*Plant Archives* Vol. 20, Supplement 2, 2020 pp. 301-305 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

# RESPONSE OF BELL PEPPER GROWTH AND YIELD OF "CALIFORNIA WONDER" VARIETY TO VARIOUS MEDIA AND PLANTING CONTAINER DIAMETERS UNDER PLASTIC HOUSE CONDITIONS

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## Abstract

An experiment was carried out in the plastic house that belongs to one of the private sector farms in Kufa district-Najaf province-Iraq in 2017 and 2018 to evaluate the growth and yield indicators of bell pepper *Capsicum annum* L. var. "California Wonder". The experiment comprised five types of planting media, containing a mixture of sandy soil and peatmoss with a volumetric ratio of 1:2 for the control and the same mixture with each type of manure (cow, sheep, chicken, and broad bean) with a ratio 1:2:1 respectively. Also, two planting container diameters (4 and 6 cm) were used. All treatments were triplicated according to split plot experiment as randomized complete block design. The findings revealed that the vegetative and root growth parameters of seedlings, fruit weight, early and total yield increased significantly due to the use of the two media (sandy soil + peatmoss + chicken manure) and (sandy soil + peatmoss + sheep manure) within a container of 6 cm diameter. Moreover, the interaction between planting media and container size wassignificant for all studied characteristics except for the fruit dry matter percent.

***Keywords*:** *Capsicum annuum* L., Pepper, Organic Fertilizer, Manure, Container size.

## Introduction

Bell pepper plant *Capsicum annuum* L., belongs to the Solanaceae family, and is acrucial crop among the vegetable crops worldwide including Iraq. Pepper fruits can beusedas fresh vegetables, pickles, spices, canning foods, and medicinal uses (Bosland and Votava, 2000). Pepper fruits have important nutritional value and phytochemical source necessary for human dietsuch ascarbohydrates, proteins and fats (Taheri-Garavand *et al.*, 2011), in addition to significant source of A and C vitamins and phenolic compounds plus minerals like iron, calcium and phosphorous (Lee *et al.*, 2005). Several studies have confirmed the need to use vigorous seedlings to ensure high productivity, this can improve the quality of seedlings through the use of the appropriate planting medium and provide soil size required for root growth by selecting the appropriate planting pot diameter (Havlin *et al.*, 2015). Recent trends have employed to use different media for producing seedlings under plastic house conditions. Moreover, quality of planting media varies among countries based on the availability of raw material manufacturing, media components and their costs. Usually, organic fertilizers are involved in agricultural practices due to containing organic matter and humic acid that both improve soil structure (Dauda *et al.*, 2008) as a result of humates and fulvates, and help in reducing bulk density, increasing ion exchange capacity, preserving moisture, improving planting media pH and temperature (Mitchell *et al.*, 2006; Evanylo *et al.*, 2008) **.**Nevertheless, animal manure plays a crucial key in improving soil fertility, particularly in regions that organic fertilizers are unavailable or inaccessible to farming community (Malomo, *et al.*, 2018). Frequently, most farmers have used fresh animal fertilizers without fermentation for economic and technical reasons, which may cause the burning plants, spreading weeds (Abou-Hadid, 2003). Contrarily, other researchers indicated the potential benefit of fermentation of animal manure in obtaining a dry matter, stable, homogeneous compounds that are easy to store and use as a fertilizer (Plaster, 1997). Further, aerobic composting could be powerful in removing or killing some pathogens growing in manurein comparison to non-composted manure (Malomo *et al.*, 2018). Preparing suitable seedbed is one of the important and detrimental factors for seedling growth (Abu Rayyan, 2010) as applied for pepper plants which have a dense root system. Therefore, seeds can be planted in a container made locally from thick paper suited to establish the root system. These pots or containers allow appropriate growth of roots by controlling the container diameter and thus determining the size and amount of soil suitable for seedling growth, as well as these containers can reduce root system damage due to transplant shock. Organic manure of poultry and sheep solution realized significantly the highest rates of vegetative growth and fruit yield parameters of eggplant "Barcelona hybrid" in comparison with other treatments (Kadhum, *et al.*, 2013). Also, three types of planting media tested on a single seedling of Anaheim chili, containing loam soil, coarse sand, and sheep manure in a ratio of 1:1:1, 1:1:2, and 1:1:3, respectively. He founded that the vegetative characteristics of seedling, the number of fruits, and the total yield significantly increased when using 1: 1: 1 (Kadhum, 2008). Further, the highest growth rates and yield parameters of bell pepper plants realized by chicken manure treatment (60 t/ha) then followed by cattle manure treatment compared to the control (Kunene *et al.*, 2019).

Given the importance of planting seedlings of the pepper crop with cultivation management using organic amendments that are not available in large quantities in most countries, this study aimed to identify the most appropriate planting medium for the growth and yield of bell pepper seedlings as well as determining the appropriate container size of potential root growth. Farmers may utilize manure treatments as substitute ways in order to avoid excessive chemical fertilizer application, and improve soil health and characteristics using organic fertilizers as reported in literature.

## Materials and Methods

### Plant material and experiment site

The experiment was carried out in the plastic house belonging to a farm of the private sector located in Kufa district, 14 km northeast of Najaf province-Iraq. Seeds of bell pepper, *Capsicum annuum* L.var. "California Wonder" were obtained from Modesto Seed Co., Inc., California, USA. California Wonder variety is considered a medium-sized, vigorous-growing, attractive form, uniformity, very thick, firm flesh, and high yield (Matloub *et al.*, 1989). The seeds were planted on 25/8/2017 using containers, made locally from thick cardboard, with two diameters (4 and 6cm)designated as D1 and D2 respectively, then the containers setup in the lath house adjacent to the plastic house in the same location aforementioned. The reason behind using a cardboard container was to maintain the water-absorbing capacity of the transplanted root system, namely no transplant shock (Roberts *et al.*, 2017) leading to early flowering and maturity during the planting season (Thakur *et al.*, 2017).

### Manure preparation

Animal wastes were collected from the field belongs to the Faculty of Agriculture-University of Kufa, while the broad bean residues were provided from a private sector field in Kufa district. Each type of organic wastes was compacted by 15 cm thickness and set on the polyethylene layer for ten days to be dried, then ground, well mixed, and kept with 60% moisture for decomposition. Next, all organic wastes, 15 cm thickness of each, were placed separately in trough with dimension (2 x 2 x 1.5 m) lined with two layers of polyethylene, then each waste type moistened with water to perform air composting on 25/3/2017. Also, urea, single superphosphate, and calcium carbonate fertilizers were added by rate (1:2:1 %) respectively of manure weight to activate the decomposition process. Further, a light layer of field soil in thickness (2 cm) was added over each layer of organic waste mixed with the fertilizers above mentioned, then the same procedure continued until reaching **(**1.5 m**)**of pile height. The pile was turned over twice a week to avoid temperature increasing. The animal manure decomposed after 3 months, while the decomposing of broad bean manure lasted 6 months (Radhi, 2010), then the complete decomposition verified via manure color when became brown without ammonia odor according to (IFOAM, 2000). Subsequently, some chemical properties of each type of organic manure after decomposition were measured (Table 1). These planting media contained a mixture of sandy soil and peatmoss with a volumetric ratio of 1:2 for the control represented by C0, and the same mixture with each type of manure (cow, sheep, chicken, and broad bean plant) with a ratio 1: 2: 1 represented by C1, C2, C3 and C4 consecutively.

### Experiment design

The current study included 10 treatments obtained by a combination of two diameters of planting container and five types of planting media. This experiment was carried out in split plot arrangement according to randomized complete block design (RCBD) with three replicates, where the container sizes were placed as main plots, while organic manure media with the control were designated as sub-plots.

### Transplanting

During the planting season, the plastic house soil, which is 56 m long and 9 m wide and total area of 504 $m^2$, was deeply ploughed twice, followed by superficial ploughing, then harrowing operations were performed. Each experimental unit included three planting lines with (2 m) length and (0.9 m) distance between lines. Then, seedlings were transplanted into holes of each line next to the irrigation sprinklers on 10/10/2017 with a distance (50 cm) between the seedlings.

The minimum temperature mean inside the plastic house was (12.2, 14.5, 17.8 and 21.9) °C, while the maximum temperature was (19.1, 22.4, 23.7 and 26.8) °C using thermometers installed inside the plastic house during December, January, February and March, respectively. All agricultural managements such as irrigation and pest control were achieved for all treatments as recommended.

### Data record and statistical analysis

After 40 days of seedlings, three plant samples were randomly selected from each experimental unit per replicate to estimate the vegetative indicators represented by plant height (cm), number of leaves, number of secondary roots and root size ($mm^3$). Also, at the end of the season, five plant samples were removed from each subplot in order to estimate the vegetative dry weight (g), average weight of the fruit (g), number of fruits per plant, first 5 harvests considered as early yield ($kg.m^{-2}$), and the total yield ($kg.m^{-2}$). Additionally, fruit samples were desiccated on June 1, 2018 using an electric oven at a degree heat (65 ° C) for 72 hours to calculate the percentage of fruit dry matter. Collected data were statistically analyzed and Duncan's multiple range test was determined for mean comparisons at the level of 5% (Al-Rawi and Khafullah, 2000) using SAS program (SAS Institute Inc., 2000).

**Table 1:** Some chemical properties of different types of organic manure used in the experiment.

| Parameter | Unit | Types of manure | | | |
|---|---|---|---|---|---|
| | | Cow | Sheep | Chicken | Broad Bean |
| EC (5:1 suspension) | $dS\ m^{-1}$ | 1.71 | 1.45 | 1.65 | 2.26 |
| pH | - | 6.53 | 6.80 | 6.28 | 7.22 |
| Total Carbon | $g.kg^{-1}$ | 300 | 330 | 255 | 350 |
| Total Nitrogen | $g.kg^{-1}$ | 28.0 | 27.3 | 30.9 | 16.5 |
| C/N ratio | - | 10.7 | 12.2 | 9.5 | 21.4 |
| Total P2O5 | $g.kg^{-1}$ | 8.7 | 10.3 | 14.2 | 7.9 |
| Total K2O | $g.kg^{-1}$ | 21.4 | 27.1 | 23.4 | 17.5 |

## Results and Discussion

Table 2 indicates that the mean of vegetative and root growth parameters represented by plant height, number of leaves per plant, number of secondary roots, size of roots, and dry weight of vegetative growth, increased significantly by (70.23 cm, 39.25 leaves, 80.11 roots, 32.95 $mm^3$, and 86.03 g) respectively when planting in the medium (sandy soil and peatmoss with chicken manure, denoted by C3). This growth increment may be due to the effect of chicken manure fertilizer that contains a good amount of macro nutrients e.g. NPK (Table 1) as a result of the decomposition of organic matter via microorganisms. This interpretation was reported by (Al-Sayed, 2006), that the element deficiency rarely appears when using chicken manure, which has a high ion exchange capacity and ability to retain moisture as well as improve soil physical and biological characteristics. Additionally, essential nutrients that present in chicken manure play a great role for photosynthetic activities and thus can boost roots and vegetative growths (John *et al.*, 2004).

In addition, the results in (Table 2) show that the vegetative and root growth indicators have increased when planting within a 6 cm diameter container, and this may be due to the formation of a potential root system and thereby increasing the efficiency of root absorption for nutrients as confirmed by (Al-Shtiwi, 2000). Further, the findings in the same table indicate that the interaction between container sizeand planting media has significantly influenced the studied traits where the treatment (6 cm diameter container x sandy soil and peatmoss with chicken manure, denoted by D2C3) gave the highest mean for plant height 77.06 cm, 43.22 leaf/plant, 97.13 root/plant, root size 43.69 $mm^3$, and vegetative dry weight 88.43 g. In contrast, the interaction treatment (4 cm diameter container x sandy soil and peatmoss only, denoted by D1C0) resulted the lowest mean forplant height 59.69 cm, 32.58 leaf/plant, 64.56 root/plant, root size 30.23$mm^3$, and vegetative dry weight 74.86 g.

**Table 2:** Influence of the media composition and seed container diameter on some vegetative and root growth indicators of bell pepper.

| Treatments | | Plant Height (cm) | Leaf Number | Secondary root Number | Root Size ($mm^3$) | Vegetative Dry Weight (g) |
|---|---|---|---|---|---|---|
| | | Effect of media composition | | | | |
| C0 | | 58.30d | 26.78c | 63.43b | 28.10b | 75.72d |
| C1 | | 67.10b | 38.70a | 78.56a | 29.55b | 81.33b |
| C2 | | 68.50b | 38.91a | 78.77a | 31.39ab | 81.52b |
| C3 | | 70.23a | 39.25a | 80.11a | 32.95a | 86.03a |
| C4 | | 64.36c | 32.84b | 71.09ab | 29.03b | 77.48c |
| | | Effect of container diameter | | | | |
| D1 | | 57.30b | 35.28b | 59.84a | 29.45b | 79.85b |
| D2 | | 65.45a | 39.46a | 65.16a | 31.87a | 84.19a |
| | | Effect of the interaction | | | | |
| D1 | C0 | 59.96 d | 32.58b | 64.56c | 30.23c | 74.86c |
| | C1 | 68.43b | 37.76ab | 81.19ab | 31.71b | 77.12b |
| | C2 | 69.48b | 39.61a | 84.90ab | 32.65bc | 76.89b |
| | C3 | 71.95b | 40.83a | 86.08a | 32.98ab | 83.25ab |
| | C4 | 65.10c | 34.94b | 78.75b | 31.07bc | 75.66b |
| D2 | C0 | 62.70d | 33.92b | 74.39b | 31.67b | 79.13b |
| | C1 | 70.64b | 38.53ab | 89.67a | 33.51ab | 80.25b |
| | C2 | 75.36a | 41.28a | 96.05a | 33.25a | 84.96a |
| | C3 | 77.06a | 43.22a | 97.13a | 34.69a | 88.43a |
| | C4 | 66.13c | 35.20b | 78.50b | 31.59bc | 78.91b |

Same letters are not significantly different based on Duncan Multiple Range test at 5% probability.

The results related of fruit yield parameters (Table 3) indicated that the mean of yield indicators revealed significant variations among the media types as well as the two container diameters except for the fruit dry matter percent was not significant for both main and interaction effects. The planting medium (sandy soil and peatmoss with chicken manure, denoted by C3) gave the highest mean of, number of fruits, early yield, and total yield by (18.33 fruit/plant, 0.90 $kg.m^{-2}$, and 2.71 $kg.m^{-2}$) respectively, these results are consistent with (Kadhum, 2008; Kunene, *et al.*, 2019). This could also be further explained that poultry manure enhanced soil microbial activity and increased effectiveness of absorbing water and macro and micro nutrients to the plants as compared to the other treatment (Snr, *et al.*, 2020). The maximum mean of fruit weight realized by the medium (sandy soil and peatmoss with sheep manure, denoted by C2) where gave 78.50g. It appears that the fruit yield indicators (Table 3) have increased significantly when planting within a 6 cm diameter container by (79.10 g, 19.25 fruit/plant, 1.97 $kg.m^{-2}$ and 3.04 $kg.m^{-2}$)for fruit weight, number of fruits, early yield, and total yield consecutively. This indicates an increase in efficiency of root absorption of nutrients by forming an appropriate root mass size, which could reflect the growth and development of pepper plants during the subsequent stages which led to an increase in the fruit yield components.

Additionally, there was a significant interaction effect between container size and planting media (Table 3)for the yield parameter means where the treatment (6 cm diameter container x sandy soil and peatmoss with chicken manure, denoted by D2C3) realized the highest mean by 80.52 g, 21.23 fruit/plant, 1.13 $kg.m^{-2}$, 3.41 $kg.m^{-2}$ for fruit weight, number of fruits, early yield, and total yield respectively. In

general, the treatment (6 cm diameter container x sandy soil and peatmoss with sheep manure, denoted by D2C2) was not significantly different from (D2C3) for fruit weight plus early and total yield .Regardless the container size, these results were similar with (Kadhum *et al.*, 2013).

**Table 3:** Influence of media composition and seed container diameter on some yield indicators of bell pepper plant.

| Treatments | | Fruit Dry Mater (%) | Fruit Weight (g) | Fruit No. per Plant | Early Yield ($kg.m^{-2}$) | Total Yield ($kg.m^{-2}$) |
|---|---|---|---|---|---|---|
| | | Effect of media composition | | | | |
| C0 | | 12.12a | 64.30d | 13.80c | 0.59b | 1.77c |
| C1 | | 12.14a | 75.10ab | 14.56c | 0.72ab | 2.18b |
| C2 | | 12.22a | 78.50a | 16.05b | 0.83a | 2.51a |
| C3 | | 12.31a | 74.00b | 18.33a | 0.90a | 2.71a |
| C4 | | 12.09a | 67.36c | 14.20c | 0.63b | 1.91b |
| | | Effect of container diameter | | | | |
| D1 | | 12.21a | 68.30b | 17.46b | 0.79b | 2.38b |
| D2 | | 12.29a | 79.10a | 19.25a | 1.97a | 3.04a |
| | | Effect of the interaction | | | | |
| D1 | C0 | 12.52a | 63.30d | 14.80c | 0.62c | 1.87c |
| | C1 | 12.89a | 74.10ab | 16.66b | 0.82b | 2.46b |
| | C2 | 12.91a | 73.00b | 16.98b | 0.82b | 2.47b |
| | C3 | 13.08a | 78.50a | 19.33a | 1.01a | 3.03a |
| | C4 | 12.56a | 66.36c | 15.40c | 0.68c | 2.04bc |
| D2 | C0 | 12.10a | 65.13.cd | 15.20c | 0.65c | 1.97bc |
| | C1 | 12.23a | 76.43a | 16.30c | 0.83ab | 2.49b |
| | C2 | 12.40a | 76.89a | 17.80b | 0.91a | 2.73ab |
| | C3 | 13.20a | 80.52a | 21.23a | 1.13a | 3.41a |
| | C4 | 12.04a | 67.02bc | 15.23c | 0.68c | 2.04c |

Same letters are not significantly different based on Duncan Multiple Range test at 5% probability.

## Conclusion

This study highlights the feasibility of improving the vegetative growth parameters of bell pepper seedlings and increase the fruit and yield traits throughout utilizing fermented animal fertilizer in general and chicken or sheep manure in particular. Besides, using a container size of 6 cm may enhance root characteristics of pepper seedlings for better absorption of water and nutrients. Moreover, it is noteworthy that cardboard containers could help mitigate seedlings from transplant shock to ensure sufficient water-absorbing capacity for rapid root establishment leading to early flowering and maturity during the planting season. It is suggested that further research be directed to set several container sizes with chicken and sheep manures to validate the recommendation.

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