 *Egypt. J. Hort.* **Vol. 42,** No. 1, pp. 691 - 706 (2015)

# Effect of Organic Fertilizers, Irrigation Regimes and Biological Amendments on Growth and Production of Sweet Pepper

**E. M. El-Said**
*Vegetable Research Department, Horticulture Research Institute, Agricultural Research Centre,Cairo, Egypt.*

ORGANIC fertilizer regimes consisting of combinations of compost, liquid fertilizers and conventional fertilizer with or without biological amendments (Rhizosphere bacteria and vascular arbuscular mycorrhiza, VAM) were evaluated under three irrigation regimes (60, 80 and 100% of evapo-transpirantsio, ET) in two experiments with open field pepper grown in peat-based substrate. Therefore, field experiments were conducted at private farm, near Mansoura City, Dakahlia Governorate, Egypt, during summer seasons of 2012 and 2013. The irrigation regime treatments were randomly distributed among the main plots, organic fertilizer treatments arranged among the sub plots, while biological amendment treatments were allocated as sub-sub plots.

The combined interaction of irrigation at 80% of ET and conventional fertilizer with microbial soil amendments had significant effects on vegetative growth characters (dry weight) and chemical composition (N, P and K content) of sweet pepper plants. This treatment led to the significant increase in early and total yield of sweet pepper plants and the highest significant values of fruit quality (fruit flesh thickness, acidity, T.S.S. % and vitamin C). The combined interactions recommended doses of mineral fertilizers, irrigation regime and VAM with rhizosphere bacteria gave the highest significant increase in early and total yields.

Organic fertilizer, irrigation water regimes and microbial inoculation, either separately or in different interactions had significant effects in in pepper’s early yield, total yield, total number of fruits per plot, fruit flesh thickness and quality parameters.

**Keywords:** Organic, Irrigation, Mycorrhiza, Biological, Sweet pepper.

Organic production methods encourage the use of organic waste materials as substitutes for chemical fertilizers. This may be an effective way to use the high volumes of urban yard waste and waste organic materials emanating from dairy, poultry, sheep, or greenhouse operations and is therefore of potentially significant environmental value (Cheng *et al*., 2004 and Mazuela *et al*., 2005). Chong and Purvis (2004) and Chong (2005) had developed recommendations for the use of a variety of waste and compost products in the nursery industry, some of which could be applied to organic production settings. Amending soil or potting media with some organic wastes can improve soil physical properties with increased porosity and water holding capacity as well as improved biological characteristics (Marinari *et al*., 2000, Celik *et al*., 2004 and Lee *et al*., 2004).

A full range of organic wastes, from municipal wastes to agricultural residues, could potentially be used as compost feedstock, depending on local availability and country legislation for organic products. For example, composts produced from different types of agricultural residues may be are suitable materials for container media or in field soils (Martı´nez *et al*., 2005). Rippy *et al*. (2004) found that several combinations of vermicompost plus organic liquid feeds produced yields similar to those of conventional hydroponic treatments.

Liquid fertilizers formulated for organic agriculture are often made from organic wastes and can be applied as a foliar spray or through drip irrigation lines as an alternative to chemical fertilizer. Cheng *et al*. (2004) used a greenhouse tomato crop to recover part of the nutrients from swine wastewater to reduce the risk of nitrogen (N) and phosphorus (P) losses to the environment. This has proven to be a feasible and promising alternative technology for converting swine wastewater into value-added product. Liedl *et al*. (2004) found that liquid effluent of digested poultry litter appeared to function as well as a commercial hydroponic fertilizer for tomatoes after balancing the forms of N ($NO_3/NH_4$) and supplementing with Ca $(NO_3)_2$ and $MgSO_4$. Abbasi *et al*. (2004) used fish emulsion in a peat mix to grow radish and cucumber seedlings. The result suggested that fish emulsion had both nutritive value for plant growth as well as disease suppressive properties and thus might be useful for organic or conventional transplant production.

Arbuscular mycorrhizae (AM) are beneficial fungi that colonize roots of almost all vascular plants (Singh and Adholeya, 2002). Linderman and Davis (2001) added *Glomus intraradices*, an AM fungus, to soil in containers sown with onion (*Allium cepa* L.) seed, and plants harvested after 10 weeks were more vigorous, when a medium was amended with coconut (*Cocos nucifera* L.) dust, making up 60% of the volume, inoculation with *G. intraradices* the development of ornamental flowers was depressed (Linderman and Davis, 2003). Seedling growth of bell pepper (*Capsicum annuum* L.) was detrimentally affected by the use of *Glomus intraradices* (Douds & Reider, 2003 and Russo, 2006).

Rhizosphere bacteria can be beneficial to plant development (Glick, 2004). Nodule-forming bacteria (*Rhizobium* sp., now *Sinorhizobium* sp.) allow for absorption of N in legumes, and nitrogen fixing bacteria can be associated with roots of nonleguminous crops (Emitiazi, *et al*., 2003). These bacteria can interact synergistically with mycorrhizal fungi to increase root colonization by both nodulation of roots and amount of nutrients available to plant (Suresh and Bagyaral, 2002). Rhizosphere bacteria have also been reported to reduce the severity of disease in the later stages of the development of cucurbits (Kokalis-Burelle *et al*., 2003). In an organic system, addition of beneficial bacteria enhanced tomato yield and quality comparable with a conventional production system (Rippy *et al*., 2004). Use of *Sinorhizobium* sp. bacteria appeared to provide a benefit to the development of bell pepper transplant (Russo, 2006).

Drip irrigation with its ability to small and frequent applications of water has created interest among the farmers because of less water requirement, increasing the production and better quality produce. The production of pepper crop is affected adversely by moisture deficit. The drip irrigation system is observed to be economical and cost effective as compared with conventional surface irrigation (Singh, 2007). Paul *et al*. (2013) found that, the use of drip irrigation system either alone or in combination with mulching, could increase the capsicum yield up to an extent of 57 % over surface irrigation method with the same quantity of water.

This investigation was designed to determine the effect of organic fertilizers, soil microbial amendments, and water regimes on pepper growth, yield and quality of fruits.

## Materials and Methods

*Plant materials and growth conditions*

The experiment was conducted during the two seasons of 2012 and 2013 in a clay loam soil at a private farm near Mansoura City, Egypt (latitude 30$^o$11/ N, longitude 28$^o$ 26/ E and altitude +7 m above sea level). Some physical and chemical properties of the experimental soil at the depth of 0-30 cm were determined according to the standard procedures as described by Page (1982) (Table 1). The local climate is hot and dry during the summer. The average monthly air temperature during the period of study was shown in Table 2. Sweet pepper cv. California Wonder was used in this experiment.

**TABLE 1. Chemical analysis of soil before conducting the experiment .**

| Chemical analysis | 2012 | 2013 |
|---|---|---|
| Soil cations in saturation extract 1 : 5 (meq/100 g soil): | | |
| $Ca^{++}$ | 0.690 | 0.870 |
| $Mg^{++}$ | 0.370 | 0.350 |
| $Na^{+}$ | 1.700 | 1.550 |
| $K^{+}$ | 0.350 | 0.125 |
| Soil anions in saturation extract 1 : 5 (meq/100 g soil): | | |
| $HCO_3^{-}$ | 0.340 | 0.340 |
| $Cl^{-}$ | 0.910 | 0.800 |
| $SO_4^{--}$ | 1.510 | 1.490 |
| | | |
| pH value | 7.931 | 7.820 |
| EC $dSm^{-1}$ (in soil paste) | 0.541 | 0.532 |
| Organic matter | 2.160 | 1.321 |
| | | |
| Nitrogen | | |
| Total (mg/100 g soil) | 217.600 | 183.460 |
| Available (mg/100 g soil) | 41.05 | 35.180 |
| Phosphorus | | |
| Total (mg/100 g soil) | 237.007 | 144.20 |
| Available (mg/100 g soil) | 21.205 | 15.980 |
| Soluble (mg/100 g soil) | 8.285 | 6.00 |
| Potassium | | |
| Total (mg/100 g soil) | 562.000 | 520.00 |
| Available (mg/100 g soil) | 105.821 | 95.210 |
| Soluble (mg/100 g soil) | 0.412 | 0.170 |

**TABLE 2. The monthly mean temperature and relative humidity during crop period in 2012 and 2013 seasons .**

| Months | Temperature °C | | | | | | Relative humidity % | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2012 | | | 2013 | | | 2012 | | | 2013 | | |
| | Max. | Min. | Average | Max. | Min. | Average | Max. | Min. | Average | Max. | Min. | Average |
| April | 22 | 12 | 17 | 24 | 12 | 18 | 86 | 47 | 67 | 85 | 48 | 67 |
| May | 28 | 20 | 24 | 28 | 20 | 24 | 85 | 44 | 65 | 86 | 44 | 65 |
| June | 31 | 19 | 25 | 33 | 21 | 27 | 85 | 43 | 64 | 84 | 42 | 63 |
| July | 34 | 20 | 27 | 35 | 21 | 28 | 84 | 41 | 63 | 82 | 42 | 62 |

Data from Ministry of Agriculture (Agriculture Extension Services)

*Experimental design, treatments and crop management*

A split split-plot design based on randomized complete blocks was used. Three irrigation treatments were assigned to the main plots, organic and conventional fertilizers were devoted to the sub-plots and biological amendments were distributed in sub sub-plots. Treatments were replicated three times to make a total of 54 plots. Each experimental sub sub-plot consisted of five ridges each of 0.80 m wide and 5 m long with plot area of 20 $m^2$. On March, $1^{st}$ in both seasons of the study, 45 day old sweet pepper seedlings were transplanted in open field on one side of the ridge at 40 cm apart.

Irrigation treatments: 60%, 80% and 100% of evapo-transpirantions (ET).

One meter gap was provided between each main plot to avoid overlap effect of irrigation treatment. Before start of irrigation treatments, crop received equal amount of water immediately after planting which was enough for the proper establishment of plants. The amount of irrigation water applied was measured by a standard 0.2 m diameter pan (K= 0.60, 0.80 and 1.00). The water requirement of the crop was computed on daily basis by using the following equation as suggested by Shukla *et al*. (2001).

V = Ep x Kp x Kc x Sp x Sr x Wp

Where,

V = Volume of water required (litre / day / plant)

Ep = Pan evaporation as measured by Class-A pan evaporimeter (mm/day)

Kc = Crop co-efficient (co-efficient depends on crop growth stage)

Kp = Pan co-efficient

Sp = Plant to plant spacing (m)

Sr = Row to row spacing (m)

Wp = Fractional wetted area, which varies with different growth stage (0.3 to 1.0). The values of pan coefficient and crop coefficients were taken from (Doorenbos and Pruitt, 1977). The water requirement of capsicum crop was estimated on daily basis for all months considered under study.

*Fertilizer treatments*

Recommended doses for mineral fertilizers, nitrogen at a rate of 120 kg $fed^{-1}$, phosphate fertilizer at 75 kg $P_2O_5$ $fed^{-1}$ and potassium fertilizer at rate of 100 kg $K_2O$ $fed^{-1}$.

The compost was contained 1.8% available N, 16.4% organic carbon, E.C. 0.85, C/N ratio 16.8 and pH 6.89 (average two seasons). Phosphorus and potassium contents in the compost used in this 2-yr trial were in the range of 0.41 to 0.35 mg $kg^{-1}$ for P and 21 to 22 mg $kg^{-1}$ for K. Compost was prepared according to the method described by Hatem *et al*., (2008). Compost was completely applied before planting at rowing preparation at 20 ton $fed^{-1}$.

The organic liquid fertilizer, cow dung (cattle/buffalo) manure, which was used for making the liquid manure (Flickety, 2011 method), was also tested consisting of N (198 mg $L^{-1}$), P (132 mg $L^{-1}$), K (300 mg $L^{-1}$), Ca (145 mg $L^{-1}$) and Mg (25 mg $L^{-1}$). It was used through drip irrigation at a rate of 20 $m^3$ $fed^{-1}$. The volume of manure applied with treatment not considers the content of mineral nitrogen because this fraction will be lost by evaporation before incorporation into the soil. Organic nitrogen (2.53 kg $m^{-3}$) was calculated as difference between total nitrogen and $NH_3$-N.

*Biological treatments*

A fresh peat based inoculants of rhizosphere bacteria *Sinorhizobium* sp. and mycorrhiza AM, obtained from Soils, Water and Environment Res. Inst., Agric. Res. Center, Egypt, was prepared as reported by El-Assiouty and Abo-Sedera (2005) by thoroughly mixing the bacteria cells suspension (1010 cells/ml) with sterilized peat moss at the ratio of 2:1 (v/w) under aseptic conditions. The peat inoculums was used at the rate of 2 kg $fed^{-1}$ by mixing with soft dust (1:10 w/w) and supplied as soil inoculation into root absorption zone of plants before first irrigation. A mixture of multi-arbuscular mycorrhizal fungi, provided by Prof. Safwat El-Haddad, Plant Pathology Inst., Agric. Res. Center, Giza, Egypt, was used. This mixture consists of equal proportions of spores of *Glomus mosseae* (Nicol. & Gerd.) Gerd. & Trappe, *Glomus intraradices* Schenck & Smith, *Glomus clarum* Nicol. & Schenck, *Gigaspora gigantean* (Nicol. & Gerd.) Gerd. & Trappe, and *Gigaspora margarita* (Becker & Hall) in suspension form at concentration of 106 unit $L^{-1}$. Mass production of AM inoculum was carried out using the pot culture technique and Sudan grass as a host plant. Spores of the previous formula were inoculated on surface sterilized (10% sodium hypochlorite for 30 min) Sudan grass seeds, which were sown in plastic pots (40 cm diameter) containing twice-sterilized sandy loam soil. A mixture of multi-arbuscular mycorrhizal fungi was added into the plots with bacterial inoculants.

The other agricultural practices for growing sweet pepper plants were followed according to the instruction laid down by the Egyptian Ministry of Agriculture, Egypt.

*Data and measurements*

*Foliage dry weight*

At 105 days from transplanting, five plants from each plot were randomly taken and dried at 70°C till constant weight for determination of dry weight per plant.

*Yield and some fruit characters*

All harvested fruits from each plot at marketable green ripe stage along the season were used to determine average number of marketable fruits per plant and total yield per feddan. Early yield per feddan was calculated from the first three picking. A representative sample of 10 sweet pepper fruits from each experimental plot were taken from the $4^{th}$ harvest for determination of fruit quality characters, *i.e.,* fruit flesh thickness, fruit dry matter, total soluble solids (T.S.S.), acidity and vitamin C, according to the methods described by AOAC (1990).

*Chemical composition of pepper plant*

Representative samples of sweet pepper plant foliage from each plot at the same time were used to determine N, P and K contents. Total nitrogen was determined according to the methods described by Bremner and Mulvaney (1982), phosphorus was estimated colormetrically according to Olsen and Sommers (1982) and potassium was determined flame photometrically as described by Jackson (1973).

*Statistical analysis*

The difference of the treatments was compared using the least significant difference (LSD) test at $P \leq 0.05$ according to Snedecor and Cochran (1989).

## Results and Discussion

*The effect of irrigation regimes, organic & conventional fertilizers and soil microbial amendments on the biomass, fruit number and early & total yields of sweet pepper.*

The effects of the tested factors can be categorized as follows: combined effect of the three factors together, single effect of one factor and combined effect of all the possible interaction between the two factors. The interaction effect among irrigation regimes, organic fertilizers and microbial soil amendments had significant effects on plant foliage dry weight, total fruit number per plot and early and total yields per feddan, in both seasons (Table 3). Irrigation sweet pepper at 80% ET and the addition of recommended doses of mineral fertilizers plus microbial inoculants (Rhizosphere bacteria *Sinorhizobium* sp. and mycorrhiza AM) exhibited significant positive effects on yield parameters compared with other treatments (Table 3).

When organic and biofertilizers were kept constant, irrigation regimes had a significant effect on biomass and yield parameters (Table 3). Irrigation sweet pepper at 80% ET level recorded the highest significant values of growth and yield studied parameters in comparison with both irrigation treatments. This result corroborated the findings of Paul *et al*. (2013). In drip irrigation system, water is applied at a low rate for a longer period at frequent intervals near the plant root zone through lower pressure delivery system, which increases the availability of nutrients near the root zone with a reduction in leaching losses. More nutrient availability, especially near the root zone might have increased the translocation of photosynthesis to storage organ of capsicum resulting in an increased in the weight of capsicum (Sankar *et al*., 2008).

**TABLE 3. Foliage D. W. and total yield of sweet pepper plants as affected by organic fertilizers, irrigation regimes and biofertilizer amendments in 2012 and 2013 seasons .**

| No. | A (irrigation regimes) | B (Fertilizers) | C (Biological amendments) | Foliage D.W. / plant (g) 2012 | Foliage D.W. / plant (g) 2013 | Fruit No. / plant 2012 | Fruit No. / plant 2013 | Early yield (ton/fed.*) 2012 | Early yield (ton/fed.*) 2013 | Total yield (ton/fed.*) 2012 | Total yield (ton/fed.*) 2013 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 100 % ET crop | Mineral | W. | 97.24 | 100.32 | 14.51 | 15.98 | 2.53 | 2.82 | 13.75 | 13.98 |
| 2 | | | Wt. | 85.10 | 86.38 | 13.52 | 14.50 | 2.00 | 2.46 | 11.88 | 12.43 |
| 3 | | Compost | W. | 102.14 | 104.90 | 14.33 | 15.52 | 2.22 | 2.58 | 12.90 | 13.18 |
| 4 | | | Wt. | 86.30 | 88.25 | 13.23 | 15.02 | 1.76 | 2.12 | 11.33 | 12.03 |
| 5 | | Liquid manure | W. | 99.81 | 102.11 | 14.37 | 15.72 | 2.38 | 2.65 | 13.08 | 13.42 |
| 6 | | | Wt. | 91.11 | 99.90 | 13.32 | 14.40 | 1.87 | 2.24 | 11.40 | 12.16 |
| Means | | | | 93.62 | 96.98 | 13.88 | 15.19 | 2.13 | 2.48 | 12.39 | 12.87 |
| 7 | 80 % ET crop | Mineral | W. | 103.43 | 105.26 | 15.16 | 16.48 | 2.85 | 2.96 | 14.48 | 15.10 |
| 8 | | | Wt. | 93.14 | 95.30 | 14.05 | 15.36 | 2.18 | 2.60 | 12.36 | 13.11 |
| 9 | | Compost | W. | 106.20 | 107.17 | 14.65 | 15.33 | 2.43 | 2.79 | 13.70 | 14.00 |
| 10 | | | Wt. | 93.03 | 97.76 | 13.65 | 15.10 | 2.06 | 2.45 | 11.90 | 12.80 |
| 11 | | Liquid manure | W. | 108.25 | 110.70 | 14.73 | 15.98 | 2.66 | 2.86 | 13.98 | 14.38 |
| 12 | | | Wt. | 95.78 | 99.18 | 13.74 | 15.19 | 2.03 | 2.53 | 12.03 | 13.06 |
| Means | | | | 99.97 | 102.56 | 14.33 | 15.57 | 2.37 | 2.70 | 13.08 | 13.74 |
| 13 | 60 % ET crop | Mineral | W. | 80.67 | 81.64m | 13.42 | 14.88 | 1.97 | 2.50 | 11.73 | 12.43 |
| 14 | | | Wt. | 78.13 | 81.02m | 13.38 | 14.63 | 1.93 | 2.40 | 11.52 | 12.22 |
| 15 | | Compost | W. | 89.34 | 92.34h | 12.86 | 13.83 | 1.63 | 1.83 | 10.90 | 11.18 |
| 16 | | | Wt. | 88.18 | 90.16i | 12.44 | 14.18 | 1.60 | 1.78 | 10.82 | 11.13 |
| 17 | | Liquid manure | W. | 83.22 | 85.79k | 13.20 | 14.22 | 1.73 | 2.02 | 11.14 | 11.90 |
| 18 | | | Wt. | 81.16 | 83.70i | 13.10 | 13.50 | 1.68 | 1.90 | 11.08 | 11.76 |
| Means | | | | 83.45 | 85.78 | 13.07 | 14.21 | 1.76 | 2.07 | 11.20 | 11.77 |
| *LSD 5 %* | | | | # | # | # | # | # | # | # | # |
| *Irrigation regimes* Fertilizers*Biological amendments* | | | | 1.01 | 1.73 | 0.21 | 0.18 | 0.09 | 0.08 | 0.18 | 0.25 |
| *LSD 5% (factor A) irrigation regime* | | | | 4.08 | 3.89 | 0.07 | 0.07 | 0.20 | 0.21 | 0.30 | 0.33 |
| *Irrigation regimes* Fertilizers (A*B)* | | | | 2.36 | 1.96 | 0.10 | 0.10 | 0.11 | 0.08 | 0.14 | 0.09 |
| *Fertilizers*Biological amendments (B*C)* | | | | 0.62 | 1.00 | 0.12 | 0.10 | 0.06 | 0.04 | 0.10 | 0.15 |
| *Irrigation regimes*Biological amendments (A*C)* | | | | 0.62 | 1.00 | 0.12 | 0.10 | 0.06 | 0.04 | 0.10 | 0.15 |
| *Fertilizers B:* | | | | # | # | # | # | # | # | # | # |
| *Mineral* | | | | 94.20 | 96.90 | 14.00 | 15.16 | 2.25 | 2.62 | 12.62 | 13.21 |
| *Compost* | | | | 93.22 | 96.76 | 13.52 | 14.88 | 1.95 | 2.26 | 11.93 | 12.39 |
| *Liquid* | | | | 89.62 | 91.66 | 13.74 | 15.12 | 2.06 | 2.36 | 12.11 | 12.78 |
| *LSD 5 % (factor B) fertilizers* | | | | 0.36 | 0.58 | 0.06 | 0.06 | 0.07 | 0.05 | 0.08 | 0.05 |
| *Biological amendments C:* | | | | # | # | # | # | # | # | # | # |
| *With (W.)* | | | | 96.70 | 98.22 | 14.13 | 15.46 | 2.27 | 2.56 | 12.85 | 13.29 |
| *Without (Wt.)* | | | | 87.99 | 91.29 | 13.38 | 14.65 | 1.90 | 2.28 | 11.59 | 12.30 |
| *LSD 5 % (factor C) Biological amendments* | | | | 1.36 | 1.13 | 0.07 | 0.06 | 0.03 | 0.03 | 0.06 | 0.08 |

* 1feddan (fed.)= 0.42 hectare (ha)

Recommended doses of mineral fertilizers or application of soil amendments had significant effects in all studied parameters as compared to other treatments (Table 3).

The combined effect of all the possible interaction between the two factors had significant effects on most studied parameters (Table 3).

Studies comparing yield of organically and conventionally grown crops often give inconsistent results. Some studies have found yield to be lower in organic than in conventional treatments in both field and greenhouse crops (Heeb *et al*., 2005, 2006, Mäder *et al*., 2002). On the other hand, no significant differences in total marketable yield of sweet pepper (Del Amor, 2007) and tomato (Rippy *et al*., 2004) have been observed when comparing organic and mineral fertilization, although in the study with tomato, the harvest duration was relatively short. Herencia *et al*. (2007) also found that crop yield was not statistically different between organic and mineral fertilizer treatments. Our results make sure with previous studies.

The use of bacteria appeared to increase plant dry weight and total yield per feddan. Even if bacteria do not infect plant tissues, they are capable of changing the rhizosphere in a way that could contribute to an environment beneficial to plant development (Dobbelaere *et al*., 2003 and Russo, 2006). Use of AM appeared to improve plant growth and productivity of sweet pepper. Mycorrhiza fungi can affect the environment around roots by physical and biological means (Suresh and Bagyaral. 2002).

*The effect of irrigation regimes, organic & conventional fertilizers and soil microbial amendments on the fruit chemical composition and fruit dry matter of sweet pepper.*

Nitrogen, phosphorus and potassium concentrations and percentage of fruit dry matter were significantly affected by main effects and interactions (Table 4).

Amendments with bacteria and fungi (*Sinorhizobium* sp. and mycorrhiza AM), fertilizers (liquid manure) and irrigation regime (80% ET) had significant effects of fruit element composition (N, P and K) and fruit dry matter, in comparison with other treatments, in both seasons (Table 4).

Irrigation of sweet pepper at 80% of ET had a significant effect on mineral composition and fruit dry matter (Table 4).

Application of compost manure or mineral fertilizer or microbial amendments had increased values of NPK contents and fruit DM (Table 4).

The interaction of irrigation regime x organic & conventional fertilizers, the amendment x fertilizer and the amendment x irrigation regime interaction had significant effects on N, P and K fruit contents and fruit DM, in both seasons (Table 4).

Based on the results, drip irrigation treatment (80% of ET) increased yield by 4.67% and 6.22%, in both seasons, respectively, as compared to irrigation at 80% of ET. This result is in close agreement with the findings of Tiwari *et al*. (1998) on okra and Paul *et al*. (2013) on pepper plants. The beneficial effect of NPK characters advantage better water-use-efficiency through drip irrigation is attributed to the continuous supply of water in required quantity at right time without flooding to cause hypoxia. Therefore, the roots remain well aerated (Lingaiah *et al*., 2005).

Because organic production systems depend on mineralization of nutrients from organic substrates, they are more dependent on soil biological activity than are conventional production systems in which plant-available forms of N and P are supplied in the form of soluble chemical fertilizers. Consequently, we hypothesized that mineralization of macronutrients would be the primary factor limiting yields in organic treatments and that measurements of gross biological activity, which are indicative of gross nutrient mineralization (Table 4), would be correlated with yields across the range of organic treatments (Table 3). These findings are in line with those reported by Zhai (2009) on organic tomatoes.

Biological control using the arbuscular mycorrhizal fungi (AM) has special significance being an ecofriendly and cost effective strategy for disease management, in addition to the positive effects on the plant growth and nutrition. Several researchers have studied the application of *Glomus mosseae*, *G. intraradices*, *G. clarum*, *Gigaspora gigantea*, and *G. margarita* on various crops. It was found that they have an important role in the enhancement of plant growth, nutrition, water relations and resistance to plant diseases caused by several pathogens on different host species (Leta and Selvaraj, 2013, Sennoi *et al*., 2013). In addition, Russo *et al*. (2006) reported that addition of *Sinorhizobium* bacteria provided a benefit to transplant growth of pepper and thus mineral status of foliage.

*The effect of irrigation regimes, organic & conventional fertilizers and soil microbial amendments on the fruit quality parameters of sweet pepper*.

Treated sweet pepper plants with organic fertilizers (liquid manure), and biological amendments (*Sinorhizobium* sp. and mycorrhiza AM) under 80% of evapo-transpiration had significant effects on fruit quality parameters, expressed as, fruit flesh thickness, vitamin C, total soluble soils and acidity, in comparison with other treatments, in both seasons (Table 5).

When irrigated sweet pepper at 80% ET level, fruit quality increased significantly as compared to other both irrigation levels (100 and 60% ET), in both seasons (Table 5).

Application of compost manure or microbial amendments had significant increase of quality parameters (Table 5).

As for bilateral interactions between different factors, it had significant effect of all fruit quality parameters (Table 5).

**TABLE 4. Chemical composition and fruit D. W. of sweet pepper plants as affected by organic fertilizers, irrigation regimes and biofertilizer amendments in 2012 and 2013 seasons.**

| Treatments | | | | Nitrogen (%) | | Phosphorus (%) | | Potassium (%) | | Fruit DM (%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | A (irrigation regimes) | B (Fertilizers) | C (Biological amendments) | 2012 | 2013 | 2012 | 2013 | 2012 | 2013 | 2012 | 2013 |
| 1 | 100 % ET crop | Mineral | W. | 3.90 | 4.10 | 0.82 | 0.92 | 3.31 | 3.54 | 9.30 | 9.16 |
| 2 | | | Wt. | 3.49 | 3.83 | 0.80 | 0.90 | 3.26 | 3.48 | 8.73 | 8.91 |
| 3 | | Compost | W. | 3.32 | 3.63 | 0.70 | 0.80 | 3.24 | 3.42 | 8.62 | 8.32 |
| 4 | | | Wt. | 3.66 | 3.76 | 0.76 | 0.76 | 3.28 | 3.34 | 8.81 | 8.62 |
| 5 | | Liquid manure | W. | 3.80 | 3.90 | 0.68 | 0.78 | 3.22 | 3.50 | 8.93 | 9.08 |
| 6 | | | Wt. | 3.28 | 3.60 | 0.65 | 0.76 | 3.20 | 3.31 | 8.54 | 8.18 |
| Means | | | | 3.58 | 3.80 | 0.74 | 0.82 | 3.25 | 3.43 | 8.82 | 8.71 |
| 7 | 80 % ET crop | Mineral | W. | 3.98 | 4.18 | 0.90 | 0.95 | 3.43 | 3.56 | 9.10 | 9.39 |
| 8 | | | Wt. | 3.68 | 3.80 | 0.90 | 0.95 | 3.40 | 3.46 | 8.89 | 8.80 |
| 9 | | Compost | W. | 3.91 | 3.96 | 0.86 | 0.86 | 3.34 | 3.52 | 9.07 | 9.30 |
| 10 | | | Wt. | 3.45 | 3.70 | 0.78 | 0.88 | 3.31 | 3.38 | 8.71 | 8.40 |
| 11 | | Liquid manure | W. | 4.12 | 4.20 | 0.93 | 0.97 | 3.45 | 3.60 | 9.12 | 9.48 |
| 12 | | | Wt. | 3.90 | 4.03 | 0.89 | 0.94 | 3.36 | 3.54 | 9.01 | 9.22 |
| Means | | | | 3.84 | 3.98 | 0.88 | 0.93 | 3.38 | 3.51 | 8.98 | 9.10 |
| 13 | 60 % ET crop | Mineral | W. | 3.40 | 3.72 | 0.72 | 0.82 | 3.18 | 3.40 | 8.98 | 8.43 |
| 14 | | | Wt. | 3.18 | 3.50 | 0.64 | 0.81 | 3.13 | 3.27 | 8.32 | 8.05 |
| 15 | | Compost | W. | 3.28 | 3.41 | 0.64 | 0.94 | 3.16 | 3.25 | 8.40 | 7.92 |
| 16 | | | Wt. | 3.00 | 3.33 | 0.62 | 0.86 | 3.10 | 3.21 | 8.20 | 7.83 |
| 17 | | Liquid manure | W. | 3.22 | 3.28 | 0.66 | 0.92 | 3.16 | 3.29 | 8.48 | 8.10 |
| 18 | | | Wt. | 3.10 | 3.52 | 0.63 | 0.88 | 3.11 | 3.18 | 8.26 | 7.78 |
| Means | | | | 3.20 | 3.46 | 0.65 | 0.87 | 3.14 | 3.27 | 8.44 | 8.02 |
| *LSD 5 %* | | | | # | # | # | # | # | # | # | # |
| *Irrigation regimes* Fertilizers*Biological amendments* | | | | 0.06 | 0.09 | 0.03 | 0.02 | 0.07 | 0.03 | 0.32 | 0.02 |
| *LSD 5% (factor A) irrigation regime* | | | | 0.13 | 0.11 | 0.06 | 0.05 | 0.11 | 0.09 | 0.12 | 0.08 |
| *Irrigation regimes* Fertilizers (A*B)* | | | | 0.07 | 0.04 | 0.03 | 0.03 | 0.06 | 0.04 | 0.24 | 0.04 |
| *Fertilizers*Biological amendments (B*C)* | | | | 0.04 | 0.05 | 0.02 | 0.11 | 0.03 | 0.02 | 0.18 | 0.02 |
| *Irrigation regimes*Biological amendments (A*C)* | | | | 0.04 | 0.05 | 0.02 | 0.11 | 0.03 | 0.02 | 0.18 | 0.02 |
| *Fertilizers B:* | | | | # | # | # | # | # | # | # | # |
| *Mineral* | | | | 3.61 | 3.86 | 0.80 | 0.89 | 3.29 | 3.45 | 8.89 | 8.80 |
| *Compost* | | | | 3.57 | 3.76 | 0.74 | 0.86 | 3.25 | 3.40 | 8.72 | 8.64 |
| *Liquid* | | | | 3.44 | 3.63 | 0.72 | 0.85 | 3.24 | 3.35 | 8.64 | 8.40 |
| *LSD 5 % (factor B) fertilizers* | | | | 0.02 | 0.03 | 0.01 | 0.01 | 0.02 | 0.01 | 0.11 | 0.01 |
| *Biological amendments C:* | | | | # | # | # | # | # | # | # | # |
| *With (W.)* | | | | 3.66 | 3.82 | 0.77 | 0.88 | 3.28 | 3.45 | 8.89 | 8.80 |
| *Without (Wt.)* | | | | 3.42 | 3.67 | 0.74 | 0.86 | 3.24 | 3.35 | 8.61 | 8.42 |
| *LSD 5 % (factor C) Biological amendments* | | | | 0.04 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.14 | 0.02 |

TABLE 5. Quality parameters of sweet pepper plants as affected by organic fertilizers, irrigation regimes and biofertilizer amendments in 2012 and 2013 seasons .

| No. | Treatments | | | Fruit flesh thickness (mm) | | Vit. C (mg/100 g FW) | | Acidity (mg/ 100 ml juice) | | TSS (%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | A (irrigation regimes) | B (Fertilizers) | C (Biological amendments) | 2012 | 2013 | 2012 | 2013 | 2012 | 2013 | 2012 | 2013 |
| 1 | 100 % ET crop | Mineral | W. | 4.40 | 4.42 | 126.60 | 150.1 | 154.30 | 167.3 | 6.6 | 6.0 |
| 2 | | | Wt. | 4.28 | 4.36 | 125.80 | 146.30 | 153.20 | 165.8 | 6.5 | 6.2 |
| 3 | | Compost | W. | 4.20 | 4.22 | 137.8 | 160.60 | 162.60 | 176.30 | 6.7 | 6.2 |
| 4 | | | Wt. | 4.30 | 4.30 | 135.30 | 154.20 | 160.80 | 170.8 | 6.7 | 6.1 |
| 5 | | Liquid manure | W. | 4.38 | 4.40 | 133.60 | 162.80 | 158.30 | 178.60 | 6.6 | 6.3 |
| 6 | | | Wt. | 4.18 | 4.19 | 131.20 | 152.70 | 158.00 | 169.10 | 6.6 | 6.0 |
| Means | | | | 4.29 | 4.32 | 131.72 | 154.45 | 157.87 | 171.12 | 6.6 | 6.1 |
| 7 | 80 % ET crop | Mineral | W. | 4.50 | 4.56 | 148.60 | 166.30 | 168.30 | 182.0 | 6.8 | 6.5 |
| 8 | | | Wt. | 4.32 | 4.34 | 131.00 | 156.70 | 156.10 | 172.20 | 6.6 | 6.1 |
| 9 | | Compost | W. | 4.43 | 4.52 | 146.40 | 164.40 | 163.20 | 180.80 | 6.8 | 6.3 |
| 10 | | | Wt. | 4.28 | 4.26 | 140.20 | 158.00 | 163.30 | 174.80 | 6.7 | 6.2 |
| 11 | | Liquid manure | W. | 4.66 | 4.60 | 150.80 | 170.40 | 170.70 | 182.30 | 6.8 | 6.8 |
| 12 | | | Wt. | 4.42 | 4.50 | 143.30 | 158.30 | 165.80 | 176.60 | 6.8 | 6.2 |
| Means | | | | 4.43 | 4.46 | 143.38 | 162.35 | 164.58 | 178.12 | 6.7 | 6.4 |
| 13 | 60 % ET crop | Mineral | W. | 4.22 | 4.26 | 117.60 | 133.60 | 142.20 | 156.20 | 6.2 | 5.5 |
| 14 | | | Wt. | 4.08 | 4.10 | 116.00 | 137.70 | 140.80 | 154.70 | 6.2 | 5.3 |
| 15 | | Compost | W. | 4.11 | 4.00 | 122.70 | 142.00 | 150.10 | 163.30 | 6.5 | 5.8 |
| 16 | | | Wt. | 3.96 | 3.94 | 120.20 | 138.80 | 146.60 | 160.80 | 6.3 | 5.7 |
| 17 | | Liquid manure | W. | 4.16 | 4.12 | 120.60 | 140.70 | 148.20 | 162.7 | 6.4 | 5.8 |
| 18 | | | Wt. | 4.00 | 3.90 | 118.30 | 136.20 | 144.10 | 158.30 | 6.2 | 5.7 |
| Means | | | | 4.09 | 4.05 | 119.23 | 137.17 | 145.33 | 159.33 | 6.3 | 5.6 |
| *LSD 5 %* | | | | # | # | # | # | # | # | # | # |
| *Irrigation regimes* Fertilizers*Biological amendments* | | | | 0.14 | 0.07 | 7.85 | 2.67 | 1.31 | 0.45 | 0.02 | 0.23 |
| *LSD 5% (factor A) irrigation regime* | | | | 0.19 | 0.18 | 1.85 | 8.48 | 5.23 | 4.90 | 0.06 | 0.18 |
| *Irrigation regimes* Fertilizers (A*B)* | | | | 0.19 | 0.05 | 2.65 | 3.79 | 3.19 | 2.42 | 0.03 | 0.18 |
| *Fertilizers*Biological amendments (B*C)* | | | | 0.08 | 0.04 | 2.55 | 1.54 | 0.76 | 0.26 | 0.01 | 0.13 |
| *Irrigation regimes*Biological amendments (A*C)* | | | | 0.08 | 0.04 | 2.55 | 1.54 | 0.76 | 0.26 | 0.01 | 0.13 |
| *Fertilizers B:* | | | | # | # | # | # | # | # | # | # |
| *Mineral* | | | | 4.30 | 4.34 | 133.77 | 153.52 | 157.78 | 171.27 | 6.61 | 6.20 |
| *Compost* | | | | 4.30 | 4.29 | 132.97 | 153.00 | 157.52 | 171.13 | 6.57 | 6.05 |
| *Liquid* | | | | 4.21 | 4.21 | 127.60 | 147.45 | 152.49 | 166.37 | 6.48 | 5.94 |
| *LSD 5 % (factor B) fertilizers* | | | | 0.05 | 0.02 | 1.53 | 0.89 | 0.44 | 0.15 | 0.01 | 0.01 |
| *Biological amendments C:* | | | | # | # | # | # | # | # | # | # |
| *With (W.)* | | | | 4.34 | 4.34 | 133.86 | 154.54 | 157.56 | 172.17 | 6.59 | 6.13 |
| *Without (Wt.)* | | | | 4.20 | 4.21 | 129.03 | 148.10 | 154.30 | 167.01 | 6.51 | 5.95 |
| *LSD 5 % (factor C) Biological amendments* | | | | 0.11 | 0.03 | 1.07 | 2.19 | 1.84 | 1.44 | 0.02 | 0.10 |

Our results are in agreement with those reported by Jones *et al*. (2000), they stated that water deficit during this period would have the greatest negative impact on yield and quality. Optimum soil water content during flowering was at 80% of the available water and that either higher or lower water content resulted in suboptimal fruit yields. Soil water should be maintained between 75 and 80% of field capacity (Jones *et al*., 2000). The higher pepper marketable yield and quality recorded under mild stress conditions, has been previously reported by several authors (Karam *et al*., 2009).

Concerning the effect of bio-organic treatment, the result may be due to the role of organic and bio-fertilizer on increasing the availability of nitrogen for plant absorption which in turn increases the vegetative growth and increasing yield as well as improving quality. Also, the superiority of the bio fertilizer may be due to the release of the fixed nitrogen, hence increasing the concentration and availability of this element in root zone. Nitrogen also enhances protein synthesis, division and enlargement of cells as well as stimulates photosynthesis processes. This is in agreement with results reported by (Reyes *et al*., 2008, Ghoname and Shafeek, 2005) on sweet pepper plants.

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(*Received* 1/3/2015;
*accepted* 20/5/2015)

# تأثير معاملات التسميد العضوي وأنظمة الري والتسميد الحيوي على النمو والإنتاجية في الفلفل الحلو

**السعيد محمود السعيد**
أقسام بحوث الخضر – معهد بحوث البساتين – مركز البحوث الزراعية – القاهرة – مصر.

تم تقييم نظم الأسمدة العضوية التي تتكون من مزيج من السماد العضوي الصناعي- الكمبوست، الأسمدة السائلة والأسمدة التقليدية مع أو بدون اللقاحات البيولوجية (بكتيريا ريزوسفير وفطريات الميكورهيزا ( *Sinorhizobium* sp., mycorrhiza AM تحت تأثير ثلاثة أنظمة للري (٦٠، ٨٠ و١٠٠٪ من البخر نتح) في تجربتين حقليتين في حقل مفتوح تحت ظروف الري بالتنقيط على نبات الفلفل الحلو. لذلك، أجريت تجارب حقلية في مزرعة خاصة، بالقرب من مدينة المنصورة بمحافظة الدقهلية، مصر، خلال مواسم الصيف من عام ٢٠١٢ وعام ٢٠١٣.

تم توزيع المعاملات عشوائيا من خلال تصميم القطع المنشقة مرتين، حيث وزعت أنظمة الري على القطع الرئيسية، والأسمدة العضوية والتقليدية على القطع المنشقة واللقاحات الميكروبية على القطع تحت الشقية.

أدي التفاعل المشترك باستخدام نظام الري عند ٨٠٪ من البخر نتح والكمية الموصي بها من السماد المعدني بالإضافة إلى اللقاحات الميكروبية ببكتريا الريزوسفير وفطريات الميكورهيزا إلى حدوث زيادة معنوية في الصفات محل الدراسة مثل الوزن الجاف للعرش، عدد الثمار، المحصول المبكر والمحصول الكلي. كما أدي التفاعل المشترك لهذه المعاملة إلى حدوث زيادة معنوية في التركيب الكيماوي للثمار (النتروجين، الفوسفور، البوتاسيوم)، المادة الجافة، كذلك صفات الجودة (سمك لحم الثمار، الحموضة، نسبة المواد الصلبة الذائبة الكلية وفيتامين ج).

أدت الأسمدة العضوية، وأنظمة مياه الري والتلقيح الميكروبي، إما بشكل منفصل أو في التفاعلات المختلفة الى حدوث تأثيرات معنوية في المحصول المبكر والمحصول الكلي، عدد الثمار للنبات، وزيادة سمك لحم الثمار ومعايير الجودة.