EXOGENOUS APPLICATION OF ANTIOXIDANTS ON LEAF CHLOROPHYLL, YIELD DYNAMICS AND BERRY QUALITY OF SWEET PEPPER (*Capsicum annuum* L.)

An experiment was carried out to investigate the influences of seven levels of antioxidants on BARI Mistimorich-1 and BARI Mistimorich-2 varieties of sweet pepper at the Central Research Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. Antioxidants were applied to sweet pepper varieties which had a significant effect on physiology, yield and quality of sweet pepper. Among those treatments, ascorbic acid (AA) at 200 ppm with salicylic acid (SA) at 200 ppm was more potential to enhance chlorophyll a (30%), chlorophyll b (39.39%), total chlorophyll (33.73%), number of flower plant-1 (17.63%), number of fruits plants-1 (56.73%), fruit yield plant-1 (43.61%), total soluble sugar (28.67%) and vitamin C (22.75%) compared to control. The variety of BARI Mistimorich-2 produces 4.55% higher fruit yield than BARI Mistimorich-1. Among those antioxidants, AA at 200 ppm with SA at 200 ppm demonstrate the best potentiality to solve flower and fruit dropping problems and ultimately lead to higher production of sweet pepper.

**ABSTRACT**

Species are vital for the agricultural economy, especially for domestic consumption and exchange earnings. It provides vitamin a, c and e and supply of thiamine, beta carotene, folic acid and vitamin B6. It's used in numerous shapes like green, condiments, spices, pickles and sauces. Sweet pepper (*Capsicum annuum* L.) Is also a promising farming crop in Bangladesh? It is a recently introduced crop in our country usually acquainted as capsicum or bell pepper, belongs to the Solanaceae family. Pepper may be a crucial agricultural crop, not only contribute to its economic importance but also for the nutritional value of its fruits, it is an excellent supply of natural colors and inhibitor compounds vital for human health (Howard, Talcott, Brenes, & Villalon, 2000). It's medicinal properties and used form of a vegetable that can be consumed as raw as a dish or fried. It is also often supplemental to soups, omelets, stews, brochettes, rice, pasta and pizza.

**Article History**

Received: 12 October 2020
Revised: 2 November 2020
Accepted: 26 November 2020
Published: 10 December 2020

**Keywords**

Capsicum
Antioxidants
Ascorbic acid
Salicylic acid
Chlorophyll
Vitamin C.
Ascorbic acid (AA) is taken into consideration as one of the universal non-enzymatic antioxidants molecules that play a task in the detoxification of ROS and intermediating many vital functions in plants each under stress and traditional conditions. However, its physiologically active type is ascorbate that cited as a very important soluble antioxidant molecule throughout a biological system (Akram, Shafiq, & Ashraf, 2011; Qian et al., 2014). Exogenous foliar application of AA is also effective against lipids and protein protection below abiotic stresses-induced oxidative adversaries (Naz, Akram, & Ashraf, 2016). El-Hifny and El-Sayed (2011) observed that AA spraying enriches the macronutrient contents of sweet pepper fruits. Different investigators found similar results on the stimulatory effects of AA on different plants like eggplant (Ei-Tohamy, Ei-Abagy, & Ei-Gready, 2008) and lettuce (Shafeek, Helmy, Marzauk, & Magda).

Salicylic acid (SA) is known as a phenoplast compound made inside the regulation of plant growth and improvement and its response to biotic and abiotic stress factors (Miura & Tada, 2014) SA is engaged in the regulation of most plant biological processes like a chemical process, proline metabolism, nitrogen metabolism, antioxidant defense system and protects against abiotic stresses (Khan, Fatma, Per, Anjum, & Khan, 2015). El-Al and Faten (2009) found that the foliar application of salicylic acid plays a significant role in raising the productivity of sweet pepper. The non-enzymatic antioxidative system consists of compounds as ascorbic acid (vitamin c), salicylic acid, α- e, carotenoids, and flavonoids, whereas the catalyst antioxidative system consists SOD, ascorbate peroxidase (APX), glutathione catalase (GR), enzyme (CAT), peroxidase (POD) and polyphenol oxidase (PPO), etc. Scavenge the reactive oxygen species (ROS) produced in plant cells throughout oxidative stress inside the most role of the inhibitor system and therefore facilitate the plants to beat such stress conditions (Mandal, Yadav, Yadav, & Nema, 2009).

However, the production of sweet pepper is decreased due to flower and fruit drop that is caused by a physiological and hormonal imbalance inside the plants particularly below unfavorable environments (Erickson & Markhart, 2001). There is plenty of research data on the application of varied technologies on sweet pepper that are obtainable in different countries, however very little or no is documented on the comparative study of foliar application of antioxidants with different sweet pepper verities in Bangladesh. Considering the above-named facts, a pot experiment has been designed to assess the optimum concentration of antioxidants i.e. ascorbic and salicylic acids and their impact on the growth, morphology, yield and quality of sweet pepper.

2. MATERIAL AND METHODS

2.1. Experimental Area

A pot experiment was conducted at the central research Field of Sher-e-Bangla Agricultural University, Dhaka-1207 from Nov, 2019 to May, 2020. The soil of the experimental pot belongs to the overall soil category, shallow red-brown terrace soil with silty clay. Soil hydrogen ion concentration was 5.6 and has organic carbon 0.45%.

2.2. Treatment and Experimental Layout

Sweet pepper was used as the check crop during this experiment. The experiment comprised two factors viz. variety: BARI Mistimorich-1 and BARI Mistimorich-2 and antioxidant concentrations: control, AA@100 ppm, AA@200 ppm, SA@100 ppm, SA@200 ppm, AA@100 ppm + SA@100 ppm and AA@200 ppm + SA@200 ppm. The randomized complete block design (RCBD) was followed within the experiment includes 3 replications. There were 14 pots for each replication resulting in 42 pots containing 24 kg of soil in each pot.

2.3. Crop Husbandry

Seeds (0.23 g m⁻²) were sown in the seedbed for healthy seedlings. The fertilizers were applied 10-ton cowdung ha⁻¹, 250 kg carbamide ha⁻¹, 350 kg TSP ha⁻¹, 250 kg MP ha⁻¹, 110 kg gypsum ha⁻¹ and 5 kg zinc sulfate ha⁻¹ as a
supply of NPKSZn. The half quantity of cowdung was applied before the final preparation of pots and the rest ½ quantity of cowdung, TSP, MoP, gypsum, zinc sulfate and 1/3rd of urea were applied inside 2 installments after 25 and 50 days after transplanting. Intercultural operations were done to make sure the general growth of the crop. Plant protection measures were followed as and once necessary.

2.4. Application of Antioxidants

In this experiment, the ascorbic acid and salicylic acid solution were applied in 3 installments. The 1st, 2nd and 3rd sprays were done at 25, 45 and 65 DAT with a hand sprayer.

2.5. Data Collection

Plants were chosen haphazardly from every pot. Data on the subsequent parameters were recorded throughout the experiment such as- chlorophyll a (mg l⁻¹), chlorophyll b (mg l⁻¹), Total chlorophyll (mg l⁻¹), number of flower plant⁻¹, number of fruits plants⁻¹, Fruit yield plant⁻¹ (g), total soluble sugar (%) and vitamin c (mg/100g).

2.6. Statistical Analysis

The data obtained from different parameters were statistically analyzed following the computer-based package Statistix 10 and mean separation were done by LSD at 5% level of significance (Gomez & Gomez, 1984).

3. RESULTS

3.1. Chlorophyll Content

The varieties (except chlorophyll a), antioxidants and their interaction positively responded to the different photosynthetic pigments like chlorophyll a, chlorophyll b and total chlorophyll Figure 1, Figure 2 and Table 1, respectively. Among the varieties, treatments and interactions, BARI Mistimorich-2, T₀ (AA@200+SA@200) and combination of BARI Mistimorich-2 with T₀ (AA@200+SA@200) exhibit the highest content of chlorophyll a, chlorophyll b and total chlorophyll, respectively. On the contrary, BARI Mistimorich-1, T₀ (control) and combination of BARI Mistimorich-1 with T₀ (control) exhibit the lowest content of chlorophyll a, chlorophyll b and total chlorophyll, respectively.

![Figure 1. Effect of varieties on chlorophyll content of sweet pepper.](image-url)
Figure 2: Effect of antioxidants on chlorophyll content of sweet pepper.

Table 1: Interaction effect of varieties and antioxidants on chlorophyll contents of sweet pepper.

| Varieties × antioxidants | Chl a (mg/l) | Chl b (mg/l) | Total Chlorophyll (mg/l) |
|--------------------------|-------------|-------------|-------------------------|
| BARI Mistimorich-1 ×     |             |             |                         |
| Control                  | 0.52g       | 0.33g       | 0.84i                   |
| AA@100                   | 0.53fg      | 0.34g       | 0.87hi                  |
| AA@200                   | 0.59e       | 0.42de      | 1.01e                   |
| SA@100                   | 0.55fg      | 0.37f       | 0.92g                   |
| SA@200                   | 0.61de      | 0.42cd      | 1.06cd                  |
| AA@100+SA@100            | 0.68ab      | 0.43cd      | 1.10b                   |
| AA@200+SA@200            | 0.66abc     | 0.45ab      | 1.11ab                  |
| BARI Mistimorich-2 ×     |             |             |                         |
| Control                  | 0.51g       | 0.33g       | 0.85i                   |
| AA@100                   | 0.54fg      | 0.36f       | 0.90gh                  |
| AA@200                   | 0.61de      | 0.42de      | 1.03de                  |
| SA@100                   | 0.56f       | 0.41e       | 0.97f                   |
| SA@200                   | 0.64bcd     | 0.43bcd     | 1.07bc                  |
| AA@100+SA@100            | 0.64bcd     | 0.43bcd     | 1.07bc                  |
| AA@200+SA@200            | 0.68a       | 0.47a       | 1.15a                   |
| LSD (0.05)               | 0.034       | 0.022       | 0.427                   |
| CV (%)                   | 3.4         | 3.25        | 2.55                    |

Note: Values followed by the same letter(s) did not differ significantly at 5% level of probability.

3.2. Number of Flowers Plant⁻¹

The flower number plant⁻¹ differed remarkably among varieties, antioxidants and their interaction effect. Out of varieties, BARI Mistimorich-2 gave a higher flower number than BARI Mistimorich-1 Table 2. Among the treatment variations, T₆ (AA@200+SA@200) showed the highest flower number than other treatments whereas, T₀ (control) showed the lowest flower number Table 3. In their combinations, BARI Mistimorich-2 with T₀ (AA@200+SA@200) treatment exhibits the highest flower number whereas, the BARI Mistimorich-1 with T₀ (control) exhibits the lowest flower number Table 4.

3.3. Number of Fruits Plant⁻¹

The fruits number plant⁻¹ varied notably among antioxidants and their interaction effect except varieties. Among the varieties, BARI Mistimorich-2 showed a statistically higher fruit number than BARI Mistimorich-1 Table 2. In between treatment variations, T₆ (AA@200+SA@200) exhibits the maximum fruit number than other treatments whereas, the T₀ (control) showed the minimum fruit number Table 3. In their combinations, BARI Mistimorich-2 with T₀ (AA@200+SA@200) treatment indicates the highest fruit number whereas, the BARI Mistimorich-1 with T₀ (control) indicates the lowest fruit number Table 4.
3.4. Fruit Yield Plant (g)

The application of antioxidants significantly increased the fruit yield of plants. Among the varieties, BARI Mistimorich-2 gave a higher fruit yield than BARI Mistimorich-1 Table 2. In between treatment variations, T6 (AA@200+SA@200) exhibits the maximum fruit yield than other treatments whereas, the T0 (control) showed the minimum fruit yield Table 3.

In their combinations, BARI Mistimorich-2 with T6 (AA@200+SA@200) treatment indicates the highest fruit yield whereas, the BARI Mistimorich-1 with T0 (control) indicates the lowest fruit yield Table 4.

3.5. Total Soluble Sugar (%)

Total soluble sugar differed significantly by the application of different antioxidants except for varieties Table 2, Table 3 and Table 4, respectively.

Among the varieties, treatments and interactions, BARI Mistimorich-2, T6 (AA@100+SA@100) treatment and combination of BARI Mistimorich-2 with T6 (AA@200+SA@200) treatment showed the maximum soluble sugar, respectively. On the other hand, BARI Mistimorich-1, T0 (control) treatment and combination of BARI Mistimorich-1 with T0 (control) treatment showed the minimum soluble sugar, respectively.

3.6. Vitamin C (mg/100g)

Vitamin C varied considerably by the application of different antioxidants except for varieties Table 2, Table 3 and Table 4, respectively.

Among the varieties, treatments and interactions, BARI Mistimorich-2, T6 (AA@100+SA@100) treatment and combination of BARI Mistimorich-2 with T6 (AA@200+SA@200) treatment exhibit the maximal vitamin c, respectively. On the other hand, BARI Mistimorich-1, T0 (control) treatment and combination of BARI Mistimorich-1 with T0 (control) treatment exhibit minimal vitamin c, respectively.

Table 2. Effect of variety on yield dynamics and berry quality of sweet pepper.

| Variety            | Number of flowers plant | Number of fruits plant | Fruits yield plant (g) | TSS (%) | Vitamin c (mg/100g) |
|--------------------|-------------------------|------------------------|------------------------|---------|---------------------|
| BARI Mistimorich-1 | 31.33b                  | 7.81a                  | 387.62b                | 3.39a   | 119.48a             |
| BARI Mistimorich-2 | 32.38a                  | 8.09a                  | 405.24a                | 3.54a   | 122.29a             |
| LSD (0.05)         | 0.85                    | ns                     | 14.88                  | 0.19    | 3.12                |
| CV (%)             | 4.19                    | 6.52                   | 5.92                   | 8.99    | 4.07                |

Note: Values followed by the same letter(s) did not differ significantly at 5% level of probability.

Table 3. Effect of treatments on yield dynamics and berry quality of sweet pepper.

| Treatments            | Number of flowers plant | Number of fruits plant | Fruits yield plant (g) | TSS (%) | Vitamin c (mg/100g) |
|-----------------------|-------------------------|------------------------|------------------------|---------|---------------------|
| Control               | 29.33e                  | 6.17d                  | 305.00d                | 3.00c   | 107.83d             |
| AA@100               | 30.17de                 | 7.33c                  | 370.00c                | 3.20bc  | 111.50d             |
| AA@200               | 31.33cd                 | 8.33b                  | 413.33ab               | 3.57ab  | 124.17b             |
| SA@100               | 31.50cd                 | 7.33c                  | 391.67bc               | 3.25bc  | 118.17c             |
| SA@200               | 32.83bc                 | 8.33b                  | 425.00a                | 3.64a   | 124.17b             |
| AA@100+SA@100        | 33.33ab                 | 8.50b                  | 431.67a                | 3.72a   | 128.50ab            |
| AA@200+SA@200        | 34.50a                  | 9.67a                  | 438.00a                | 3.86a   | 131.83a             |
| LSD (0.05)           | 1.58                    | 0.62                   | 2.83                   | 0.37    | 5.84                |
| CV (%)               | 4.19                    | 6.52                   | 5.92                   | 8.99    | 4.07                |

Note: Values followed by the same letter(s) did not differ significantly at 5% level of probability.
Table 4. Interaction effect of varieties and antioxidants on yield dynamics and berry quality of sweet pepper.

| Varieties × antioxidants | Number of flowers plant⁻¹ | Number of fruits plant⁻¹ | Fruits yield plant⁻¹ (g) | TSS (%) | Vitamin c (mg/100g) |
|--------------------------|---------------------------|--------------------------|--------------------------|---------|---------------------|
| BARI Mistimorich-1 ×     |                           |                          |                          |         |                     |
| Control                  | 28.69f                   | 6.00e                    | 293.33f                  | 2.90f   | 106.67e             |
| AA@100                   | 29.67f                   | 7.33d                    | 333.33de                 | 3.03ef  | 109.67e             |
| AA@200                   | 31.00def                 | 8.00cd                   | 406.67abc                | 3.50abcde| 123.33bc            |
| SA@100                   | 31.00def                 | 7.33d                    | 383.33d                  | 3.20cdef| 114.67de            |
| SA@200                   | 32.00bcde                | 8.33c                    | 416.67abc                | 3.60abcd| 123.33bc            |
| AA@100+SA@100            | 32.67abcd                | 8.33c                    | 426.67ab                 | 3.70abc| 128.33abc           |
| AA@200+SA@200            | 34.33a                   | 9.33bc                   | 433.33ab                 | 3.78ab  | 130.33ab            |
| BARI Mistimorich-2 ×     |                           |                          |                          |         |                     |
| Control                  | 30.00defg                | 6.33e                    | 316.67ef                 | 3.10def | 109.00e             |
| AA@100                   | 30.67defg                | 7.33d                    | 386.67cd                 | 3.37bcde| 113.33c             |
| AA@200                   | 31.67cdef                | 8.67bc                   | 420.00abc                | 3.65abc | 125.00bc            |
| SA@100                   | 32.00bcd                 | 7.33d                    | 400.00bc                 | 3.30bcde| 121.67cd            |
| SA@200                   | 33.67abc                 | 8.33c                    | 433.33ab                 | 3.68abc | 125.00bc            |
| AA@100+SA@100            | 34.00ab                  | 8.67bc                   | 436.67ab                 | 3.73ab  | 128.67abc           |
| AA@200+SA@200            | 34.67a                   | 10.00a                   | 445.33a                  | 3.93a   | 133.33a             |
| LSD (0.05)               | 2.24                     | 0.87                     | 39.36                    | 0.52    | 8.26                |
| CV (%)                   | 4.19                     | 6.52                     | 5.92                     | 8.99    | 4.07                |

Note: Values followed by the same letter (s) did not differ significantly at 5% level of probability.

4. DISCUSSION

Antioxidants particularly ascorbic acid and salicylic acid play a possible role in enhancing the physiological method that overcomes the environmental stresses leading to optimum yield.

The effect of antioxidants on plant growth may be because of the plant hormone action of antioxidants also as, its improved role in several metabolic and physiological processes and enhancing the synthesis of carbohydrates (Wassel, Hameed, Gobara, & Attia, 2007). SA application multiplied chlorophyll a and b in plants (Zaki & Radwan, 2011). El Bassiouny, Gobarah, and Ramadan (2005) reportable that foliar spray with antioxidant (vitamin E) on bean plants elicited increments in chlorophyll a and b content. Within the same respect, the prevalence of spraying salicylic acid and vitamin e these results is also because of the role of antioxidants in enhancing some physiological and organic chemistry aspects (Maity & Bera, 2009) or increasing N,P,K and Ca content, activity in inhibitor enzymes and glutathione content (Khan et al., 2009) on the leguminous plant.

The application of antioxidants increased flower production, reduced flower abscission that contributed to the most varieties of flowers per plant. This results in agreement with the findings of Choudhury., Islam, Sarkar, and Ali (2013) who found that the best range of flowers per plant was obtained in combined application +CPA and GA3 within the summer tomato. It was noticed that the application of NAA increased flower production, reduced flower abscission that contributed to the utmost number of flowers per plant compared to plants that were treated with other hormones and management (Chaudhary, Sharma, Shakya, & Gautam, 2006).

The application of antioxidants increased fruit production, reduced fruit abscission that contributed to the most variety of fruits per plant compared to plants treated with different antioxidants and management. Sarkar, Jahan, Kabir, Kabir, and Rojoni (2014) additionally reported that plant growth regulators have nice potential to facilitate the flower and fruit set also because of the yield of summer tomato. Deb, Suresh, Saha, and Das (2009) found a major response of NAA regarding the number of fruits per plant. It was noticed that the application of 4-CPA enhances fruit set by reducing fruit abscission that contributed to a better range of fruit plant⁻¹ (Das, Sarkar, Alam, Robbani, & Kabir, 2015).

The increments in flowering and fruit yield because of treating the plants with ascorbic acid and salicylic acid treatments might be connected with their impact on increasing the vegetative growth parameters and photosynthetic pigments that affect plant growth and successively enhanced its productivity. Nour, Mansour, and Eisa (2012) reported that yield and its components of pods were remarkably affected by different antioxidants in
snap bean. Hosain, Kamrunnahar, Munshi, and Rahman (2020) observed that SA greatly influenced the grains yield of rice by the phenomenal reduction of stress. Bhaalekar, Kadam, Shinde, Patil, and Asane (2009) where he disclosed that spraying of NAA recorded higher fruit yield compared to control. Sarkar et al. (2014) proclaimed that plant growth regulators have significant potential to facilitate the flower and fruit set additionally as the yield of summer tomato.

The increment in fruit parameters due to ascorbic acid and salicylic acid may be attributed to increasing vegetative growth, chemical pigments and uptake of nutrients. similar findings nearly were attained for SA in tomato (Fathy, Farid, & El-Desouky, 2000) and bean (Zaghlool, Ibrahim, Sharaf, & Eldeen, 2001). In this respect, Hayat and Ahmad (2007) found that hydroxy acid may be a plant hormone that increased plant bio productivity. The application of SA raised total soluble solids, total sugars, and antioxidants in sweet pepper fruit (Mahmood, Abbasi, Hafiz, & Zakia, 2017).

The antioxidants (ascorbic acid and salicylic acid) incorporate a positive role to extend vitamin c content within the fruits. Ascorbic acid includes a well-documented role in several aspects of radix management and inhibitor activity within the plant cell, this biological science making known to highlight recent development in another facet of antioxidant metabolism (Seth, Melino, & Ford, 2007). Vitamin c was also enhanced in ‘California Wonder’ sweet pepper fruit in response to hydroxy acid treatment at 0.1 g L⁻¹ (El-Yazeid, 2011). Ascorbic acid content was found superior in the tomato plant by the applying of PGR (GA₃) (Rahman, Saki, Hosain, & Rashid, 2019).

5. CONCLUSIONS

In conclusion, long-run exposure to cold prolonged cell cycle duration and resulted in reduced plant growth. The foliar application of antioxidants (ascorbic acid and salicylic acid) treatments were typically effective in alleviating the injury caused by cold through stimulating the vegetative growth, photosynthetic pigments, and bioconstituents activities that could be reflected on the yield and quality of sweet pepper fruit. Foliar spraying with ascorbic acid at 200 ppm combined with salicylic acid at 200 ppm being the most effective. It is postulated that the foliar spraying with ascorbic acid and salicylic acid at low temperatures may positively regulate the pepper growth and therefore improved productivity.

**Funding:** The author sincerely acknowledges the financial grant offered by the Ministry of Science and Technology, Bangladesh in carrying out the research project.

**Competing Interests:** The authors declare that they have no competing interests.

**Acknowledgement:** All authors contributed equally to the conception and design of the study.

**REFERENCES**

Akram, N. A., Shafiq, F., & Ashraf, M. (2011). Ascorbic acid-a potential oxidant scavenger and its role in plant development and abiotic stress tolerance. *Frontiers in Plant Science, 8*, 1-17. Available at: https://doi.org/10.3389/fpls.2017.00613.

Bhaalekar, M., Kadam, V., Shinde, U., Patil, R., & Asane, G. (2009). Effect of plant growth regulator and micronutrients on growth and yield of chilli (Capsicum annum L.) during summer season. *Advances in Plant Sciences, 22*(1), 111-113.

Chaudhary, B., Sharma, M., Shakya, S., & Gautam, D. (2006). Effect of plant growth regulators on growth, yield and quality of chilli (Capsicum annum L.) at Rampur, Chitwan. *Journal of the Institute of Agriculture and Animal Science, 27*, 65-68. Available at: https://doi.org/10.3126/jiaas.v27i0.697.

Choudhury., S., Islam, N., Sarkar, M., & Ali, M. (2013). Growth and yield of summer tomato as influenced by plant growth regulators. *International Journal of Sustainable Agriculture, 3*(1), 25-28.

Das, S., Sarkar, M. D., Alam, M., Robbani, M., & Kabir, M. (2015). Influence of plant growth regulators on yield contributing characters and yield of bell pepper (Capsicum annum) varieties. *Journal of Plant Sciences, 10*(2), 63-69. Available at: https://doi.org/10.3923/jps.2015.63.69.

Deb, P., Suresh, C. P., Saha, P., & Das, N. (2009). Effect of NAA and GA₃ on yield and quality of tomato (Lycopersicon esculentum Mill.). *Environment and Ecology, 27*(3), 1048-1050.
Ei-Tohamy, W., Ei-Abagy, H., & Ei-Greaddy, N. (2008). Studies on the effect of putrescine, yeast and vitamin C on growth, yield and physiological responses of eggplant (Solanum melongena L.) under sandy soil conditions. *Australian Journal of Basic Applied Science, 2*(2), 296-300.

El-Al, A., & Fatani, S. (2009). Effect of urea and some organic acids on plant growth, fruit yield and its quality of sweet pepper (Capsicum annuum). *Research Journal of Agriculture and Biological Sciences, 5*(4), 372-379.

El-Hifny, I. M., & El-Sayed, M. (2011). Response of sweet pepper plant growth and productivity to application of ascorbic acid and biofertilizers under saline conditions. *Australian Journal of Basic and Applied Sciences, 5*(6), 1273-1283.

El-Yazeid, A. (2011). Effect of foliar application of salicylic acid and chelated zinc on growth and productivity of sweet pepper (Capsicum annuum L.) under autumn planting. *Research Journal of Agriculture and Biological Sciences, 7*(6), 423-433.

El Bassiouny, H. M., Gobarah, M. E., & Ramadan, A. A. (2005). Effect of antioxidants on growth, yield and favism causative agents in seeds of Vicia faba L. plants grown under reclaimed sandy soil. *Journal of Agronomy, 4*(4), 281-287.

Erickson, A. N., & Markhart, A. H. (2001). Flower production, fruit set, and physiology of bell pepper during elevated temperature and vapor pressure deficit. *Journal of the American Society for Horticultural Science, 126*(6), 697-702.Available at: https://doi.org/10.21273/JASHS.126.6.697.

Fathy, E.-S., Farid, S., & El-Desouky, S. (2000). Induce cold tolerance of outdoor tomatoes during early summer season by using ATP, yeast, other natural and chemical treatments to improve their fruiting and yield. *Journal of Agricultural Science of Mansoura University, 25*(1), 377-401.

Gomez, K. A., & Gomez, A. A. (1984). Statistical procedures for agricultural research (pp. 67-215). New York: John wiley and Sons. Inc.

Hayat, S., & Ahmad, A. (2007). The role of salicylates in rhizobium legume symbiosis and abiotic stresses in higher plants. *Salicylic Acid–A Plant Hormone (pp. 151-162).* Dordrecht: Springer.

Hosain, M. T., Kamrunnahar, R., M. M., Munshi, M. H., & Rahman, M. S. (2020). Drought stress response of rice yield (Oryza sativa L.) and role of exogenous salicylic acid. *International Journal of Bioscience, 16*(2), 222-230.Available at: https://doi.org/10.12692/ijb/16.2.222-230.

Howard, L., Talcott, S., Brenes, C., & Villalon, B. (2000). Changes in phytochemical and antioxidant activity of selected pepper cultivars (Capsicum species) as influenced by maturity. *Journal of Agricultural and Food Chemistry, 48*(5), 1713-1720.Available at: https://doi.org/10.1021/jf990916l.

Khan, M. I. R., Fatma, M., Per, T. S., Anjum, N. A., & Khan, N. A. (2015). Salicylic acid-induced abiotic stress tolerance and underlying mechanisms in plants. *Frontiers in Plant Science, 6*, 1-17.Available at: https://doi.org/10.3389/fpls.2015.00462.

Khan, W., Rayirath, U. P., Subramanian, S., Jithesh, M. N., Rayorath, P., Hodges, D. M., . . . Prithiviraj, B. (2009). Seaweed extracts as biostimulants of plant growth and development. *Journal of Plant Growth Regulation, 28*(4), 386-399.Available at: https://doi.org/10.1007/s00344-009-9103-x.

Mahmood, N., Abbasi, N. A., Hafiz, I., Ali, I., & Zakia, S. (2017). Effect of biostimulants on growth, yield and quality of bell pepper cv. Yolo Wonder. *Pakistan Journal of Agricultural Science, 54*, 311-317.Available at: https://doi.org/10.21162/PAKJAS/17.5653.

Maity, U., & Bera, A. (2009). Effect of exogenous application of brassinolide and salicylic acid on certain physiological and biochemical aspects of green gram (Vigna radiata L. Wilczek). *Indian Journal of Agricultural Research, 43*(3), 194-199.

Mandal, S., Yadav, S., Yadav, S., & Nema, R. K. (2009). Antioxidants: A review. *Journal of Chemical and Pharmaceutical Research, 1*(1), 102-104.

Miura, K., & Tada, Y. (2014). Regulation of water, salinity, and cold stress responses by salicylic acid. *Frontiers in Plant Science, 5*, 1-12.Available at: https://doi.org/10.3389/fpls.2014.00004.

Naz, H., Akram, N. A., & Ashraf, M. (2016). Impact of ascorbic acid on growth and some physiological attributes of cucumber (Cucumis sativus) plants under water-deficit conditions. *Pakistan Journal of Botany, 48*(3), 877-883.
Nour, K., Mansour, N., & Eisa, G. (2012). Effect of some antioxidants on some physiological and anatomical characters of snap bean plants under sandy soil conditions. *New York Science Journal, 5*(5), 1-9.

Qian, H., Peng, X., Han, X., Ren, J., Zhan, K., & Zhu, M. (2014). The stress factor, exogenous ascorbic acid, affects plant growth and the antioxidant system in Arabidopsis thaliana. *Russian Journal of Plant Physiology, 61*(4), 467-475.

Rahman, M. S., Saki, M. J., Hosain, M. T., & Rashid, S. (2019). Cumulative effect of zinc and gibberelic acid on yield and quality of tomato. *International Journal of Bioscience, 14*(5), 350-360. Available at: https://doi.org/10.12692/ijb/14.3.350-360.

Sarkar, M., Jahan, M. S., Kabir, M., Kabir, K., & Rojoni, R. (2014). Flower and fruit setting of summer tomato regulated by plant hormones. *Applied Science Report, 7*, 117-120. Available at: https://doi.org/10.15192/PSCP.ASR.2014.3.3.117120.

Seth, D., Melino, V., & Ford, C. M. (2007). Ascorbate as a biosynthetic precursor in plants. *Annals of Botany, 99*(1), 3-8. Available at: https://doi.org/10.1093/aob/mcl236.

Shafeek, M., Helmy, Y., Marzauk, N. M., & Magda, A. Shalaby and Nadia, M. Omer, 2013. Effect of foliar application of some antioxidants on growth, yield and chemical composition of Lettuce plants (Lactuca Sativa L.) under plastic house condition. *Middle East Journal of Applied Sciences, 3*(2), 70-75.

Wassel, A. H., Hameed, M. A., Gobara, A., & Attia, M. (2007). *Effect of some micronutrients, gibberellic acid and ascorbic acid on growth, yield and quality of white Banaty seedless grapevines*. Paper presented at the 8th African Crop Science Society Conference, El-Minia, Egypt. African Crop Science Society.

Zaghlool, A. M., Ibrahim, S. I., Sharaf, & Eldeen, H. A. M. (2001). The effect of naphthaline acetic acid (NAA), salicylic acid (SA) and their combination on growth, fruit setting yield and some correlated components in dry bean (Phaseolus vulgaris L.). *Annals of Agricultural Science, 46*(2), 451-463.

Zaki, R., & Radwan, T. (2011). Improving wheat grain yield and its quality under salinity conditions at a newly reclaimed soil by using different organic sources as soil or foliar applications. *Journal of Applied Sciences Research, 7*(1), 42-55.