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Investigating the Possible Added Value of Hydroponically Produced Lettuce over Soil Produce

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Abstract: Hydroponic is a subset of hydroculture; a plant growing method without soil using mineral nutrient solutions, with advantages including saving water, better growth rate, weeds-free environment, fewer pests and diseases. Lettuce is a vegetable crop that can be grown in hydroponic system. This research investigated the possible added value of hydroponic compared to conventional culturing on lettuce production. The experimental design was randomized blocks with two treatments and triplicates. Hydroponic culture improved lettuce fresh weight, roots' length, leaves number and leaf area, while soil culture produced lettuce with higher dry biomass leaves and root systems. The levels of vitamin C, total phenolic compounds and chlorophyll in hydroponically produced lettuce were 7, 42 and 270 mg/100g leaf fresh weight, respectively, while these were 12, 55 and 350 mg/g leaf fresh in conventionally produced lettuce, respectively. Hydroponic system shortened the time needed to reach the harvesting stage, produced best vegetative growth with higher fresh weight of whole plant, leaf and root, longer roots with higher leaves number and larger leaves area and no pests were observed.

Key words: *Lactuca sativa* · Water · Nutrient Solution · Nutritional Value

INTRODUCTION

Conventional agriculture is the practice of growing crops in soil, in the open air, under irrigation and active application of nutrients, pesticides and herbicides, while hydroponic is a method of growing plants without soil using mineral nutrient solutions [1, 2]. Operating such systems requires greater professional skills and continuous monitoring and attention is also required.

Hydroponics is a technology in which different vegetable crops are cultivated in nutrient solution with or without the presence of an artificial medium (among others are washed sand, gravel, vermiculite, coconut fiber, carbonized rice husk, sawdust, etc.) that will serve as mechanical support for root development [3]. Hydroponic culture has the following advantages: saving water, better crop growth rate, weeds free environment, fewer pests and diseases, less use of pesticides, minimal pollution, investment of small areas, possibility of being established even in large cities, possibility of using areas unsuitable for conventional farming, such as arid and degraded soils, shortening of the plant cycle and showing fast economic return, optimal water-and nutrient-use efficiency and reducing overall production costs [4, 5]. On the other hand, there are some disadvantages such as, the high installation cost, the need for continuous monitoring, especially the supply of electrical power and control of nutrient solution [6].

Lettuce (*Lactuca sativa* L.) is a cool-weather crop and its growing in hot climates needs special care. Lettuce is well-grown on sandy-loam soil high in organic matter. Field-grown lettuce requires good drainage to avoid certain fungal diseases such as bottom rot. In addition, lettuce is thriving when the average

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daily temperature is between 15 and 21°C. It should be planted in early spring or late summer because at high temperatures, growth is stunted, leaves may be bitter and the seed stalk forms and elongates rapidly. However, since some types and varieties of lettuce withstand heat better than others, lettuce became an all-year grown food crop [7, 8]. Lettuce planting in Jordan is relatively easy-to-grow crop, it grows throughout the year and represents about 3.5 % of the total area of cultivated crops in Jordan. Lettuce takes about 40-60 days from planting to harvest depending on weather conditions and variety [9]. Lettuce is primarily intended for the domestic market, while Chinese lettuce is primarily intended for export to the Saudi and Gulf markets [10].

According to researchers [11,12], two systems could be used to grow Lettuce hydroponically: Vertical Farming Systems (VFS) and Horizontal Farming System (HHS). In hydroponic the growth depends upon the composition of nutrient solution [13]. Lettuce treated with modified Hoagland inorganic nutrient solution had increased leaf number, plant height, fresh weight and dry weight compared to those produced under conventional (soil planting) system [14]. In another conducted experiment; hydroponically produced lettuce have higher number of leaves, plant height, plant fresh and dry weight, root fresh and dry weight, root length and yield in compare to soil produced lettuce, on the other hand, higher chlorophyll, total phenols and carotenoids content were observed in the soil produced lettuce compared to hydroponically produce [15].

The higher yields of greenhouse hydroponics result from the controlled environmental conditions, which allow for continuous production year-round. These conditions also promote a reduction in the number of days required for each harvest cycle, allowing for multiple crops per year [16]. The volume of water consumed per plant in a hydroponic system is not different from that grown using conventional methods; however, the hydroponic system delivers the water more efficiently [17].

This research work aimed to make a comparison between lettuce grown under hydroponic and soil systems in terms of vegetative growth as well as chemical composition and quality of the produced leaves. Lettuce (Iceberg type) was used for its nutritional and economic importance in Jordan.

MATERIALS AND METHODS

The experiment was carried out at Al-Balqa Applied University. Two systems were prepared indoors (inside the green house) to allow more control of environmental conditions; the first system was the conventional system (soil planting); in which raised beds were prepared and covered with black plastic much to reduce evaporation and prevent weed growth. Lettuce seedlings (Iceberg type) were planted in holes made in the mulch near the drippers of a drip irrigation system, then irrigation and fertilization were applied according to programs considered by farmers.

The second system is the hydroponic system, which was applied inside a greenhouse where three basins were prepared and covered with white plastic mulch to reduce water loss. Each basin was filled with 400 L of tap water, so that the height of water to 20 cm.

Preparation of Nutrient Solutions: Lettuce was cultured using the modified Hoagland nutrient solution [14], in which; three solutions of 10 L each were prepared and named as A, B and C; the first solution (A) was prepared by dissolving 3.65 kg of Calcium Nitrate and 10 gm of Iron (6 % Fe as EDDHA) in 10 L of tap water. The second solution (B) is prepared by dissolving 3.325 kg of NPK (12:12:36) (NPK or N: P_2O_5: K_2O) and 0.4 kg of Magnesium Sulfate in 10 L of tap water. The third solution (C) was prepared by dissolving 1 L of Nitric Acid (85 % concentration) in 9 L of tap water.

Preparing the Growing Media: After the preparation of solutions, 1:1 A:B solutions were added to each water filled basin until the EC reached about 1.5-2 dS/m, after that the solution C was added to adjust the pH of the basin nutrient medium to around 5.7.

Each basin was received 800 ml from A-solution, 800 ml from B-solution and 1200 ml from C-solution.

Hydroponic Planting: Small holes, 25 cm apart, were made in a polyester plate, which were installed above the nutrient solutions in the basins. Small plastic pots; perforated at the bottom, were filled with 1:1 (Peatmoss: Perlite). Lettuce seedlings were then transplanted into the plastic pots fixed inside the polyester holes.

Experimental Design: A randomized complete block design (RCBD), with two treatments (systems) and three replicates per treatment was employed. All data obtained were statistically analysed by ANOVA [18]. The mean separation of the different treatments was compared by the Least Significant Difference (LSD) test using SAS and differences with probability level at p = 0.05 were considered significant.

Parameters Measured

Vegetative Growth Parameters: At the end of the experiment; eight lettuce plants were harvested in each replicate and used to determine the vegetative growth parameters as follows: number of leaves per plant, average leaf area (Outer leaves were collected from each plant and their area was measured using a Portable Area Meter and the average leaf area was calculated).

Average root length (for each harvested plant; all of the roots were removed, its length was determined by ruler, then average readings were considered per plant), fresh and dry weight (biomass, leaves and roots) of lettuce plants produced under both planting systems. Fresh weight was determined by a digital scale balance and the average reading was considered. In addition, the same harvested plants were used to determine the dry weight. Drying was carried out in an oven at 60°C, then the percentage of the dry weight was considered for each parameter. Also, leaf moisture content percentage, in addition to root per canopy percentage for the fresh and dry weights were calculated [19, 20].

Determination of Plant Compounds Content: At the end of the experiment, different leaf samples, mature and young leaves, were taken for the analyses. Three leaf samples were taken per replicate and used to determine certain compounds and then average values for each parameter and replicate were considered. Total phenolic compounds were measured using the Folin-Ciocalteu assay and results were expressed as mg gallic acid equivalent (GAE) per 100 g fresh weight, ascorbic acid (vitamin C) was measured by classical titration method using 0.2 % of 2, 6-dichlorophenyl indophenol solution (DCPIP), which was expressed as mg ascorbic acid/100 g fresh weight and chlorophyll contents were determined by a spectrophotometer [21, 22].

RESULTS AND DISCUSSION

Vegetative Growth: Results showed that all of the fresh weight parameters (whole plant and single leaf) were significantly higher in hydroponically produced lettuce in comparison with soil produced lettuce (Table 1), which can be attributed to the continuous availability of water in the hydroponic system and lack of any water stress conditions. However, lettuce grown on soil had significantly higher dry weight (whole plant and single leaf) compared to the hydroponically produced lettuce due to the differences in the water potential and the magnitude of the different components of the water potential between soil and hydroponically grown plants, which might affect the water uptake.

The effect of planting systems on lettuce root showed that root fresh weight was higher in hydroponically produced lettuce in comparison with soil produced lettuce (Table 2), but without significant differences. The high availability of water in the hydroponic system may be the main reason for that. On the other hand, root dry weight showed a significant difference between the applied two systems and hydroponic system produced the highest root dry weight per plant, which might indicate that photosynthates translocation from leaves to roots, was enhanced under hydroponic system.

The root/canopy ratio is another factor that provides evidence that hydroponic culture improved the quality of lettuce plants in terms of significantly lower root/canopy ratio on fresh weight basis, which is fundamental for freshly eaten leafy green vegetables such as lettuce (Table 2). Our findings are in agreement with other researchers [23].

The effect of planting systems on lettuce root length, number of leaves and leaf area showed that longer roots with higher number of leaves and larger leaf area were obtained in hydroponically produced lettuce compared to soil produced lettuce treatment (Table 3).

Lack of mechanical impedance in the hydroponic system enhanced root growth. Moreover, in the hydroponic system, all nutrients were dissolved and directly found in the solution under proper EC and pH conditions, which might enhance plant growth in terms of root length, leaf number and leaf area as shown in Table 3. In soil grown lettuce, the situation is complex due to the expected interaction between the liquid phase and the solid phase; i.e. ion exchange and adsorption reactions, precipitation reactions, surface and pore diffusion of certain ions, etc., which can adversely affect the availability of nutrients and, thus, plant growth.

Most of the current results are in agreement with those reported earlier by other researchers [14, 15], who found that all of the measured vegetative parameters were higher in the hydroponically produced lettuce compared to conventionally produced lettuce taking into account possible differences in the properties of soil used in these experiments.

Nutritional Composition: The effect of the planting systems on lettuce nutritional contents; vitamin C, total phenolic compounds and chlorophyll content, which were measured and calculated on fresh weight basis, indicated that vitamin C, total phenols and chlorophyll content in hydroponically produced lettuce were significantly lower compared to those in conventionally produced lettuce (Table 4).

Table 1: Effect of planting systems on lettuce plant fresh weight, dry weigh and leaf moisture content*

Planting systems	Whole plant fresh weight (g/plant)	Whole plant dry weight (g/plant)	Leaf fresh weight (g/leaf)	Leaf dry weight (g/leaf)	Leaf moisture content (%)
Soil culture	221 b**	89.3 a	16.7 b	8.2 a	51.0 b
Hydroponic culture	369 a	117.2 b	18.5 a	6.8 b	63.2 a
LSD $_{0.05}$	25.3	1.8	2.1	0.9	1.8

*Values are the mean of three replicates.

**Means within each column having different letters are significantly different according to LSD at 5 % level.

Table 2: Effect of planting systems on Lettuce root fresh and dry weight and root per shoot fresh and dry weight*

Planting systems	Root fresh weight (g/plant)	Root dry weight (g/plant)	Root/canopy ratio on fresh weight basis	Root/canopy ratio on dry weight basis
Soil culture	44.8 a**	7.5 b	34.0 a	9.20 a
Hydroponic culture	48.2 a	9.8 a	19.1 b	9.12 a
LSD $_{0.05}$	7.3	2.1	6.8	3.1

*Values are the mean of three replicates.

**Means within each column having different letters are significantly different according to LSD at 5 % level.

Table 3: Effect of planting systems on Lettuce root length, number of leaves and leaf area*

Planting systems	Root length	No. of leaves /plant	Leaf area (cm^2)
Soil culture	14.4 b**	13 b	252 b
Hydroponic culture	26.3 a	20 a	310 a
LSD $_{0.05}$	6.5	3.5	36.8

*Values are the mean of three replicates.

**Means within each column having different letters are significantly different according to LSD at 5 % level.

Table 4: Effect of planting systems on lettuce plants nutritional contents*:

Planting systems	Vit. C (mg/100 g leaf fresh wt.)	Total Phenolic compounds (mg/100 g leaf fresh wt.)	Chlorophyll (mg/100 g leaf fresh wt.)
Soil culture	12 a**	55 a	350 a
Hydroponic culture	7 b	42 b	270 b
LSD $_{0.05}$	2.5	6.5	62

*Values are the mean of three replicates.

**Means within each column having different letters are significantly different according to LSD at 5 % level.

The low levels could be attributed to the dilution effect of the higher moisture content in leaves of hydroponically grown lettuce (Table 1). Also, the leaf area, which was significantly higher in hydroponically produced lettuce in comparison to that grown conventionally (Table 2) could contribute to the lower value of these nutrients. A large number of studies have been performed on the factors affecting the plant content of vitamin C. Most of the studies agreed that environmental factors, such as light intensity, heat, oxygen and light may significantly cause a reduction in the content of vitamin C [24]. In our study, hydroponically produced lettuce showed a significantly higher leaf area compared to the conventionally produced lettuce, which means that the hydroponically produced lettuce is exposed to higher amount of light, which in turn decrease their vitamin C content.

The levels of vitamin C reported in our study was close to previous findings [25], were they found that lettuce *Levistro* contained 9.60 mg/100g fresh weight and that in lettuce *Kibou*, vitamin C was 5.25 mg/100g fresh weight. Also, in another study, the levels of vitamin C in lettuce (*Lactuca sativa*) was around 12mg/100 g fresh weight [26]. While [27] found that the levels of vitamin C in Iceberg lettuce was around 4.2 mg/100 g fresh weight.

Vitamin C is an important micronutrient to the human body; it is an essential anti-oxidant and needed for the absorption of some nutrients as well as strengthening the immune system [24]. Due to the inability of the human body to synthesize vitamin C, it is important to supply vitamin C by diet [24,28]. The daily recommended level of vitamin C is 75 and 90 mg/day for females and males; respectively [28]. In our study, the hydroponically produced lettuce gives 7 mg/100 g leaf fresh weight, which is half the amount given by conventionally produced lettuce, meaning that lettuce alone does not cover vitamin C requirement, however, for the relative dietary contributions of a given food, it is not only the nutrient concentrations that matter, but also the level of food consumption that are essential. Therefore, a serving of lettuce can provide about 23 % of the recommended daily vitamin C intake.

On the other hand, it has been reported that the main compounds in Iceberg lettuce were phenolic acids, with a percentage of 94 % [27]. In our study, the level of phenols was significantly higher than that of vitamin C (Table 4). The level of phenols reported by our study was 42 mg/100 g fresh weight, which was higher than that reported earlier [27]; that was around 18 mg/100 fresh weight of Iceberg lettuce.

Polyphenols have been *described* to have stronger antioxidant activity than vitamins C [29]. As both vitamin C and phenols are important anti-oxidants and play an essential role in the anti-oxidant potential of the plant, the results of our study that the level of phenols was significantly higher than that of vitamin C, indicate that polyphenol support vitamin C to improve the anti-oxidant potential of the lettuce.

Generally, the anti-oxidant potential of lettuce can be affected by stress conditions including water shortage, which can increase the total amount of phenolic compounds [30,31]. However, in our study the level of phenols in lettuce produced hydroponically was potentially higher that in soil produced lettuce (Table 4).

Since lettuce is one of the green leafy vegetables, the rate of the photosynthesis is considered relatively high. An important component required for the photosynthesis is chlorophyll. Chlorophyll is the primary pigment of leafy green vegetables and has an important role in assessing the vegetable health status [32, 33]. Content of chlorophyll varied ranging from 76.06 to 446.18 mg/ m^{-2} depending on leaf color [32]. In our study, chlorophyll content in hydroponically produced lettuce was significantly higher than that in lettuce produced conventionally (Table 4). Based on our findings, the type of lettuce culturing whether conventionally or hydroponically did not induce difference in the nutritional value of lettuce, represented by the amount of vitamin C, phenols and chlorophyll. However, because hydroponically produced lettuce has significantly higher number of leaves per plant, which means high amount of dietary fiber, we highly recommend the use of hydroponic type of culturing since it produces lettuce with more beneficial health effect.

CONCLUSIONS

Hydroponic culture produced best vegetative growth with higher fresh weight of whole plant, leaf and root, longer roots with larger area and number of leaves. It also shortened the time needed to reach harvesting stage with no pests appeared, meaning no need for pesticide applications. However, it did not add any nutritional value. Soil culture produced lettuce with higher dry matter of whole plant, leaf and root systems.

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REFERENCES

1. Anderson, T.S., M.R. Martini, D. De Villiers and M.B. Timmons, 2017. Growth and Tissue Elemental Composition Response of Butterhead Lettuce (*Lactuca sativa*, cv. Flandria) to Hydroponic Conditions at Different pH and Alkalinity. Horticulturae, 3(41): 1-15.
2. Hasan, S.Z., 2007. Tomato Production through Utilization of Hydroponic Technology. Technical Report. Available at: https://www.researchgate.net/publication/307967772_TOMATO_PRODUCTION_THROUGH_UTILIZATION_OF_HYDROPONIC_TECHNOLOGY
3. Filho, A.F., C.A. Azevedo, M. Azevedo, J.D. Fernande, C.R. Silva and P.D. Fernandes, 2018. Monitoring, Calibration and Maintenance of Optimized Nutrient Solutions in Curly Lettuce (*Lactuca sativa*, L.) Hydroponic Cultivation. Australian Journal of Crop Science, 12(04): 572-582
4. Teixeira, N.T., 1996. Hidroponia: uma alternativa para pequenas áreas. Agropecuária, Guaíba.
5. Takeshima, H. and T.H. Joshi, 2019. Protected Agriculture, Precision Agriculture and Vertical Farming: Brief Reviews of Issues in the Literature Focusing on the Developing Region in Asia. Report number: IFPRI Discussion Paper 01814. Affiliation: International Food Policy Research Institute.
6. Faquin, V., A.E. Furtini Neto and L.A.A. Vilela, 1996. Produção de Alface em Hidroponia. UFLA, Lavras.
7. Kuepper, G., J. Bachmann and R. Thomas, 2002. Specialty Lettuce and Greens: Organic Production. NCAT Agriculture Specialists.
8. Tahboub, A.B., T.R. Abu-Zahra and A.A. Al-Abbadi, 2010. Chemical Composition of Lettuce (*Lactuca sativa*) Grown in Soils Amended with Different Sources of Animal Manure to Stimulate Organic Farming Conditions. Journal of Food, Agriculture & Environment, 8(3&4): 736-740.

9. FAO, 2016. Lettuce and Chicory World Production. (Accessed 03 July 2018). http://www.fao.org/faostat/en/#data/QC.
10. Ministry of Agriculture, 2018. Annual report, Amman, Jordan. (In Arabic), pp: 121-127.
11. Calabria, J.L., P.N. Lens and D.H. Yeh, 2019. Zeolite Ion Exchange to Facilitate Anaerobic Membrane Bioreactor Wastewater Nitrogen Recovery and Reuse for Lettuce Fertigation in Vertical Hydroponic Systems. Environmental Engineering Science, 36(6): 690-698.
12. Touliatos, D., I.C. Dodd and I.C. McAinsh, 2016. Vertical Farming Increases Lettuce Yield Per Unit Area Compared to Conventional Horizontal Hydroponics. Food and Energy security, Association of Applied Biologists.
13. Domingues, D.S., H.W. Takahashi, C.A. Camara and S. Nixdorf, 2012. Automated System Developed to Control pH and Concentration of Nutrient Solution Evaluated in Hydroponic Lettuce Production. Computers and Electronics in Agriculture, 84: 53-61.
14. Peng, Y., G. Yan-Zhi and Q. Ling, 2018. Effects of Ozone-Treated Domestic Sludge on Hydroponic Lettuce Growth and Nutrition. Journal of Integrative Agriculture, 17(3): 593-602.
15. El-Helaly, M.A. and O.S. Darwish, 2019. Effect of Culture System; Aerponic, Hydroponic and Sandy Substrate on Growth, Yield and Chemical Compositions of Lettuce. Plant Archives, 19(2): 2543-2550.
16. Barbosa, G.L., F.D. Gadelha, N. Kublik, A. Proctor, L. Reichelm, E. Weissinger, G.M. Wohlleb and R.U. Halden, 2015. Comparison of Land, Water and Energy Requirements of Lettuce Grown Using Hydroponic vs. Conventional Agricultural Methods. International Journal of Environmental Research and Public Health, 12: 6879-6891.
17. Zhou, W.L., W.K. Liu and Q.C. Yang, 2012. Quality changes in hydroponic lettuce grown under pre-harvest short-duration continuous light of different intensities. J. Hortic. Sci. Biotechnol., 87: 429-434.
18. Steel, R.G.D. and J.H. Torrie, 1980. Principles and Procedures of Statistics, McGraw-Hill, New York.
19. Abu-Baker, S.M., T.R. Abu-Zahra, Y.A. Alzu`bi, T. Ammari and A.B. Tahboub, 2010. Nitrate Accumulation in Spinach (*Spinacia oleracea* L.) Tissues under Different Fertilization Regimes. Journal of Food, Agriculture & Environment, 8(2): 778-780.
20. Al-Shadiadeh, A.N., F.M. AL-Mohammady and T.R. Abu-Zahra, 2012. Factors Influencing Adoption of Protected Tomato Farming Practices Among Farmers in Jordan Valley. World Applied Sciences Journal, 17(5): 572-578.
21. Abu-Zahra, T.R. and A.A. Tahboub, 2009. Strawberry (*Fragaria* X Ananassa Duch) Fruit Quality Grown Under Different Organic Matter Sources in a Plastichouse at Humrat Al-Sahen. Acta Horticultura, 807: 353-358.
22. Jaikishun, S., A. Hoosein and A.A. Ansari, 2018. Short Communication: The Effects of Vermicompost and Vermiwash from the Medicinal Plants, Neem (*Azadirachta indica*) and Lime (*Citrus aurantifolia*), on the Growth Parameters of Lettuce in a Hydroponic System. Nusantara Bioscience, 10(2): 91-95.
23. Li, Q., X. Li, B. Tang and M. Gu, 2018. Growth Responses and Root Characteristics of Lettuce Grown in Aeroponics, Hydroponics and Substrate Culture. Horticulturae, 4(35): 1-9.
24. Combs, G., 2008. "The vitamins: fundamental aspects in nutrition and health / Gerald F. Combs." SERBIULA (sistema Librum 2.0).
25. Djoković, A., G.R. Pavlović, J. Mladenović and M. Djurić, 2011. "Vitamin C content of different types of lettuce varieties." Acta Agriculturae Serbica, 17: 83-89.
26. Cintya, H.J., E. Silalahi, P. De Lux and R. Siburian, 2018. "The Influence of Fertilizer on Nitrate, Nitrite and Vitamin C Contents in Vegetables." Oriental Journal of Chemistry, 34: 2614-2621.
27. Llorach, R., A.S. Martínez, F.A. Tomás, M. Barberán, I. Gil and F. Ferreres, 2008. Characterisation of polyphenols and antioxidant properties of five lettuce varieties and escarole. Food Chemistry, 108(3): 1028-1038.
28. Rolfes, S.R., K. Pinna and E.N. Whitney, 2018. Understanding normal & clinical nutrition. Standalone Book, 15th edition.
29. Rice-Evans, C., N. Miller and G. Paganga, 1997. "Antioxidant properties of phenolic compounds." Trends in Plant Science, 2(4): 152-159.
30. Oh, M.M., E.E. Carey and C.B. Rajashekar, 2010. "Regulated Water Deficits Improve Phytochemical Concentration in Lettuce." Journal of the American Society for Horticultural Science J. Amer. Soc. Hort. Sci., 135(3): 223.

31. Malejane, D.N., P. Tinyani, P. Soundy, Y. Sultanbawa and D. Sivakumar, 2017. "Deficit irrigation improves phenolic content and antioxidant activity in leafy lettuce varieties." Food Science & Nutrition, 6(2): 334-341.
32. Lu, F., Z. Bu and S. Lu, 2019. "Estimating Chlorophyll Content of Leafy Green Vegetables from Adaxial and Abaxial Reflectance." Sensors (Basel), 19(19).
33. Abu-Zahra, T.R., 2012. Vegetative, Flowering and Yield of Sweet Pepper as Influenced by Agricultural Practices. Middle-East Journal of Scientific Research, 11(9): 1220-1225.