Middle-East Journal of Scientific Research 11 (9): 1220-1225, 2012
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2012.11.09.1612

Vegetative, Flowering and Yield of Sweet Pepper as Influencedby Agricultural Practices

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Abstract: A greenhouse experiment was conducted during the season of 2010/2011; at a Station of Princess Tasneem Bent Ghazi for Technological Research in Humrat Al-Sahen; about 15 km from As Salt-Jordan, to compare the effect of four fermented organic matter sources (cattle, poultry and sheep manure in addition to 1:1:1 mixture of the three organic matter sources) in which 4 kg organic matter m^{-2} were used, with that of the conventional agriculture (chemical fertilizers) treatments on pepper cultivar Marvellogrowth and yield, by using a randomized complete block design (RCBD) with four replicates. Obtained results showed that chemical fertilizers increased plant growth (number of leaves/plant, leaf area and plant fresh weight). Otherwise a positive effect of the animal manure were observed on plant dry weight, root per canopy percentage and leaf chlorophyll content. Organic matter accelerated flowering date, while the conventional treatment delayed it. Conventional treatment influenced the total yield per replicate and extended the period of pepper fruit production compared to organic matter treatments.

Key words: *Capsicum annum* % Yield % Flowering % Fresh Weight % Chlorophyll % Manure

INTRODUCTION

Bell pepper (*Capsicum annum* L.), which belongs to the Solanacea family, is one of the most varied and widely used foods in the world; it was originated in the Mexico and Central America regions and Christopher Columbus encountered it in 1493 [1]. Its fruits are harvested and consumed at different maturity stages; green, red and not fully ripe 2.A phenolic compound called capsaicin is responsible for the pungency in peppers. Pepper is grown as an annual crop due to its sensitivity to frost; pepper is actually a herbaceous perennial and will survive and yield for several years in tropical climates [1-4].

Ever since people have become aware that health is linked to health environment, the control and reduction of pollution has become the focus of worldwide concern 4. Conventional and organic agricultural practices represent dynamic systems that can vary greatly depending upon region, soil quality, prevalence of pests, crop, climate and farm philosophiesand this makes comparisons very difficult [5].

Fruit weight was ranged from 128-210 gm depending upon c ultivars [6]. Number of fruits $plant^{-1}$ and fruit yield was significantly higher under integrated nutrient management (INM) compared with organic nutrient supply. The yield reduction in the latter was 22.1% in 2005 and 21.7% in 2006 compared with INM(7). Also, the comparison of different organic amendments and combined application of organic amendments, along with biofertilizers revealed that there was 25.1-45.9 % reduction in bell pepper yield compared with conventionally produced peppers also conventional treatment produced significantly higher number of fruits per plant than other organic treatments [8]. Addition of sheep manure increased bell pepper plant size, number of flowers and number of marketable fruits compared to the unamend soil [9]. Amending soils with composted materials has been reported to increase pepper yields [10]. However, combining compost and inorganic fertilizer has generally been more effective in producing a positive plant response than separate application of either material alone.

28 t ha^{-1} estimated level of cattle manure was responsible for maximum yield of fruits per plant (389 gm) and for commercial fruits (7.8 t ha^{-1}), while biofertilizer used in spray application, the levels of 14.5 and 14.0 t ha^{-1} of cattle manure, respectively, promoted maximum production of fruits per plant of 485 gm and maximum

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productivity of commercial fruits of 9.6 t ha^{-1}. The combination of cattle manure and biofertilizer in the leaves was the best organic fertilization form in the bell pepper, with additional of 1.8 and 1.3 t ha^{-1} in the productivity of commercial fruits, comparing with those obtained with cattle manure and biofertilizer used in the soil, respectively [11].

Manures had greatly affected the growth; the most significant impact was observed when cow manure was applied to soil, the lowest dry weight, height and leaf area index and soil organic matter were measured in the control treatment [12]. The use of bio-fertilizer speeds up plant growth by influencing the roots and stems growth rate and affects the formation of the foliage, increased content of photosynthetic pigments and also influences the yield [13].

Calcium application increased the marketable yield from 1.67 to 2.38 kg/plant, while higher K levels decreased marketable yield from 2.2 to 1.66 kg/plant, due to decreases in the number of fruits per plant and the mean fruit weight [14].

Application of mineral fertilizers combined with organic manure led to a decrease in pepper fruit productivity [15]. On the other hand; comprising of growing media having Soil: Farm Yard Manure: Sand (2:1:1), fertigation with water soluble fertilizers at the rate of 250 kg/ha NPK recorded highest plant height (102.60 cm), more number of flowers per plant (31.73), more number of fruit per plant (18.03), more fruit set (60.04%) and higher productivity (1.08 kg/plant and 8.64 kg/m^2) [16].

Lower availability of plant nutrients in plots applied with organic amendments is expected due to slower release rates of nutrients from organic materials particularly during initial years of conversion to organic production [8].

Pepper producers often use large amounts of agrochemicals in an attempt to improve and protect fruit quality and plant vigor. Also vegetable growers in Jordan routinely apply manure to their soil either alone or in combination with mineral fertilizers. However, there is limited research on the effects of these organic amendments on growth and yield of crops. This research was aimed to develop scientific data on bell pepper yield in response to the application of different agricultural practices; conventional and organic types.

MATERIALS AND METHODS

This study was conducted during the 2010/2011 season, under a plastichouse conditions at Station of Princess Tasneem Bent Ghazi for Technological Research in Humrat Al-Sahen; about 15 km from As Salt-Jordan. The climate in this region is rather hot and dry during summer, warm and rainy in winter.

Organic Matter Preparation and Soil Solarization: Three months prior to transplanting, three different organic matter sources (cattle, poultry and sheep manure) were fermented [17]. On the other hand during hot summer months (from August to October), soil solarization was done [18].

Treatments Applications: A plastichouse was installed over the solarized area, the conventional planting was done according to the system applied in the farm where the experiment was conducted and that included the use of fertilizers (50 kg ha^{-1} week^{-1} of 20 N - 20 P - 20 K as fertigation and 118 kg ha^{-1} of ammonium nitrate as side dressing) [19, 20] and chemicals for pest control. For organic culture planting; four fermented organic matter sources were used (cattle, poultry, sheep manure in addition to 1:1:1 mixture of the three organic matter sources), with amount of 4 kg m^{-2}. Marvello pepper cultivar was transplanted on 26th of October 2010 and experiment was finished by the 29th of May 2011.

Experimental Design and Statistical Analysis: Five treatments were conducted in a randomized complete block design with four replicates. All data obtained were statistically analyzed according to the design used in this experiment [21] and differences between treatment means were compared by using Least Significant Difference at 5 % significant level.

Parameters Measured: For measurements or analysis, the fruits were harvested at three time intervals during the experiment period; they were collected when green and fully grown, then at the end of the experiment average readings were considered.

Vegetative Growth

Number of Leaves per Plant: At the end of the experiment, ten pepper plants per replicate were randomly selected and their leaves counted, then the total number of leaves per plant was considered.

Leaf Area: Twenty leaves per replicate were collected at the end of May, 2011 and their area was measured using a Portable Area Meter (Patent Pending, LI-3000A, SR. No. 2516. LI-COR, U. S. A.) and the average leaf area was calculated.

Plant Fresh and Dry Weight: The average weight were considered for the ten freshly harvested plants per replicate and then dried in an oven at 60°C to a constant weight [22].

Root per Canopy Percentage: Root per canopy fresh weight percentage was considered for ten freshly harvested plants per replicate. Plants were removed from the beds, the roots washed with water, then separated from the crown of the plants using hand shears, weights were measured by digital scale balance for roots and canopies separately for each replicate and the root/ canopy fresh weight percentage was calculated.

Leaf Chlorophyll Content: At the end of the experiment, a representative sample of pepper leaves were collected per replicate, then the chlorophyll content were determined and expressed as Chlorophyll Concentration Index (CCI) [23].

Flowering: When plants began blooming, counting of the blooming plants started in each replicate every day, until 50 percent of the plants per replicate were in bloom, then the number of days from planting until blooming was recorded.

Yield Measurements

Total Yield: This parameter was measured directly in the field by weighing the total freshly harvested fruits per replicate, using a digital scale balance. At the end of the experiment, all weights for each replicate were summed.

Total Number of Fruits: It was considered at the end of the experiment by counting all the harvested fruits per replicate.

Number of Fruits per Plant: It was considered at the end of the experiment by dividing the total number of fruits for each replicate over the number of plants in that replicate.

Average Fruit Weight: This parameter was measured at the end of the experiment by dividing the total yield weight by total number of fruits.

Yield per Plant: This parameter was calculated at the end of the experiment by dividing total yield per replicate over the number of plants in that replicate.

Length of Production Period: Measured for each replicate by counting the days from first harvest until the production of that replicate, ceased.

RESULTS AND DISCUSSION

Number of Leaves per Plant: The highest number of leaves per plant (189.5) was obtained by the conventional treatment in comparison to other treatments (Table 1). No significant differences were found between the used organic matter sources; except with the manure treatment which produced the lowest number of leaves per plant.

Leaf Area: Leaf area was highest (47.35 cm^2) in the conventional treatment, which significantly different from all other organic matter treatments. On the other hand, the lowest leaf area was obtained from the cattle manure treatment with 27.72 cm^2, but without significant differences with the mixture manure treatment (Table 1).

Plant Fresh Weight: The significantly highest plant fresh weight (367.9 gm) was obtained by the conventional treatment (Table 1) without a significant difference with the sheep manure treatment. While the lowest significant result (274.6 gm) was obtained by the cattle manure treatment which in the same significancy with the mixture manures treatment. No significant differences were observed in the plant fresh weight for poultry and sheep manure treatments.

Plant Dry Weight: The significantly highest plant dry weight (66.15 gm) was obtained by the sheep manure treatment (Table 1) without a significant difference with the conventional, poultry and mixture manure treatments. While the lowest significant result (57.43 gm) was obtained by the cattle manure treatment.

The present results showed in general a decrease in vegetative growth of the organic treatments compared to the conventional treatment; which could be due to the higher availability of nutrients in conventional treatment especially nitrogen. These results coincide with other authors [24] whom found a significant decrease in vegetative growth, compared to conventional growing methods.

Root per Canopy Percentage: The highest root/canopy percentage was obtained by the poultry manure treatment with 14.8 %, without a significant difference with the sheep manure treatment, while the lowest root/canopy percentage (10.58%) was obtained by the conventional treatment which was significantly the lowest obtained results in compare to all other treatments (Table 2). These results indicate that, soil organic matter increased root growth and this is due to the fact that addition of organic matter improves soil physical conditions which in turn

Table 1: Bell pepper leaves number per plant, leaf area, plant fresh and dry weight as affected by organic matter source treatments*

Treatments	Leaves number per plant	Leaf area (cm^2)	Plant fresh weight (gm)	Plant dry weight (gm)
Conventional	189.50a**	47.35a	367.9a	61.68ab
Cattle manure	164.50b	27.72c	274.6c	57.43b
Poultry manure	178.75ab	38.22b	305.4bc	65.24ab
Sheep manure	183.75a	39.34b	336.3ab	66.15a
Mixture manure	177.75ab	29.28c	293.9c	59.63ab

*: Values are the mean of four replicates

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

Table 2: Bell pepper root per canopy percentage,leaf chlorophyll content and number of days needed for 50 % of bell pepper blooming as affected by organic matter source treatments*

Treatments	Root/canopy %	Leaf Chlorophyll content (CCI)***	Days to 50% of plants per replicate in blooming
Conventional	10.58c**	46.20c	35.00a
Cattle manure	12.15b	50.03bc	32.25ab
Poultry manure	14.80a	58.62ab	31.25b
Sheep manure	14.11a	61.58a	30.75b
Mixture manure	12.35b	47.94c	34.25a

*: Values are the mean of four replicates

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

***: CCI: Chlorophyll Concentration Index

Table 3: Bell peppertotal yield per replicate, number of fruits per replicate, number of fruits per plant, average fruit weight and length of production period as affected by organic matter source treatments*

Treatments	Yield/replicate (kg)	No. of fruits/rep.	No. of fruits/plant	Average fruit weight (gm)	Length of production period (days)
Conventional	39.20a**	302a	15.1a	129.8a	71a
Cattle manure	30.68c	219c	11.0c	144.5a	65bc
Poultry manure	33.15bc	260abc	13.2abc	128a	65.3bc
Sheep manure	34.20b	288ab	14.4ab	118.8a	68ab
Mixture manure	32.10bc	246bc	12.3bc	130.9a	62c

*: Values are the mean of four replicates

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

facilitate root growth and penetration. Moreover, the conventional treatment resulted in a large canopy with small roots, thus the root/canopy percentage was small, while the organic matter treatments produced small canopy with large roots and therefore the root/canopy percentage was larger.

Leaf Chlorophyll Content: Our research shows (Table 2) that chlorophyll content was the highest in organic matter treatments and sheep manuretreatment produced the highest significant amount of leaf chlorophyll content, while the lowest amounts of leaf chlorophyll content were obtained by the conventional treatment. A promotion effect of organic matter treatments on chlorophyll contents might be attributed to the fact that N is a constituent of chlorophyll molecule; moreover, nitrogen is the main constitute of all amino acids in protein and lipids that acting as a structural compound of the chloroplast [25]. Contradictory data about the relationship between growth and chlorophyll content of leaves have been reported in whichbio-fertilizers increased the content of photosynthetic pigments [13].

Flowering: Flowering date was accelerated by the use of organic matter treatments and delayed by the use of conventional treatment (Table 2). The earliest onset of flowering (30.75 days) was obtained by the sheep manure treatment, while the latest onset of flowering was obtained by the conventional treatment which needed 35 days to reach flowering stage. Furthermore, significant differences existed between the conventional and all other treatments except the cattle and mixture manure treatments. These results are in agreement with other results [26], in which all used composts accelerated blooming date, which may be due to continued decomposition of composts after application, resulting in increased temperature in the

rhizosphere. This increase in temperature and the higher amounts of potassium in the soil may be responsible for the acceleration of the onset of flowering in the organically treated plants. On the other hand the use of inorganic nitrogen fertilizers, with different forms and amounts may be responsible for the delay in the onset of flowering in the conventionally treated plants.

Total Yield per Replicate: The results concerning the yield are shown in Table 3. The highest total yield per replicate (39.2 kg) was obtained by the conventional treatment which significantly exceeded all other treatments, while the lowest total yield was obtained by the cattle manure treatment (30.68 kg). The highest yield obtained by the conventional treatment could be due to the supply of inorganic fertilizers. On the other hand the low availability and the slow release of nutrients from the organic matter, is supposed to be responsible for the low yield in the organic treatments compared to the conventional treatment [6]. In average the yield of the organic treatments was between 12.7-21.7 %, less compared to the conventional treatment. And these data correspond with the results obtained by other authors [7, 8, 24] whom found a decrease in average yield under organic culture compared to conventional growing methods.

Average Fruit Weight: The data of the average fruit weight had no significant differences between all the used treatments (Table 3). Our results are in agreement with early obtained data [27], which showed that fruit weight depends on the cultivar and temperature rather than on the culture system (organic or conventional). Also, only small and non-significant differences between organic and conventional systems in respect to fruit weight [28].

Length of Production Period: A longer production period was significantly obtained by the conventional treatment compared to all other organic treatments, except with the sheep manure treatment (Table 3). The application of high amounts of inorganic fertilizers may be the main reason for extending the period of pepper fruit production in the conventionally treated fruits.

CONCLUSIONS

On the basis of the obtained results it was found out that chemical fertilizers increased plant growth; since the highest vegetative growth (number of leaves/plant, leaf area and plant freshweight) was obtained by the conventional treatment. Otherwise a positive effect of the animal manure were observed; since the highest plant dry weight, root per canopy percentage and leaf chlorophyll content was obtained by the poultry and or sheep manure treatments. Organic matter accelerated flowering date, while the conventional treatment delayed it. Conventional treatment influenced the total yield per replicate, but the average fruit weight was not significantlyaffected by the used organic or nonorganic treatments.

On the other hand the application of high amounts of inorganic fertilizers extended the period of pepper fruit production in the conventionally treated fruits in compare to organic matter treatments.

ACKNOWLEDGEMENT

Special thanks to the Al-Balqa Applied University for their financing, supporting and holding all the work, also for the agriculture engineer WaffaGnemat for their working in the field as well as in the lab.

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