | 335 | Total | | | | | 552 |

**Table 3.** Effect of biofertilizers and cultivars on vegetative growth of tomato plant leaves grown under net-house conditions

| Treatments | | 2011 /2012 Plant height (cm) | leaf area $cm^2$ | No. of leaves per plant | Fresh weight ( g ) | Dry weight ( g ) | 2012/2013 Plant height (cm) | leaf area $cm^2$ | No. of leaves per plant | Fresh weight ( g ) | Dry weight ( g ) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| A | I | 511 | 348 | 62.9 | 1014 | 171 | 527 | 397 | 67.4 | 1114 | 190 |
| | M | 493 | 332 | 59.3 | 964 | 159 | 507 | 373 | 62.5 | 1022 | 178 |
| L.S.D. at 0.05 | | 9.43 | 6.12 | 1.93 | 15.62 | 3.08 | 11.15 | 4.37 | 0.92 | 24.19 | 5.36 |
| B | (R1+D) | 503 | 340 | 59.1 | 967 | 155 | 524 | 393 | 63.1 | 995 | 170 |
| | (R2+D) | 575 | 438 | 75.5 | 1192 | 223 | 589 | 489 | 81.7 | 1281 | 249 |
| | (R1) | 419 | 243 | 50.1 | 814 | 131 | 435 | 270 | 53.4 | 883 | 141 |
| | (R2) | 546 | 396 | 65.7 | 1070 | 172 | 559 | 437 | 69.6 | 1230 | 206 |
| | (C) control | 467 | 283 | 55.2 | 901 | 143 | 478 | 337 | 57.1 | 951 | 153 |
| L.S.D. at 0.05 | | 7.51 | 8.39 | 2.18 | 19.36 | 2.01 | 25.45 | 9.82 | 2.64 | 33.58 | 3.74 |

Cultivar Isabella (I) Cultivar Milas (M).

Rizobacterien at a rate of 2 liter/feddan + Delfan (amino acids) at a rate of 200ppm. ( R1+D).

Rizobacterien at a rate of 4 liter/feddan + Delfan (amino acids) at a rate of 200ppm. (R2+D).

Rizobacterien at a rate of 2 liter/feddan. (R1) 4- Rizobacterien at a rate of 4 liter /feddan. (R2).

Control Chicken manure at a rate of 10 tons per feddan (C).

The lowest vegetative growth was obtained when adding Rizobacterien at a rate of 2 liter/feddan. It can be concluded from the results that adding Rizobacterien at a rate of 4 liter/feddan + Delfan (amino acids) at a rate of 200 ppm increased the vegetative growth. The applied biofertilizers and amino acids to tomato plants increased vegetative which may be due to the increasing number of microorganisms living in the soil. Those microorganisms convert the organic materials in the soil to minerals such as nitrogen.

The interaction between the effect of biofertilizers and cultivars on vegetative growth are presented in **Table (4)**. Results showed that the highest vegetative growth characters were obtained when applying Rizobacterien at a rate of 4 liter/feddan plus Delfan (amino acids) at a rate of 200 ppm with cultivar Isabella in comparison with other treatments during the two studied seasons.

The responses of cultivar Isabella to biofertilizers and amino acids were similar to the cultivar Milas by applying 4 liter/feddan from Rizobacterien. There were no significant differences in vegetative growth among the two cultivars during the two tested seasons. The lowest vegetative growth was obtained from adding Rizobacterien at a rate of 2 liter/feddan during the two studied seasons. This enhanced vegetative growth could be due to the increase of nutrient uptake from soil by roots. These results agreed with those of **Phillps, (1971); Saber, (1996) and Awad, (1998); Abdalla, *et al* (2001) on pepper, Abou-Hussein, (2002) on potatoes, Adam, *et al* (2002) on cantaloupe, and Rizk, et al (2003) on squash.**

**B. Effect of biofertilizers and cultivars on yield productivity of tomato plants grown under net-house conditions**

Early and total yield per plant and average fruit weight of tomato, as influenced by different biofertilizers rates and cultivars, are present in **Table (5).**

Data revealed that the cultivar Isabella gave higher early yield, total yield per plant and average fruit weight under rizobacterien at a rate of 4 liter/feddan + Delfan (amino acids) at a rate of 200 ppm, with significant differences between them over all other treatments.

The differences between cultivars were significant during the two studied seasons. However,there was no significant difference observed in number of fruit per plant for the two cultivars. Data of early and total yield per plant and average fruit weight **(Table, 5)** indicated that both yields

**Table 4.** Effect of biofertilizers and cultivars interaction on vegetative growth characteristics of tomato plant leaves grown under net house conditions

| | | 2011 /2012 | | | | | 2012/2013 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Treatments | Plant height (cm) | leaf area cm2 | No. of leaves per plant | Fresh weight ( g ) | Dry weight ( g ) | Plant height (cm) | leaf area cm2 | No. of leaves per plant | Fresh weight ( g ) | Dry weight ( g ) |
| | ( R1+D) | 515 | 341 | 60.9 | 987 | 159 | 532 | 408 | 65.8 | 1025 | 173 |
| | (R2+D) | 583 | 447 | 78.4 | 1216 | 236 | 598 | 500 | 86.4 | 1334 | 257 |
| I | (R1) | 432 | 247 | 51.1 | 838 | 135 | 456 | 287 | 55.0 | 930 | 145 |
| | (R2 ) | 553 | 401 | 68.1 | 1110 | 178 | 565 | 444 | 71.6 | 1293 | 219 |
| | (C) control | 472 | 300 | 55.8 | 917 | 145 | 482 | 348 | 58.2 | 987 | 154 |
| | (R1+D) | 491 | 339 | 57.2 | 947 | 151 | 516 | 377 | 60.3 | 966 | 166 |
| | (R2+D) | 567 | 429 | 72.5 | 1168 | 211 | 580 | 478 | 76.9 | 1228 | 242 |
| M | (R1) | 406 | 238 | 49.0 | 790 | 127 | 414 | 253 | 51.7 | 836 | 136 |
| | (R2) | 538 | 389 | 63.3 | 1030 | 165 | 553 | 430 | 67.5 | 1167 | 194 |
| | (C) control | 461 | 265 | 54.6 | 885 | 141 | 473 | 326 | 56.0 | 914 | 151 |
| L.S.D. at 0.05 | | 17.2 | 35.9 | 3.74 | 45.06 | 6.29 | 13.27 | 41.89 | 4.68 | 36.39 | 8.47 |

Cultivar Isabella (I) Cultivar Milas (M).

Rizobacterien at a rate of 2 liter/feddan + Delfan (amino acids) at a rate of 200ppm. ( R1+D).

Rizobacterien at a rate of 4 liter/feddan + Delfan (amino acids) at a rate of 200ppm. (R2+D).

Rizobacterien at a rate of 2 liter/feddan. (R1) 4- Rizobacterien at a rate of 4 liter /feddan. (R2).

Control Chicken manure at a rate of 10 tons per feddan (C).

**Table 5.** Effect of biofertilizers and cultivars on yield and its compositions of tomato plant grown under net-house conditions

| | | 2011 /2012 | | | | 2012/2013 | | | |
|---|---|---|---|---|---|---|---|---|---|
| Treatments | | Early yield kg/plant | No. of fruit Per Plant | Average fruit weight (g) | Total yield kg/plant | Early yield kg/plant | No. of fruit Per plant | Average fruit weight (g) | Total yield kg/plant |
| A | I | 2.09 | 38.1 | 176 | 6.70 | 1.96 | 41.6 | 166 | 6.92 |
| | M | 1.95 | 37.5 | 170 | 6.39 | 1.83 | 41.6 | 159 | 6.62 |
| L.S.D. at 0.05 | | 0.036 | N.S | 3.19 | 0.147 | 0.053 | N.S | 2.04 | 0.074 |
| | (R1+D) | 1.90 | 37.6 | 173 | 6.49 | 1.78 | 41.0 | 166 | 6.81 |
| | (R2+D) | 2.71 | 39.4 | 192 | 7.56 | 2.52 | 42.4 | 184 | 7.78 |
| B | (R1) | 1.57 | 36.0 | 152 | 5.46 | 1.48 | 39.6 | 142 | 5.60 |
| | (R2) | 2.24 | 38.6 | 184 | 7.08 | 2.12 | 42.6 | 170 | 7.26 |
| | (C) control | 1.70 | 37.5 | 164 | 6.13 | 1.59 | 42.6 | 150 | 6.40 |
| L.S.D. at 0.05 | | 0.015 | N.S | 2.02 | 0.096 | 0.032 | N.S | 4.71 | 0.028 |

Cultivar Isabella (I) Cultivar Milas (M).

Rizobacterien at a rate of 2 liter/feddan + Delfan (amino acids) at a rate of 200ppm. ( R1+D).

Rizobacterien at a rate of 4 liter/feddan + Delfan (amino acids) at a rate of 200ppm. (R2+D).

Rizobacterien at a rate of 2 liter/feddan. (R1) 4- Rizobacterien at a rate of 4 liter /feddan. (R2).

Control Chicken manure at a rate of 10 tons per feddan (C).

were significantly higher with the applying of Rizobacterien at a rate of 4 liter/feddan + Delfan (amino acids) at a rate of 200 ppm, for the two cultivars compared with all studied treatments during the two seasons**.**

The lowest early yield, total yield per plant and average fruit weight were obtained from Rizobacterien at a rate of 2 liter/feddan. Number of fruits per plant showed no significant difference between all treatments and cultivars during the two studied seasons. Applying biofertilizers plus amino acid increased yield and the components of tomato crop. The effect might be due to the increase of nutrient elements in the soil. This increase can encourage the haulm growth, which increases the photosynthetic rates leading to an increase of assimilation rates. Similar results have been found by **Saber (1996); Awad (1998); Shahaby (1981); Kumaraswany & Madalageri (1990); Shahaby *et al* (1993); Valpin & Kapulink (1994); Terry *et al* (1995); Batets *et al* (1999); Verranjaneyulu & Kumari (2003); El-Shaabasi *et al* ( 2005); Ahmed *et al* (2006)** and **Hasanein & Gaafer (2006).**

The interaction between cultivars and biofertilizers **(Table 6)** revealed that the two cultivars gave higher early yield, total yield per plant and average fruit weight under Rizobacterien at a rate of 4 liter/feddan + Delfan (amino acids) at a rate of 200 ppm with significant difference between them and all other treatments. The increase of fruit yield when applying biofertilizers at a rate of 4 liter/feddan plus amino acids might be due to the increase of vegetative growth and nutrient elements content of plants, which consequently led to higher early and total yield. The results were in agreement with those **of Hewedy (1999) on tomato, Abdalla, *et al* (2001) on pepper, Abou-Hussein (2002) on potatoes, Adam, *et al* (2002) on cantaloupe and Rizk, *et al* (2003) on squash.**

### C. Chemical composition of tomato fruits grown under net-house conditions

Ascorbic acid, total titratable acidity, total soluble solids and total chlorophyll of tomato fruits, as influenced by cultivars and different biofertilizers rates, are shown in **Table (7)**. Data showed that such contents were significantly higher for Isabella cultivar than cv. Milas.

Adding Rizobacterien at a rate of 4 liter/feddan plus Delfan (amino acids) at a rate of 200 ppm significantly increased ascorbic acid, total titratable acidity, total soluble solids and total chlorophyll than other treatments. However, the lowest values of the chemical composition parameters were obtained from adding rizobacterien at a rate of 2 liter/feddan and with the control, chicken manure at a rate of 2.50 ton per feddans, and Rizobacterien at a rate of 2 liter/feddan + Delfan (amino acids) at a rate of 200 ppm, respectively. The results were confirmed in the two seasons and agreed with those obtained by **Radwan, (1983) on tomato, Kabesh, *et al* (1987) on Soybean, Abdel Ati (1996) on potato and Hasanein and Gaafer (2006).**

The interaction of biofertilizers and cultivars showed that applying Rizobacterien at a rate of 4 liter/feddan + Delfan (amino acids) at a rate of 200 ppm increased the values of chemical parameters significantly for the cultivar Isabella than the Milas cultivar. On the other hand, the lowest values were obtained from Rizobacterien at a rate of 2 liter/feddan for the two cultivars during the two studied seasons **(Table 8)**.

From the previous results, it could be concluded that the best fruit quality was achieved for Isabella treated with Rizobacterien at a rate of 4 liter/feddan + Delfan (amino acids) at a rate of 200 ppm. Applying biofertilizers and amino acids increased chemical parameters. This effect could be due to that biofertilizers play a fundamental role in P or K fixed form to be soluble ready for plants, making the uptake of nutrients by plants more easy. Similar results were found by **Shahaby *et al* (1993); Valpin & Kapulink, (1994); Terry *et al* (1995); Awad, (1998); Ahmed *et al* (2006) and Hasanein & Kabeel (2006).**

### D. Effect of biofertilizers and cultivars on water productivity of tomato plants grown under net-house conditions

Cultivar Isabella gave significantly higher water productivity than cultivar Milas with significant effect during the two seasons **(Table 9)**. As for the effect of biofertilizers and amino acids, data showed that applying Rizobacterien at a rate of 4 liter/feddan + Delfan (amino acids) at a rate of 200 ppm significantly increased water productivity than other treatments. Similar results were found by **Radwan, (1983); Hewedy, (1999)** on tomato and **Abdrabbo *et al* (2009)** on cucumber.

The lowest water productivity (kg tomato/ $m^3$ of water) was obtained from Rizobacterien at a rate of 2 liter/feddan. However, adding Rizobacterien at a rate of 4 liter/feddan + Delfan (amino acids) at a rate of 200 ppm increased water productivity. This effect may be due to increase plant productivity due to improving the microorganisms living in the soil.

**Table 6.** Effect of biofertilizers and cultivars interaction on yield and its compositions of tomato plant grown under net-house conditions

| | | 2011 /2012 | | | | 2012/2013 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Treatments | Early yield kg/plant | No. of fruit per Plant | Average fruit weight (g) | Total yield kg/plant | Early yield kg/plant | No. of fruit Per plant | Average fruit weight (g) | Total yield kg/plant |
| | (R1+D) | 1.96 | 37.6 | 175 | 6.58 | 1.83 | 40.7 | 169 | 6.89 |
| | (R2+D) | 2.87 | 39.3 | 195 | 7.67 | 2.64 | 42.0 | 188 | 7.92 |
| I | (R1) | 1.60 | 36.6 | 155 | 5.69 | 1.54 | 39.8 | 147 | 5.83 |
| | (R2 ) | 2.33 | 39.3 | 186 | 7.283 | 2.19 | 43.0 | 172 | 7.40 |
| | (C) control | 1.73 | 37.7 | 166 | 6.27 | 1.61 | 42.5 | 154 | 6.55 |
| | (R1+D) | 1.84 | 37.6 | 170 | 6.40 | 1.73 | 41.3 | 163 | 6.73 |
| | (R2+D) | 2.54 | 39.4 | 189 | 7.45 | 2.39 | 42.7 | 179 | 7.64 |
| M | (R1) | 1.54 | 35.4 | 148 | 5.23 | 1.41 | 39.3 | 136 | 5.36 |
| | (R2) | 2.15 | 37.8 | 182 | 6.87 | 2.05 | 42.2 | 169 | 7.12 |
| | (C) control | 1.66 | 37.3 | 161 | 5.99 | 1.56 | 42.6 | 147 | 6.25 |
| L.S.D. at 0.05 | | 0.024 | N.S | 6.32 | 0.231 | 0.051 | N.S | 5.04 | 0.193 |

Cultivar Isabella (I) Cultivar Milas (M).
Rizobacterien at a rate of 2 liter/feddan + Delfan (amino acids) at a rate of 200ppm. ( R1+D).
Rizobacterien at a rate of 4 liter/feddan + Delfan (amino acids) at a rate of 200ppm. (R2+D).
Rizobacterien at a rate of 2 liter/feddan. (R1) 4- Rizobacterien at a rate of 4 liter /feddan. (R2).
Control Chicken manure at a rate of 10 tons per feddan (C).

**Table 7.** Effect of biofertilizers and cultivars on chemical composition of tomato fruits grown under net-house conditions

| | | 2011 /2012 | | | | 2012/2013 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Treatments | ascorbic acid mg\100g f. w. | total acidity TA % | total soluble solids % | total chlorophyll content | Ascorbic acid mg \100g f. w. | Total acidity TA | Total soluble solids % | Total chlorophyll content |
| A | I | 19.2 | 37.8 | 40.3 | 40.3 | 18.1 | 36.1 | 38.8 | 37.7 |
| | M | 18.2 | 36.6 | 39.1 | 37.9 | 16.6 | 34.3 | 37.0 | 35.3 |
| L.S.D. at 0.05 | | 0.67 | 0.31 | 0.74 | 1.63 | 0.45 | 0.19 | 0.22 | 0.94 |
| | (R1+D) | 18.7 | 37.2 | 40.1 | 39.1 | 17.6 | 35.4 | 38.7 | 37.8 |
| | (R2+D) | 21.8 | 33.0 | 45.0 | 42.7 | 19.7 | 30.7 | 43.5 | 40.4 |
| B | (R1) | 15.9 | 42.0 | 34.1 | 35.4 | 14.5 | 40.4 | 32.8 | 30.9 |
| | (R2) | 19.6 | 34.9 | 41.7 | 41.4 | 18.9 | 32.3 | 39.4 | 38.9 |
| | (C) control | 17.4 | 39.4 | 37.0 | 37.1 | 15.9 | 37.6 | 35.4 | 34.5 |
| L.S.D. at 0.05 | | 1.05 | 2.48 | 2.91 | 1.58 | 0.86 | 2.07 | 3.01 | 1.83 |

Cultivar Isabella (I) Cultivar Milas (M).
Rizobacterien at a rate of 2 liter/feddan + Delfan (amino acids) at a rate of 200ppm. ( R1+D).
Rizobacterien at a rate of 4 liter/feddan + Delfan (amino acids) at a rate of 200ppm. (R2+D).
Rizobacterien at a rate of 2 liter/feddan. (R1) 4- Rizobacterien at a rate of 4 liter /feddan. (R2).
Control Chicken manure at a rate of 10 tons per feddan (C).

**Table 8.** Effect of biofertilizers and cultivars interaction on chemical composition of tomato fruits grown under net-house conditions

| | | 2011 /2012 | | | | 2012/2013 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Treatments | ascorbic acid mg\100g f. w. | Total Acidity % | Total Soluble Solids % | Total chlorophyll content | Ascorbic acid mg\100g f. w. | Total Acidity % | Total Soluble Solids % | total chlorophyll content |
| | (R1+D) | 19.1 | 37.9 | 40.3 | 40.0 | 18.5 | 36.4 | 38.7 | 39.6 |
| | (R2+D) | 22.6 | 33.9 | 46.5 | 43.3 | 20.4 | 31.7 | 45.1 | 41.4 |
| I | (R1) | 16.3 | 42.3 | 34.9 | 380 | 15.4 | 41.3 | 33.5 | 31.5 |
| | (R2 ) | 20.2 | 34.9 | 42.2 | 41.9 | 19.8 | 33.2 | 40.4 | 40.4 |
| | (C) control | 17.8 | 39.9 | 37.5 | 38.5 | 16.2 | 38.1 | 36.2 | 35.4 |
| | (R1+D) | 18.3 | 36.4 | 39.9 | 38.1 | 16.7 | 34.4 | 38.6 | 36.1 |
| | (R2+D) | 21.0 | 32.0 | 43.5 | 42.0 | 19.0 | 29.6 | 41.9 | 39.4 |
| M | (R1) | 15.5 | 40.8 | 33.3 | 33.1 | 13.5 | 39.5 | 32.0 | 30.3 |
| | (R2) | 19.0 | 34.8 | 41.1 | 40.8 | 18.1 | 31.4 | 38.3 | 37.3 |
| | (C) control | 16.9 | 38.9 | 36.4 | 35.7 | 15.5 | 37.0 | 34.5 | 33.5 |
| L.S.D. at 0.05 | | 0.63 | 0.94 | 1.61 | 1.79 | 0.51 | 1.49 | 0.73 | 2.17 |

Cultivar Isabella (I) Cultivar Milas (M).
Rizobacterien at a rate of 2 liter/feddan + Delfan (amino acids) at a rate of 200ppm. ( R1+D).
Rizobacterien at a rate of 4 liter/feddan + Delfan (amino acids) at a rate of 200ppm. (R2+D).
Rizobacterien at a rate of 2 liter/feddan. (R1) 4- Rizobacterien at a rate of 4 liter /feddan. (R2).
Control Chicken manure at a rate of 10 tons per feddan (C).

**Table 9.** Effect of biofertilizers and cultivars on water productivity of tomato plants grown under net-house conditions

| | | 2011/2012 | 2012/2013 |
|---|---|---|---|
| | Treatments | kg/ $m^3$ | kg/ $m^3$ |
| A | I | 16.7 | 17.2 |
| | M | 15.9 | 16.5 |
| | L.S.D. at 0.05 | 0.44 | 0.16 |
| | (R1+D) | 16.1 | 16.9 |
| | (R2+D) | 18.8 | 19.3 |
| B | (R1) | 13.6 | 13.9 |
| | (R2) | 17.6 | 18.0 |
| | (C) control | 15.2 | 15.9 |
| | L.S.D. at 0.05 | 0.63 | 0.74 |

Cultivar Isabella (I) Cultivar Milas (M).
Rizobacterien at a rate of 2 liter/feddan + Delfan (amino acids) at a rate of 200ppm. ( R1+D).
Rizobacterien at a rate of 4 liter/feddan + Delfan (amino acids) at a rate of 200ppm. (R2+D).
Rizobacterien at a rate of 2 liter/feddan. (R1)
4- Rizobacterien at a rate of 4 liter /feddan. (R2).
Control Chicken manure at a rate of 10 tons per feddan (C).

The interaction of biofertilizers and cultivars on water productivity are present in **Table (10)**. Results showed that applying Rizobacterien at a rate of 4 liter/feddans + Delfan (amino acids) at a rate of 200 ppm increased water productivity during the two studied seasons. These results agreed with **Abdrabbo, (2007)** who concluded that applying such agriculture practices i.e. use proper cultivar and appropriate organic fertilizers led to the improve of water productivity due to the increase of plant yield.

**Table 10**. Effect of biofertilizers and cultivars interaction on water productivity of tomato plant grown under net house conditions

| | | 2011 /2012 | 2012/2013 |
|---|---|---|---|
| | Treatments | kg / $m^3$ | kg / $m^3$ |
| | ( R1+D) | 16.4 | 17.1 |
| | (R2+D) | 19.1 | 19.7 |
| I | (R1) | 14.1 | 14.5 |
| | (R2 ) | 18.1 | 18.4 |
| | (C) control | 15.6 | 16.3 |
| | (R1+D) | 15.9 | 16.7 |
| | (R2+D) | 18.5 | 19.0 |
| M | (R1) | 13.0 | 13.3 |
| | (R2) | 17.1 | 17.7 |
| | (C) control | 14.9 | 15.5 |
| | L.S.D. at 0.05 | 0.69 | 0.42 |

Cultivar Isabella (I) Cultivar Milas (M).
Rizobacterien at a rate of 2 liter/feddan + Delfan (amino acids) at a rate of 200ppm. (R1+D).
Rizobacterien at a rate of 4 liter/feddan + Delfan (amino acids) at a rate of 200ppm. (R2+D).
Rizobacterien at a rate of 2 liter/feddan. (R1)
4- Rizobacterien at a rate of 4 liter /feddan. (R2).
Control Chicken manure at a rate of 10 tons per feddan (C).

## CONCLUSION

Tomato fertilized with rizobacterien at a rate of 4 liter/feddan + Delfan (amino acids) at a rate of 200 ppm gave higher plant length, higher number of leaves per plant, higher leaf area, and higher fresh and dry weight. This treatment enhanced tomato production as it increased total and marketable yields, beside the increase of yield compo-

nents, when compared with other fertilizer treatments. Regarding water productivity for the water unit, it is consider a vital subject under arid climate conditions with scarcity of water. This study recommends the use of advanced agronomic practices in tomato production which include cover greenhouse with nets, select the proper cultivar (Isabella) and apply the proper concentration of bio fertilizers (Delfan amino acid (200ppm)).

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