

Strawberry (*Fragaria ananassa* Duch.) Plant Productivity Quality in Relation to Soil Depth and Water Requirements

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Abstract The cultivated strawberry (*Fragaria ananassa* Duch.), a member of the *Rosaceae*, is the most important soft fruit worldwide. The effect soil types and depth on strawberry yield in a greenhouse as well as its association with water management are still not well known. The aim of this work was to evaluate the effect of different soil depth and water requirements on strawberry plant yield and quality in a greenhouse. The experiment was carried in a greenhouse at Thennaba farm, Tulkarm, located in the West Bank, Palestine during the autumn and spring seasons of 2012/2013. The experimental design was a completely randomized design included two groups (Set A & Set B) in the green house half dunum (10 dunum = 1ha) for each Set, contains 20 rows and 3000 plants with two different soil depths 15 and 7 cm for A and B, respectively. The results showed that the strawberry plant productivity was higher in set (B) with 7 cm soil depth: was 2115 kg in comparing with set (A) 15 cm soil depth: was 1645 kg for the agricultural season. The water requirements was higher in set (A) (314 m³/ agricultural season) in comparison with Set (B) (193 m³/ agricultural season) during the nine months of agriculture period. It means that the soil depth gives directly effects on water requirements.

Keywords Strawberry, Soil depth, Productivity, Water requirements, Quality

1. Introduction

Strawberry (*Fragaria ananassa* Duch.) is one of the most delicious and fragrantly sweet flavored fruits of the world, very popular in many countries [1]. Growing strawberry in Palestine started in 1976. The area in which strawberry was grown was about 1-2 dunums (1 dunum = 0.1 ha). The growing of strawberry aimed to: studying how successful is planting strawberry according to climate, soil and irrigation water and studying how acceptable is the crop to the farmer. The situation continued as it was until 1971. At that time, planting strawberry was mainly planted in the north Gaza where water (less than 250 ppm chloride) and soft sandy soil are available. The crop continued to be planted in the north of Gaza till the arrival of the Palestinian authority in Gaza Strip, 1993. After the arrival of Palestinian authority, nearly 30 dunums were planted with straw berry in Rafah and Khan Yunus, Especially in Al- Mawasi area [2].

Strawberry (*Fragaria ananassa* Duch.) is a crop which is cultivated in greenhouse in West Bank, Palestine. Therefore, developing new methods to increase its yield and quality

can play an important role in improving the performance of strawberry greenhouses. One of the modern soil cultivation methods is organic method. The later has some advantages such as control of crop nutrition, the capacity to increase planting density, decreasing diseases and pests and increasing the quantity and quality of the product have attracted many growers [3].

Fruit quality is also affected by agro technical treatments, i.e. mulching, irrigation, chemical protection, fertilization, and before establishing a plantation: crop rotation and intercropping, proper preparation of the field, planting date, or the health status and type of seedling [4, 5]. There are two main functions of the mulch used in the cultivation of strawberry, to provide a barrier between the ground and the plants so that the berries will be kept from getting dirty, and to isolate them as much as possible from becoming infected with pathogenic fungi that cause the berries to rot [6]. The addition of organic mulch can increase enzyme activity, but can also decrease microbial biomass [7]. Whereas, the application of vermicompost increases dehydrogenase activity and microbial [8].

Soil quality may be inferred from measurable soil properties termed soil quality indicators [9]. Organic farming practices compared to conventional farming practices have been shown to improve soil quality indicators based on traditional measures of biological,

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chemical, and physical properties [10-12].

Proper irrigation of strawberries is essential to maintain a healthy and productive planting. Excessive soil moisture promotes root rot, particularly on heavy soils. Applying insufficient irrigation water results in drought stress. Drought stress during fruit development results in a reduced fruit size and yield, and poorer fruit quality. The goal of a well-managed irrigation program is to maintain soil moisture between field capacity and the point of allowable depletion, or in other words, to make sure that there is always readily available water. The amount of readily available water is related to the effective rooting depth of the plant, and the water holding capacity of the soil [13].

Straw is the most popular mulch used in Poland for strawberry production, but synthetic mulches e.g. polyethylene films are also used [14]. Similar studies have also been carried out in other countries with the use of natural mulches [15, 16] and also biodegradable films of organic origin [17-19].

Due to the importance of strawberry for the local farmers, it is essential to investigate the factors affecting productivity and quality of this crop. The objective of this work was to evaluate the effect of soil depths, types and water requirements on strawberry productivity and quality.

2. Materials & Methods

The experiment was carried in a greenhouse at Thennaba farm, Tulkarm, located in the west bank, Palestine, during the autumn and spring seasons of 2012/2013. The experiment was a completely randomized design included two groups Set (A) & Set (B) in the green house half dunum (10 dunum = 1 ha) for each Set, contains 20 rows (replicates) and 3000 plants.

Table 1. Soil characteristics measured in the strawberry experiment

Properties	Units	Mixed	Sand	Compost
pH	--	7.47	7.03	7.95
Ec	dS m ⁻¹	1.4	0.21	2.5
N- NO ₃	PPM	183.4	24.75	342
N- NH ₄	PPM	110.8	9.6	212
Carbon	%	11	4	17.1
C/N ratio	%	17.7	5.3	29
Phosphorous	%	175.4	43.42	307.08
Potassium	%	119	1.2	237
Sodium	%	132.5	27.9	237
Bulk density	g cm ⁻³	0.49	0.6	0.3
Organic matter	g/kg	24.3	0.43	47.78

Mixed soil (compost and agricultural sand) was used. The first treatment Set (A) were the strawberry plants grown on boxes in two line with soil depth 15 cm, the second treatment Set (B), the strawberry plants grown on mulch with soil depth 7 cm. The soil had 50% a compost mixed with 50% agricultural sand, soil characteristics

shown in Table 1. Strawberry seedlings with four leaves were transplanted by hand in 2 rows with 0.5 m row spacing and 0.3 m seedling spacing on September during 2012/2013 season as show in Figure 1. Drip irrigation systems were adopted in the experiment, based on the conventional schedule.

The mineral fertilizers was added with adjust irrigation. The plants were grown with 29/19°C day/night temperature regimes. Other aspects of crop management followed conventional practices. Strawberry was harvested twice weekly on late November during 2012/2013 season until the end of May 2013.

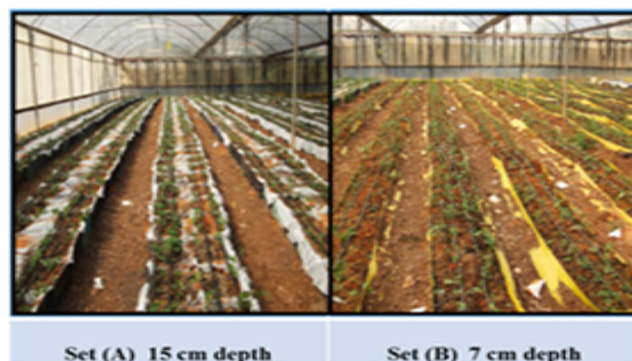


Figure 1. The two soil depth sets experimental image. Set (A) with 15 cm soil depth, and set (B) with 7 cm soil depth

Measurements:

Soil was dried at 70°C to constant weight and recorded. The dried soil samples were grounded and sieved through 2.0 mm mesh. The total Nitrogen was determined by the kjeldahl method [20]. Nitrate was determined in the soil according to Singh [21]. Bulk density of compost was estimated as a ratio between oven dry weights to their volumes as mg/m³ as reported by Okalebo et al. [22]. Soil pH was measured in a 1:5 ratio (compost: water) suspension for compost [23]. Electrical conductivity (Ec) was measured in the compost with a 1:10 (compost: water) ratio. Organic matter (OM) percent was calculated as: OM% = TOC (%) X 1.724. Total phosphorus was measured calorimetrically using a spectrophotometer after wet digesting the soil samples in concentrated H₂SO₄ + HClO₄ [24].

3. Result and Discussion

The effects of organic protected agricultural area on living systems, particularly the effect on growth of plants, have been the objective of numerous researchers. The strawberry experiment carried out used compost mixed with agricultural sand as agricultural media. The results of soil analysis shown in Table 1. Our result showed that used mixed soil between compost and agricultural sand as agricultural media was a suitable media for growth strawberry plants and for productivity.

The characteristics of organic matter increase permeability, available water capacity, air-filled porosity

and the nitrogen increased in the soil with the increase of organic nitrogen applied as well as soil organic carbon [25].

Strawberries tolerate a wide range of soil types, if the soil was properly modified. The soil should be well drained. Strawberries can't tolerate standing water or "wet feet." They grow best in a raised bed of well-drained loam soil, high in organic matter with a pH between 6 and 7 [26].

Mathur, *et al.* found that compost enhances the environmental sustainability of agriculture by decreasing chemical inputs and increasing soil organic matter. Adding different organic compost to the soil caused remarkable improvement of different growth characters and yield [27]. Adrien, stated that the application of organic manures significantly increased levels of organic C and N and the formation of water-stable aggregates, as compared with application of chemical fertilizers [28].

In general, chemical fertilizer application rates in intensive agricultural systems have increased dramatically during recent years in Palestine, especially in greenhouse vegetable production systems. Because of higher yields and income, the highest chemical fertilizer inputs can lead to marked deterioration in soil and groundwater quality and the systems are clearly unsustainable. However, the use of inorganic fertilizers alone may cause problems for human health and the environment that means the excess use of chemical fertilizers in agriculture can lead to nitrate accumulation into plant parts especially on edible parts.

Abd El-Hamied, found that the nitrate accumulation in edible plants is a problem when eaten and causing a health hazard [29].

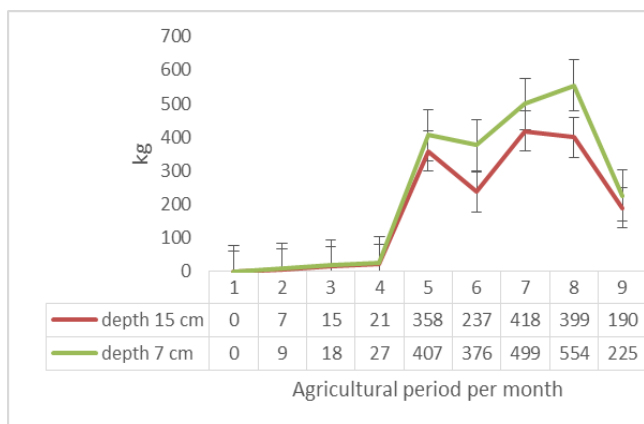


Figure 2. Monthly strawberry productivity for the two experimental set

The results obtained indicated that the strawberry plants of the Set (A) were characterized by significantly lower yields in comparison with Set (B) that means that there is significant effect in strawberry productivity according to soil depth. During the time of growing seasons the difference in quantity was clearly from the beginning of harvest stage until the end of harvest stage (Figure 2). The total fruit yield was determined as the overall yield from all the individual harvests. The results show that the strawberry plant productivity was higher in Set (B), were 7 cm soil depth used with 2115 kg in comparison with Set (A) were

15 cm soil depth 1654 kg (Figure 3).

This result does not agree with Michele and Leigh, a soil depth of greater than 25 cm is most preferable, between 15 and 25 cm can still grow productive strawberries. Less than 15 cm is not suitable for commercial production in soil. [30].

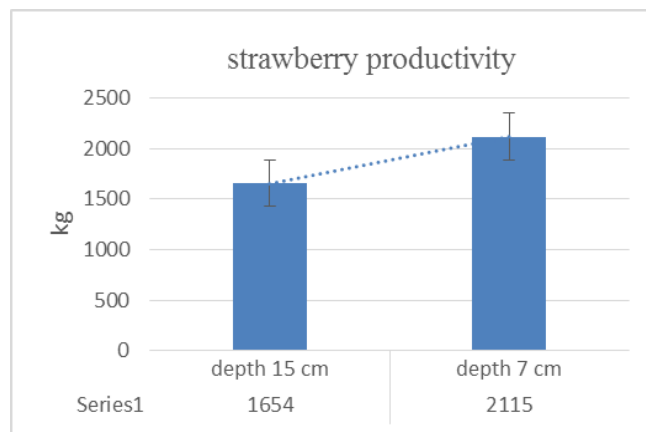


Figure 3. The average agricultural seasons strawberry productivity for the two experimental set

The results show that clearly different water requirements between Set (A) and Set (B) during the agricultural period as show in Figure 4. Were the water requirements was higher in Set (A) (314 m³/ season) in comparison with Set (B) were (193m³/ season) during the 8 months of agriculture period. It means that the soil depth used gives directly effects on water requirements.

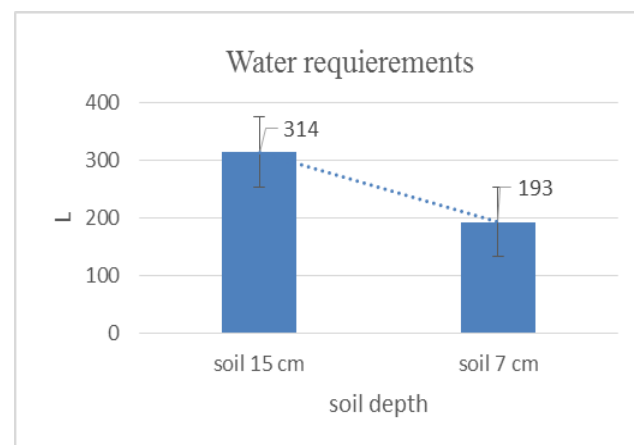


Figure 4. The average water requirement for strawberry plants for the two experimental set

Strawberries have shallow roots. To get maximum growth and yield, never let plants be stressed by lack of water. Keep newly set strawberries well irrigated. The plants will need about 2.5 to 3.5 Cm of water a week; supplement rain with irrigation as needed. The soil is sandy, you will need to pay more attention to watering and fertilization. Often, plantings on sandy soil require more frequent and lighter applications of water and fertilizer [31].

The sustainability of agricultural production depends on conservation and appropriate use and management of scarce

water resources, especially in arid and semi-arid areas where irrigation is required for the production of food and cash crops [32].

Neelam and Rajput [33]. Verify that water distribution in the soil around a buried dripper mainly depends on soil texture, dripper discharge and root water uptake. Soil water distribution patterns varied at different stages of crop growth.

These results indicated that use of soil (compost mixed with agricultural sand) could save water with an average of 18, 15, 7, 13, 15, 11, 18 and 26 m³/month, respectively, and 193 m³ for the agricultural season of the applied water to strawberry plant were used 7 cm soil depth with 314 m³ were used 15 cm soil depth as shown in Figure 5.

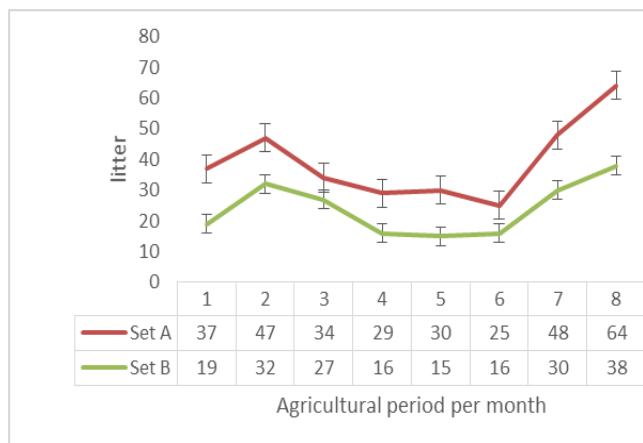


Figure 5. Monthly water requirement for strawberry plants for the two experimental set

The organic strawberries and their soils were of higher quality compared to their conventional counterparts. Specifically, the organic strawberries, while having lower concentrations of phosphorus and potassium, had higher antioxidant activity and concentrations of ascorbic acid and phenolic compounds, longer shelf life, greater dry matter, and, for 'Diamante', better taste and appearance. The organically farmed soils had more carbon and nitrogen, greater microbial biomass and activity, and greater functional gene abundance and diversity [34].

Mady indicated that levels of compost fertilizers could save water with on average of 14, 12.79, 29.07 and 44.19% of the applied water to cucumber crop under water stress treatments of 40, 60, 80 and 100 % from field capacity, respectively, and might be due to increase of field capacity, Permanent wilting point percentage and available water by adding compost fertilizer while, bulk density was opposite [35].

Also, Mamo, et, al. found that the extract compost addition was found to not only increase crop yield, but also to improve soil fertility in terms of organic C and N content, permeability, plant available water capacity and air-filled porosity [36].

Vegetative growth and yield for the strawberry plants affected by the fertilizers regimes. The results showed that using chemical and organic fertilizers regime gives early

harvested during the end of second month of agriculture in protected farms, were 7 kg was given in Set (A) comparing with 9 kg in Set (B). On the other hand it was noticed that there is declining in the quantity of fertilizers used in related with the depth of soil that is clearly shown in table 2. Were comparison between Set (A) and (B) The fertilizer regime was the same in the two set. Were used many types of chemical and organic fertilizers during the agricultural season as show in (Table 2).

Table 2. The fertilizers and quantity of fertilizers used for strawberry experiment

Fertilizer type	15 cm	7 cm	unit
sfefer 6-6-6	18	13	L
shefer 8-3-5	93	72	L
Fe + Ca	2	1	kg
korateen	45	25	L
organic fertilizer	10	5	L

Strawberry nursery plant propagation and productivity were significantly related to soil Phosphor availability, soil water content (SWC) and pH levels. High soil P nutrition at the pH 6.2 level would promote strawberry nursery plant propagation. High soil Ca and Fe concentrations might have resulted in low P concentration in the soil but further verification of P adsorption process is needed [37].

The results relating to fruit yield quantity and quality obtained in this experiment indicated a high usefulness of the strawberry and field cultivation was in Set (B) were 7 cm soil depth in comparison with Set (B) were 15 cm soil depth, added it was a relation between the soil depth and fruit loses.

Sas-Paszt *et al.* [38] indicate that mycorrhization of strawberry plants and mulching of the soil with a peat substrate or compost have a beneficial effect on the yield and firmness of strawberry fruits of the cv. 'Senga Sengana'. Moreover, these treatments produce positive effects on the growth of plant roots, i.e. their length, number of root tips, diameter, root surface area and volume. The results of the present experiment cannot confirm these effects in terms of yield because there were no significant differences.

The effects of mulching can be variable. Singht *et al.* [39] showed that the addition of vermicompost increased plant spread, leaf area, dry matter and also increased total fruit yield. On the other hand, the addition of vermicompost drastically reduced the incidence of physiological disorders like albinism, fruit malformation and the occurrence of grey mould in strawberry production a high potential in the control of pathogens of the soil [40] and the increase crops productivity [41, 42].

4. Conclusions

The mixture of compost and agricultural sand 50% for each is recommended for the cultivation of strawberries.

Strawberry plants can grow in shallow soil depth and produce high quantity and quality according to the soil type,

nutrition value, field capacity and aeration.

The use of compost for the cultivation of strawberries caused a significant increase in fruit productivity, saving water and decreasing in fertilizers used.

A high usefulness of the strawberry and field cultivation was in Set (B) were 7 cm soil depth in comparison with Set (A) were 15 cm soil depth, added it was a relation between the soil depth and fruit loses.

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