Response of Strawberry to Different Organic Fertilizers Application under Irrigation Levels

Karam A. Elzopy[1], Moubark G. Ahmed[2], Amal K. Abou El-Goud[3], S.M.Rizk[2], Mona M. Yousry[4].

1 Soil and Agricultural Chemistry, Fac. Agric. (Saba Basha), Alex. Univ.

2 Department of Self-Propagated Vegetable Plants, Horticulture Research Institute, Agriculture Research Center, Ministry of Agriculture and Reclaimed land, Egypt

3 Department of Botany (Organic Agriculture), Fac. Agric., Damietta Univ.

4 Plant Production Dept. Fac. Agric. (Saba Basha) Alex. Univ.

DOI: 10.21608/JALEXU.2023.212583.1138

Article Information

Received: May 22nd 2023

Revised: June 26 th 2023

Accepted: June 28th 2023

Published: June 30th 2023

ABSTRACT: Two field experiments were conducted at a private farm in Abdul Salam Aref, Badr Center, Beheira Governorate, Egypt during the winter growing seasons of 2020/2021 and 2021/2022 to study organic strawberry production under different irrigation levels cultivated in sandy soil. Three irrigation levels (100, 75, and 50%ET0) were arranged in main plots, and the four organic fertilizers (plant compost (3.5 and 7 t/fed.), chicken manure (1.75 and 3.5 t/fed.), vermicompost (3.5 and 7 t/fed.) and bokashi (3.5 and 7 t/fed.) were arranged in subplots. The results indicated that irrigation levels at 100% recorded the highest values of vegetative growth, i.e., plant height, plant fresh weight, number of leaves, leaf area, and total chlorophyll (SPAD) of strawberries. Also, irrigation levels at 100% gave the highest mean values of yield characteristics (i.e., fruit length, fruit weight, yield/plant, and yield/fed) and caused a significantly higher increase in the studied chemical composition (i.e., TSS, total acidity, total sugar, vitamin C in fruits, and N, P, K percentage in leaves) compared with the other treatment during both seasons. On the other hand, the application of different organic fertilizers significantly increased all these traits. However, vermicompost (7 t/fed.) recorded significant increases in plant height, plant fresh weight, leaf area, total chlorophyll, fruit length in the second season, fruit weight, yield/plant and yield/fed (in the first season), percentage of TSS and content of vitamin C. Meanwhile , chicken manure (3.5 t/fed.) caused the highest mean values of number of leaves, fruit length (in the first season), yield/plant and yield/fed (in the second season), and NPK percentages of leaves compared with the other organic treatments, while the control treatment recorded the highest value of total acidity during both seasons.

Keywords *Strawberry, irrigation levels, organic fertilizers, vermicompost, Bokashi, plant compost, Chicken manure.*

INTRODUCTION

The berry fruit strawberry (*Fragaria ananassa* Duch.) is one of the most frequently cultivated and consumed in the world. Strawberries were grown on 396.401 ha of land worldwide in 2019, and 8.885.028 tonnes were produced overall **(FAO, 2019).**Strawberry is a fruit that is popular throughout the year, can mostly be eaten fresh, and has a variety of uses in the food sector. Furthermore, due to its high antioxidant content, strawberries are a crucial part of daily nutrition meals (Wang, 2014). The globe produced over 8,861,381 tonnes of strawberries in 2020 on 384,668 ha of land, according to **FAO (2020).**

Strawberry irrigation using a drip system, in which drip tapes are set up underneath plastic mulch after beds are prepared. During the first few weeks after transplanting, drip watering is combined with overhead aluminium sprinkler irrigation to help with transplant establishment and leach out salts from the root zone. The strawberry crop is vulnerable to salinity, although salt damage can be minimised or avoided via overhead aluminium sprinkler irrigation **(Lozano *et al.*, 2016; Morales-Quintana *et al.*, 2022).** Drought stress negatively impacted the accumulation of nutrients in strawberry leaves, resulting in a reduction in photosynthetic rates, growth, and yield output, but it also improved fruit quality, such as sugar content **(Perin *et al.*, 2019).**

The growth, yield, and yield-related factors of many crops are significantly increased by organic fertilisers such chicken manure **(Avetisyan *et al.*, 2021).** The organic matter in the soil is increased by using organic manures. In turn, organic matter makes plant nourishment readily available for use by crops. However, organic manures shouldn't be viewed as merely plant food transporters. These manures also assist clay soils drain better and allow a soil to hold more water. (**Chagas *et al.* 2018 : Abou El-Goud and Yousry 2019 ; Abou El-Goud, 2020 and 2021).**

By adding plant compost to soil, soil properties such as water retention, aggregate formation, porosity, increased cation exchange capacity, and fertility are all improved. Additionally, the rhizosphere's biological and microbiological activity is growing (**Abou-El-Hassan *et al*.,2014; Mona and Amal 2020; Abou El-Goud 2021**).

Vermicompost is the end result of earth worms' biological breakdown of organic materials **(Zuo *et al*., 2018).** Vermicomposting is a technique that is frequently used to handle different kinds of organic waste. Vermicomposting is a cost-effective, environmentally responsible, and sustainable method for managing organic waste that yields organic fertiliser that is safe for use in sustainable farming practices (**Abou El-Goud, 2020 and 2021 and Abou El-Goud *et al*., 2021**)

Bokashi is one of the essentials for keeping the soil healthy so that plants may thrive and produce more and better-quality fruit and vegetables. Because humus compounds often take the form of hydrophilic compounds with the ability to bind water four to six times, they serve an important role in preserving water and reducing soil water evaporation. Increased nutrients and improved soil qualities such increased soil organic carbon, soil water content, cation exchange capacity, and pH can result from the high organic content. enhancing the aeration, water-holding capacity, soil structure, and soil temperatures to support plant growth. As a result of organic material fermenting with useful microbes, it is an organic material rich in various helpful microorganisms. In order to feed plants, promote growth, and improve crop yield, organic fertilisers are utilised. The usage of bookshi boosted the amount of N, P, and K as well as the quantity, diameter, and length of plant stems, all of which had an impact on the production's quality (**Sri Anjar Lasmin *et al*., 2018 and Abou El-Goud 2020**)

In contrast to the use of inorganic triple phosphate fertilizer, **Avetisyan *et al.* (2021)** found that manure treatments (which contain favorable quantities of macro and micronutrients) increased fruit set and size in strawberries through forming carbohydrates. In many nations throughout the world, using organic fertilizers has proven to be an effective way to regulate soil fertility. In addition to increasing fruit quality, it also ensures long-term production sustainability **(Kumar *et al*., 2018).** Numerous earlier research have demonstrated that the use of organic fertilisers in strawberry fields increases the availability of nutrients to plants, which in turn encourages plant development **(Khalil and Agah 2017).**

The main objectives of this study are:

1. Increasing organic fertilization to produce a chemical-free strawberry crop
2. Raising the fair and marketing value of the strawberry crop
3. Rationalizing water consumption in poor sandy lands

MATERIALS AND METHODS

Two field experiments were conducted at a private farm in Abdul Salam Aref, Badr Center, Beheira Governorate, Egypt, during the winter growing seasons of (2020/2021 and 2021/2022) to study organic strawberry production under different irrigation levels cultivated in sandy soil.

Samples of soil were collected at a depth of 0-30 cm from the experimental orchard for all treatments, and some physical and chemical properties of the experimental soil were determined in 2020 are shown in **Table (1).**

Table (1). Some physical and chemical properties of the experimental soil in 2020 and 2021 growing seasons before planting.

Parameter	0-30	Unit
Mechanical Analysis		
Sand	80.32	%
Silt	2.00	%
Clay	17.68	%
Textural class		
pH (1:2)	7.7	-
EC(1:2, water extract)	0.6	dS/m
O.M,	0.8	
Ca CO_3	13.13	
Soluble cations		
Ca^{2+}	2.0	meq/l
Mg^{2+}	4.0	meq/l
Na^{+}	1.8	meq/l
K^{+}	0.4	meq/l
Soluble aniosn		
$HCO3^{-}$	2.0	meq/l
Cl^{-}	4.2	meq/l
SO_4^{2-}	0.3	meq/l
Available nutrients		
Nitrogen (N)	3.4	mg/kg
Phosphorus (P)	32.6	mg/kg
Potassium (K)	450	mg/kg

Four kinds of organic manures were used in the experiments: plant compost (3.5 and 7 t/fed.), chicken manures (3.5 and 1.75 t/fed.), vermicompost (3.5 and 7 t/fed.) and Bokashi (3.5 and 7 t/fed.).

The experiments were carried out in a split-plot design with three replicates, where the three irrigation levels (100, 75, and 50% of ET0) were arranged in the main plots, and then the four organic manures (control, plant compost, chicken manures, vermicompost and Bokashi) were arranged in the sub-plots on a strawberry plant, the Festival variety.

Strawberry transplants, Festival variety were were planted in October in the first and second growing seasons, respectively. The fresh transplants were cultivated in four rows on terraces; the distance between the plants was 30 cm under the drip irrigation system.

Data recorded

A) Vegetative growth

Harvest was done on the 28th of July in both seasons, and the following data were estimated:

- Plant height (cm)
- Total fresh weight (g)
- Number of leaves/plant
- Leaf area index (LAI)
- Total chlorophyll content was determined using the chlorophyll index meter (SPAD)

B) Yield characters

- Fruit length (cm)
- Fruit weight (g)
- Yield/plant (kg/fed.)
- Yield (t/fed.)

C) Chemical composition:

The percentages of NPK content in the dry leaves and fruits were calculated. According to **Tandon (1995),** their dry weights were calculated after drying to a constant weight at 75°C for 72 hours. The plant samples were pulverized and stored for examination as described after drying. However, according to the results of wet digestion of 0.5g of the tubers powder with an H2SO4-H2O2 mixture **(Lowther, 1980)** and the following determinations were carried out in the digested solution to determine the following:

- **Nitrogen content (N %):**

Total nitrogen was determined in digested plant material colorimetrically by Nessler`s method **(Chapman and Pratt, 1978)**. Nessler’s solution (35 KI/100 ml d.w. + 20 g $HgCl_2$/500 ml d.w.) + 120 g NaOH / 250 ml d.w. Reading was achieved using a wave length of 420 nm, and N was determined as a percentage as follows:

% N = NH4 % x 0.776485

- **Phosphorus content (P %):**

Phosphorus was determined by the Vanadomolyate yellow method as given by **Jackson (1973),** and the intensity of the color developed was read in a spectrophotometer at 405nm wave length.

- **Potassium content (K%):**

Potassium was determined according to the method described by **Jackson (1973)** using a Beckman Flame photometer.

- **Total soluble solids of fruits juice (TSS %):**

The TSS% was determined using a Hand refractometer according to **Chen and Mellenthin (1981).**

- **Total acidity (%):**

Total acidity was determined by direct titration of 0.1 N sodium hydroxide using phenolphthalein 1% as an indicator and expressed as citric acid percentage according to the **AOAC (1985).**

- **Total sugars (%):**

Total sugars were determined in fresh fruit samples according to **Malik and Singh (1980).**

- **Vitamin C (ascorbic acid):**

The ascorbic acid content of the juice was determined by titration with 2,6-dichlorophenol-indo-phenol **(AOAC, 1985).** and calculated as milligrams per 100 ml of juice.

Statistical analysis:

The appropriate approach of statistical analysis of variance, as outlined by **Gomez and Gomez (1984),** was applied to the collected data. The least significant differences (L.S.D.) test was used to compare the treatment means at a 0.05 level of probability.

RESULTS AND DISCUSSIONS

A) Vegetative growth

The effects of irrigation levels and various organic fertiliser rates on strawberry plant growth characteristics, including plant height (cm), plant fresh weight (g), number of leaves, leaf area (LA), and total chlorophyll content, were shown by the results in **Table (2) and Fig. (1).** However, results indicate that the highest mean values of all vegetative growth studied increasing gradually by increasing irrigation levels at 100% (24.05 and 26.94 cm, 45.05 and 50.46 g, 25.43 and 28.48, 3.82 and 4.27 cm^2 and 48.96 and 54.84 unit SPAD), followed by 75% (23.40 and 26.20 cm, 40.55 and 45.41 g, 21.81 and 24.42, 3.44 and 3.85 cm^2 and 44.07 and 49.36 unit SPAD), as compared with 50% which recorded the lowest mean values of this traits, respectively, during both seasons.

These findings are consistent with those of other researchers (Yuan et al., 2004), who found that strawberry plants grew noticeably taller when irrigation water was increased from Ep 0.75 to Ep 1.25. Although different strawberry cultivars had different leaf areas under ideal conditions, all of them showed a fall in leaf area to a comparable level when water supply was limited, according to Grant et al. (2010). When strawberry crops were severely deficient in water, the weight and wetness of the fruit after harvest decreased. From the outcomes produced by (**Arash *et .al.*, 2015: Mona *et al*.,2021; Abou El-Goud *et al*., 2021 and Abou El-Goud, 2020 and 2021**)

Drought stress demonstrated detrimental impacts on leaf area, leaf number, and chlorophyll content on strawberry plants and beans.

On the other hand, results from the same table's analysis of the application of organic fertilizers showed that all of them significantly affected the vegetative growth characteristics of strawberries, including plant height (cm), plant fresh weight (g), number of leaves, leaf area (LA), and total chlorophyll content. In this respect, results cleared that the Vermicompost 7t/fed. recorded the higher values of plant height, plant fresh weight, leaf area and total chlorophyll (28.68 and 32.13 cm, 49.00 and 54.88 g, 4.48 and 5.02 cm^2 and 50.76 and 56.85 unit SPAD), while the higher number of leaves recorded with Chicken manure 3.5t/fed. (31.16 and 34.90), as compared to control treatments which recorded the lowest mean values of this traits, respectively, during both seasons.

The observed improvement in strawberry plant development with composted manure application could be related to enhanced nutrient availability for a longer length of time during the season, which would be predicted to improve soil physical and chemical qualities **(Abou El-Goud *et al.*, 2021).** Furthermore, Li et al. (2020) and Abou El-Goud (2020 a, b, and c) discovered that vermicompost not only improves soil texture, aeration, and compaction, thereby improving plant water and nutrient uptake, but it also produces hormones, vitamins, plant regulators, antibiotics, and beneficial microbes, all of which improve plant health. Similarly, **Najar and Khan (2013)** found that adding 6 t/ha vermicompost to tomato plots increased vegetative plant growth significantly. Vermicompost macronutrients increase crop output by activating enzymes involved in chlorophyll synthesis, growth, yield, and enzyme system maintenance **(Piya *et al.*, 2018; Abou El Goud, 2020 a, c).** During both seasons, the interaction effect of irrigation levels and varied organic fertiliser rates was very significant on plant height and number of leaves, but not on plant fresh weight, leaf area, or total chlorophyll content.

Table (2): Effect of irrigation levels and different organic fertilizer rates on vegetative growth during the 2020/2021 and2021/2022 seasons.

Treatments	Plant height (cm)		Fresh weight (g)		Number of leaves		Leaf area (LA) (cm^2)		Total chlorophyll (SPAD)	
	2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022
A) Irrigation levels										
100%	24.05a	26.94a	45.05a	50.46a	25.43a	28.48a	3.82a	4.27a	48.96a	54.84a
75%	23.40b	26.20b	40.55b	45.41b	21.81b	24.42b	3.44b	3.85b	44.07b	49.36b
50%	20.57c	23.04c	36.49c	40.87c	18.53c	20.76c	3.09c	3.46c	39.66c	44.42c
$LSD_{(0.05)}$	**0.22**	**0.25**	**0.07**	**0.08**	**0.25**	**0.28**	**0.01**	**0.01**	**0.10**	**0.10**
B) Organic fertilizer										
Control	17.56i	19.67i	32.81h	36.75h	15.54i	17.41i	2.46i	2.75i	33.26f	37.25f
Plant compost (7t/fed.)	20.26g	22.69g	38.14e	42.71e	20.26f	22.69f	3.03g	3.39g	38.39e	43.00e
Plant compost (3.5t/fed.)	18.23h	20.42h	35.50g	39.76g	17.22h	19.29h	2.82h	3.16h	42.99c	48.15c
Chicken manure (3.5t/fed.)	26.87b	30.10b	44.93c	50.32c	31.16a	34.90a	3.38e	3.79e	51.76a	57.98a
Chicken manure (1.75t/fed.)	23.23d	26.02d	41.13d	46.06d	24.93c	27.92c	3.17f	3.55f	46.43b	52.00b
Vermin compost (7t/fed.)	28.68a	32.13a	49.00a	54.88a	26.49b	29.66b	4.48a	5.02a	50.76a	56.85a
Vermin compost (3.5t/fed.)	20.91f	23.42f	46.29b	51.85b	21.19e	23.73e	4.18b	4.68b	47.03b	52.67b
Bokashi (7 t/fed.)	25.81c	28.91c	41.62d	46.62d	22.51d	25.22d	3.88c	4.34c	46.53b	52.12b
Bokashi (3.5 t/fed.)	22.51e	25.21e	36.83f	41.25f	18.01g	20.17g	3.64d	4.08d	40.93d	45.85d
$LSD_{(0.05)}$	**0.25**	**0.27**	**0.87**	**0.97**	**0.14**	**0.16**	**0.10**	**0.10**	**1.51**	**1.69**
Interaction (AXB)	**	**	**Ns**	**ns**	**	**	**ns**	**ns**	**ns**	**ns**

*Means in the same column within a treatment that followed by the same letter(s), are not significantly different at P = 0.05.

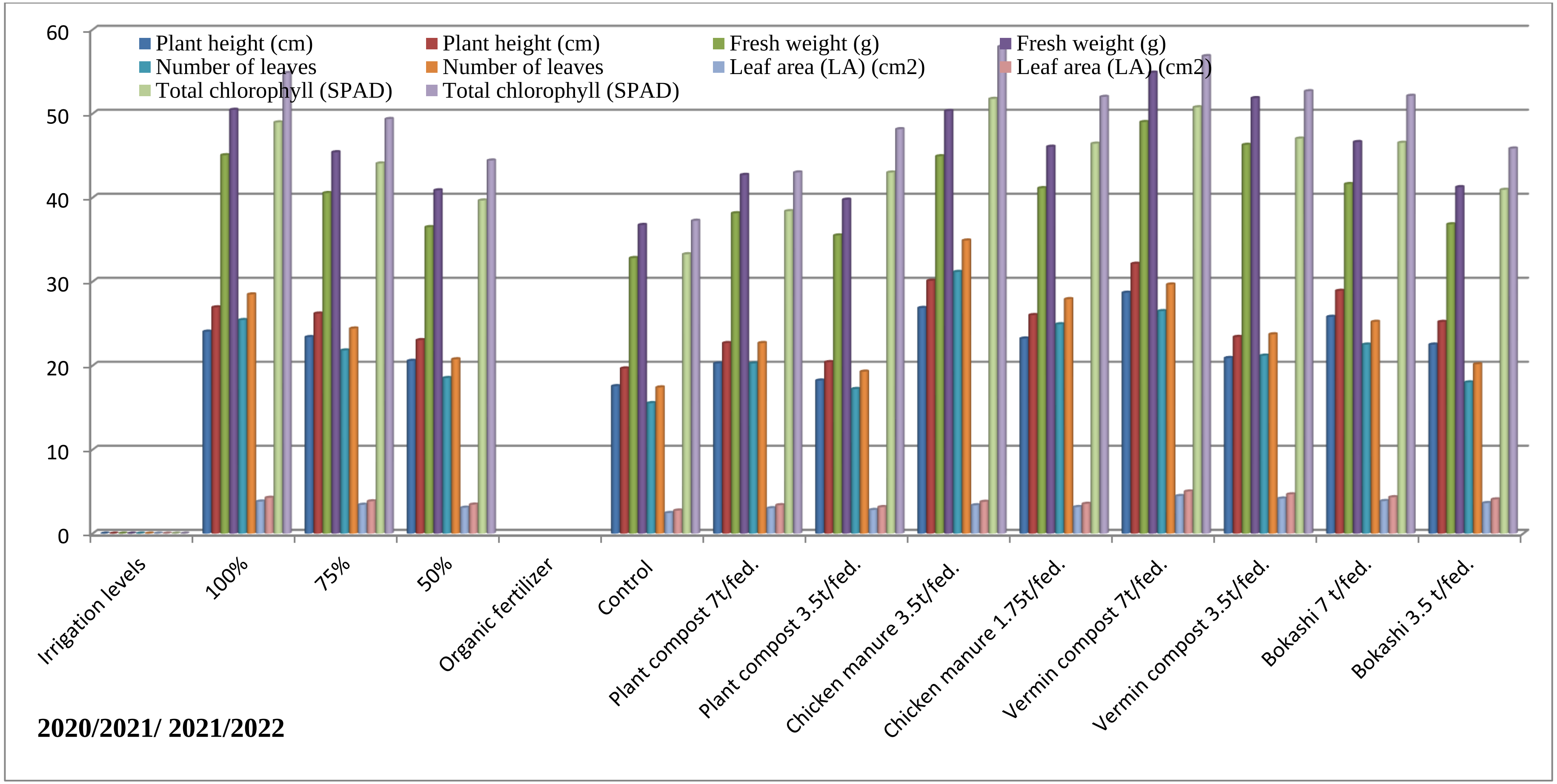

Fig. (1): Effect of irrigation levels and different organic fertilizer rates on vegetative growth during the 2020/2021 and 2021/2022 seasons.

B) Yield characters

The results in **Table (3) and Figs. (2 and 3)** demonstrated the effect of irrigation levels and varied organic fertiliser rates on strawberry yield parameters (fruit length (cm), fruit weight (g), yield/plant, and yield/fed). However, results show that the highest mean values of all yield characteristics studied increased gradually by increasing irrigation levels at 100%, which recorded higher values of fruit length, fruit weight, yield/plant, and yield/fed. (3.25 and 3.65cm, 15.89 and 19.33 g, 755.73 and 906.87 kg/plant, and 24.01 and 26.38 t/fed.) during both seasons, as compared to irrigation levels at 50%, which recorded the lowest mean values of these traits, respectively.

The moderate soil moisture level, which led to an increase in nutrient availability and uptake, as well as a reduction in soil salinity compared to low field capacity, may be linked to the positive influence of 100% or 75% of the reference evapotranspiration on fruit output and its components. Higher field capacity values enhanced growth parameters, resulting in higher rates of photosynthetic processes and carbohydrate generation, which increased final tuber yield. The drop in total yield due to water deficit, on the other hand, can be linked to a reduction in leaf area due to fewer and smaller leaves, an increase in stomatal resistance and gas exchange, and a decrease in transpiration rate, all of which resulted in a reduction in photosynthesis. **(Ghosh *et al.,* 2000).**

Better fruit size and weight under these irrigation treatments may have also contributed to higher total production in the current study. These findings are consistent with those of another author **(Yuan *et al.,* 2004),** researchers also observed a considerable increase in strawberry fruit yield under higher levels of drip irrigation, which they attributed to optimal soil moisture conditions due to frequent water application. Earlier, similar results of increased strawberry yield under drip irrigation were reported. **(Kachwaya *et al*., 2016).**

Water efficiency could be enhanced by using strawberry cultivars that are more resistant to water stress, resulting in better yield with more sustainability **(Martinez-Ferri *et al.,* 2016).** According to **Gomes *et al.* (2015),** water consumption efficiency is directly connected to the irrigation system and the frequency of water application in strawberry plant production.

In contrast, data from the same table show that organic fertilisers have an effect on strawberry production variables such as (fruit length (cm), fruit weight (g), yield/plant, and yield/fed. However, results show that vermi compost 7t/fed. recorded the highest mean values of fruit length (3.91 cm) in the second season and chicken manure 3.5t/fed. in the first season (3.39 cm), while fruit weight recorded the heaviest fruit weight with vermi compost 7t/fed (22.57 and 23.71 g), as well as yield/plant (826.15 and 998.46 kg/plant) and yield/fed (28.01 t/fed.

The highest mean values for some new sweet melon lines were scored at 100% irrigation rate during the two seasons, followed by 70% irrigation rate treatment; while 40% irrigation rate treatment possessed the lowest mean values in this regard, as reported by **(Abou Kamer *et al.,* 2022).**

Increased production may be attributable to increased availability of N, P, and K levels in soil as a result of organic manure application **(Zaman *et al.,* 2011).** According to **Al-Balikh (2008),** chicken manure produced the maximum numbers of tubers/plant, total tuber yield/ha, and marketable tuber yield/ha. The increase in tuber yield of potato plants as a result of using farmyard manure at various levels may be attributed to the positive effects of farmyard manure application on the vegetative growth characters of potato plants, which consequently increased photosynthesis efficiency and synthesis of carbohydrates such as starch content, resulting in an increase in plant tuber yield **(Ahmed *et al.,* 2009). Al-Hisnawy (2011)** got similar results using organic manure, which induced the majority of yield components. Organic manure may have boosted soil organic matter, water holding capacity, nutrient availability, soil aggregation, root system, and microbial activity **(John *et al.,* 2002).**

According to **Mona and Amal 2020** on yield and quality of watermelon (cv. Skata F1 hyprid), the use of organic manure improves the yield and its components by improving soil productivity, soil organic carbon content, soil microorganisms, soil physical structure, soil nutrient status, and crop yield. Data also agreed with other researchers, who said that when basal farmyard manure was put on poor sandy soil with 0.3 to 0.5% humus content on Charleston Grey watermelon, the fruit yield was 42.4 t/ha **(Audi *et al.,* 2013).**

In the second season, the interaction effect of irrigation levels and varied organic fertilizer rates was highly significant on fruit length, yield/plant, yield/fed., and fruit weight, but not on fruit weight in the first season.

Table (3): Effect of irrigation levels and different organic fertilizer rates on yield characteristics of strawberries during the 2020/2021 and 2021/2022 seasons.

Treatments	Fruit length (cm)		Fruit weight (g)		Yield (kg/plant)		Yield (t/ fed.)	
	2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022
A) Irrigation levels								
100%	3.25a	3.65a	15.89a	19.33a	755.73a	906.87a	24.01a	26.38a
75%	2.76b	3.10b	13.50b	17.40b	690.46b	828.54b	22.57b	24.80b
50%	2.35c	2.64c	11.48c	15.66c	621.41c	745.69c	19.18c	21.08c
LSD$_{(0.05)}$	**0.04**	**0.05**	**0.12**	**0.05**	**1.12**	**1.35**	**0.01**	**0.01**
B) Organic fertilizer								
Control	2.26i	2.79g	13.28g	14.87g	512.25g	614.70g	15.82i	16.07i
Plant compost (7t/fed.)	2.57f	3.17d	16.74e	18.75	615.22e	738.26e	18.04g	19.75f
Plant compost (3.5t/fed.)	2.31h	2.85f	14.65f	16.40f	584.07f	700.89f	17.18h	18.22h
Chicken manure (3.5t/fed.)	3.39a	2.85f	18.78c	22.60b	832.05a	998.46a	23.73a	27.25b
Chicken manure (1.75t/fed.)	3.10c	2.51h	16.93de	18.97de	782.10b	938.52b	21.71d	25.25c
Vermin compost (7t/fed.)	3.31b	3.91a	22.57a	23.71a	826.15a	991.38a	23.49b	28.01a
Vermin compost (3.5t/fed.)	2.79e	3.44c	19.47b	21.81c	763.65c	916.38c	20.28e	23.52d
Bokashi (7 t/fed.)	2.85d	3.52b	17.39d	19.48d	667.13d	800.55d	20.66e	22.20c
Bokashi (3.5 t/fed.)	2.51g	3.10e	17.36d	19.44d	620.15e	744.18e	18.52g	19.24f
LSD$_{(0.05)}$	**0.02**	**0.02**	**0.60**	**0.64**	**8.93**	**10.71**	**0.26**	**0.29**
Interaction (AXB)	**	**	**ns**	**	**	**	**	**

*Means in the same column within a treatment that followed by the same letter(s), are not significantly different at P = 0.05.

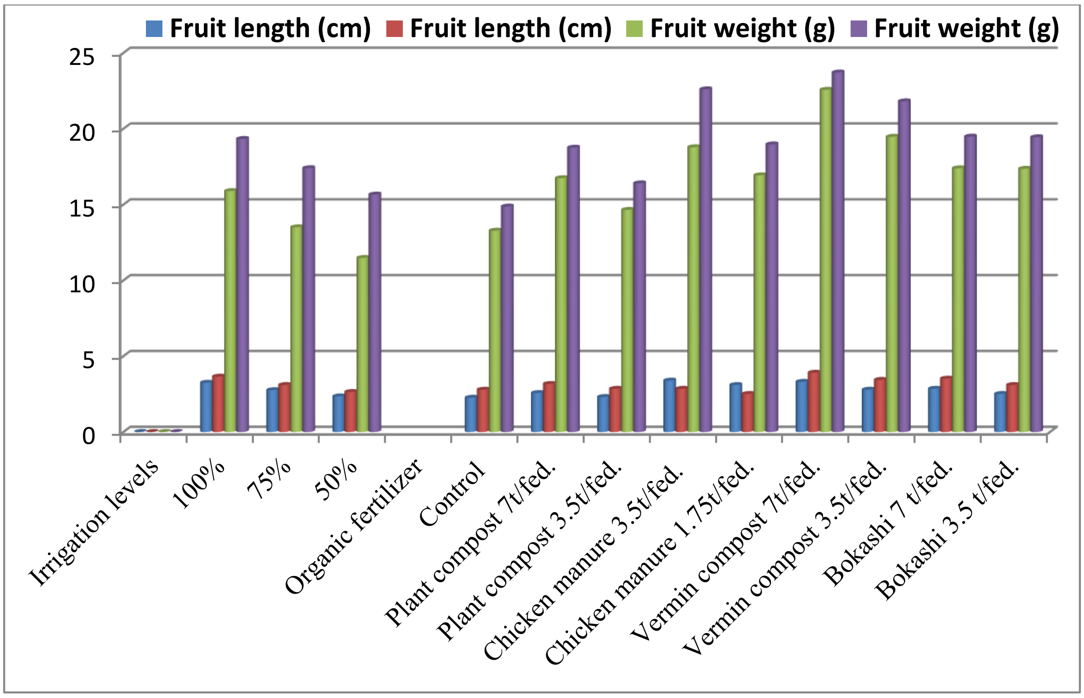

Fig. (2): Effect of irrigation levels and different organic fertilizer rates on fruit length and fruit weight of strawberries during the 2020/2021 and 2021/2022 seasons.

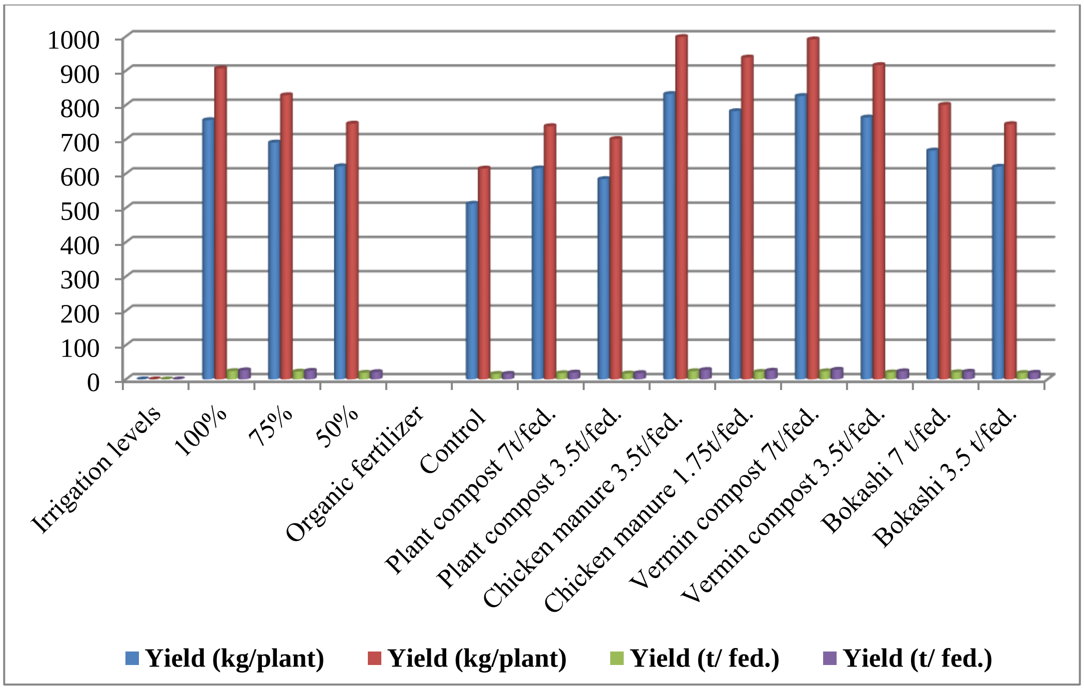

Fig. (3): Effect of irrigation levels and different organic fertilizer rates on yield/ plant and yield/ fed of strawberries during the 2020/2021 and 2021/2022 seasons**.**

C) Chemical composition

Table 4 and Figures 4-7 show the effect of irrigation levels and organic fertiliser rates on chemical composition (Acidity (%), TSS (%), VC (mg/100 g f.w.), and total sugar percentage). However, results showed that increasing irrigation levels to 100% (0.518 and 0.582%, 5.35 and 6.00%, 56.66 and 63.46 mg/100 g f.w., and 5.60 and 6.27%) resulted in the highest mean values of all these traits studied, as compared to 50%, which recorded the lowest mean values of these traits, respectively, during both seasons.

On the other hand, results showed that organic fertiliser treatment had a substantial effect on chemical composition (Acidity (%), TSS (%), VC (mg/100 g f.w.) and total sugar percentage). However, the control treatment had the highest percentage of acidity (0.618 and 0.692%) compared to all organic treatments, which had the lowest percentage of acidity. Meanwhile, during both seasons, vermicompost at 7t/fed recorded the highest levels of TSS and VC (5.85 and 6.55% and 63.69 and 71.34 mg/100 g f.w., respectively), while chicken manure at 3.5t/fed recorded the greatest percentage of total sugar (6.13 and 6.86%).

Organic fertilisers such as vermicompost and bokashi are commonly thought to play critical roles in reducing or eliminating chemical fertiliser inputs, which increase the production of active compounds such as enzymes, antibiotics, siderophores, and the plant hormone indole-1,3-acetic acid **(Abou El-Goud et al., 2021; Abou El Goud, 2020a, b, c, and Mona and Amal 2020),** which lead to increased total

According to **Odongo *et al.* (2008),** FYM increased the TSS content of strawberry fruits; however, the major negative effect of FYM on TSS was due to K dilution caused by robust leaf development induced by a modest FYM rate. According to **El-Hamid *et al.* (2006),** such increases in total sugars, TSS, and titrable acidity resulted from the synergistic effect of the differential combination of inorganic fertiliser and organic manures.

Gliessman *et al.* (1996b) and Cayuela *et al.* (1997) previously demonstrated greater quality and higher sugar contents in strawberry fruits in response to organic fertilizer treatment vs mineral fertilizer treatment. It was proposed that in an organic system, soil biotic life expands, causing plants to synthesise more vitamins and other useful compounds produced by these organisms. **El-Sheikh and Salama (1997)** showed similar results on tomatoes, where organic fertilizer boosted fruit vitamin C, acidity, and total sugars. During both seasons, the interaction effect of irrigation levels and varied organic fertilizer rates on acidity, TSS, and total sugars was highly significant.

The observed increase in mineral composition in leaf tissue from organic manure treatment in general, and composted forms (PCM and FD) in particular, is consistent with the findings of **Abou El-Goud and Yuosry (2019) and Abou El-Goud (2020 and 2021),** who discovered that organic compost increased nutrient availability, cation exchange capacity, and micronutrients. **Abou El-Goud *et al.* (2021)** obtained similar results on potatoes. By increasing root length and root hairs in the rhizosphere, bokashi fertiliser benefits roots and plant growth. Organic matter can improve soil structure and increase N, P, and K nutrients as well as other microelements for improved root development, which reflects on nutrient uptake and can optimise the photosynthetic process.

Table (4): Effect of irrigation levels and different organic fertilizer rates on Chemical composition of strawberries during the 2020/2021 and 2021/2022 seasons.

Treatments	Acidity (%)		TSS (%)		VC (mg/ 100g f.w.)		Total sugars (%)	
	2020/2021	**2021/2022**	**2020/2021**	**2021/2022**	**2020/2021**	**2021/2022**	**2020/2021**	**2021/2022**
A) Irrigation levels								
100%	0.518a	0.582a	5.35a	6.00a	56.66a	63.46a	5.60a	6.27a
75%	0.414b	0.466b	4.82b	5.40b	50.99b	57.11b	5.04b	5.69b
50%	0.331c	0.372c	4.10c	4.59c	45.89c	51.40c	4.53c	5.08c
$LSD_{(0.05)}$	**0.004**	**0.01**	**0.01**	**0.02**	**0.23**	**0.26**	**0.01**	**0.01**
B) Organic fertilizer								
Control	0.618a	0.692a	3.45i	3.87i	34.67h	38.83h	3.81i	4.27i
7t/fed.) (Plant compost	0.558b	0.627b	4.30g	4.81g	46.89f	52.52f	4.79f	5.37f
3.5t/fed.) (Plant compost	0.499c	0.561c	4.08h	4.57h	45.24g	50.66g	4.35h	4.88h
Chicken manure (3.5t/fed.)	0.296b	0.334h	5.55b	6.22b	56.63b	63.43b	6.13a	6.86a
Chicken manure (1.75t/fed.)	0.269i	0.299i	5.01d	5.61d	56.34b	63.10b	5.28d	5.92d
(7t/fed.) Vermin compost	0.330g	0.369g	5.85a	6.55a	63.69a	71.34a	5.85b	6.55b
3.5t/fed.) (Vermin compost	0.407e	0.458e	5.27c	5.91c	55.05c	61.65c	4.68g	5.25g
Bokashi (7 t/fed.)	0.367f	0.410f	4.76e	5.33e	53.03d	59.39d	5.47c	6.13c
Bokashi (3.5 t/fed.)	0.450d	0.508d	4.52f	5.06	49.10e	54.98e	5.13e	5.74e
$LSD_{(0.05)}$	**0.004**	**0.001**	**0.01**	**0.01**	**0.80**	**0.89**	**0.02**	**0.02**
Interaction (AXB)	**	**	**	**	**	**	**	**

*Means in the same column within a treatment that followed by the same letter(s), are not significantly different at P = 0.05.

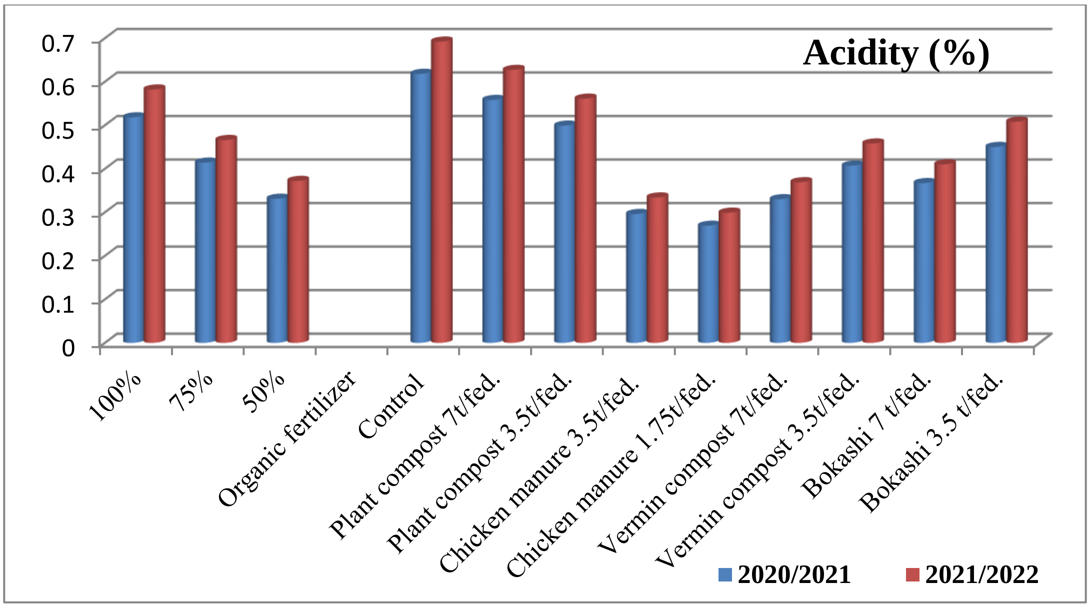

Fig. (4): Effect of irrigation levels and different organic fertilizer rates on acidity percentage of strawberries during the 2020/2021 and 2021/2022 seasons.

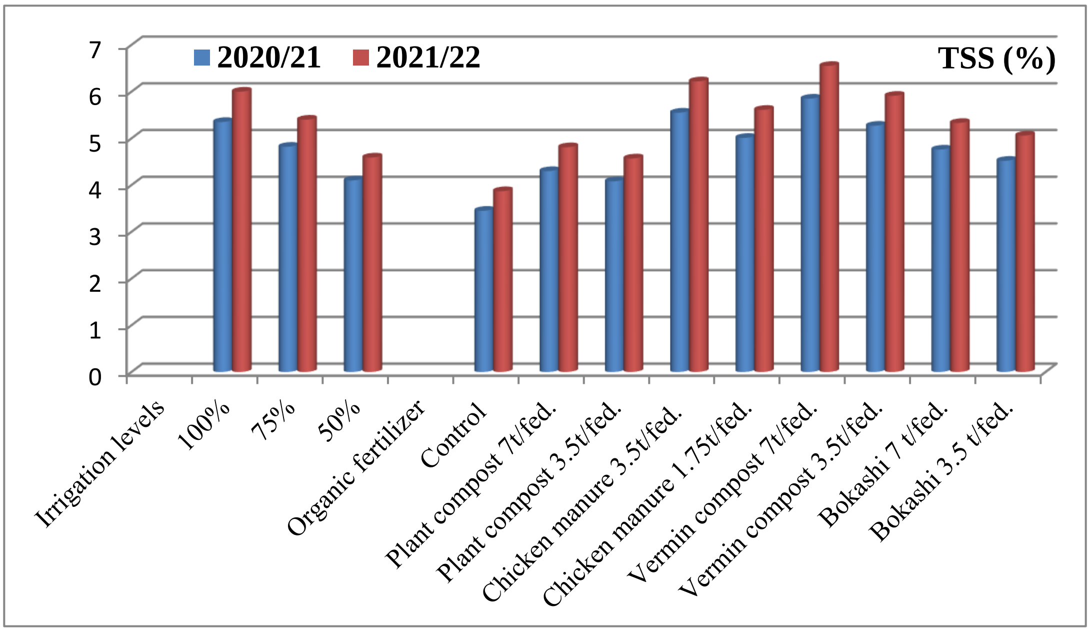

Fig. (5): Effect of irrigation levels and different organic fertilizer rates on TSS percentage of strawberries during the 2020/2021 and 2021/2022 seasons.

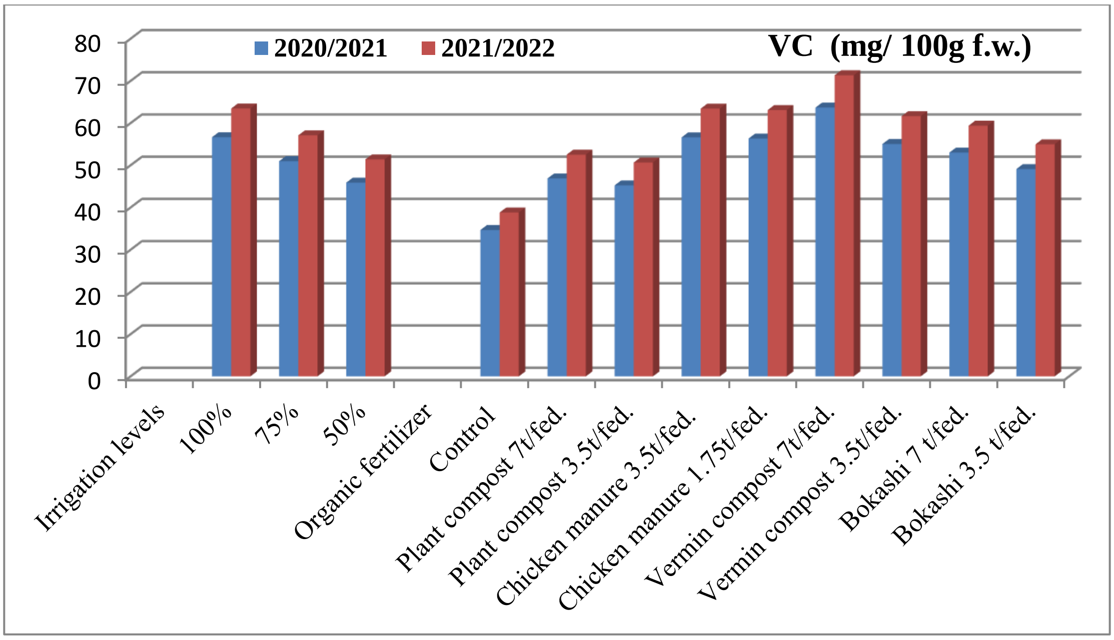

Fig. (6): Effect of irrigation levels and different organic fertilizer rates on VC (mg/ 100g f.w.) during the 2020/2021 and2021/2022 seasons.

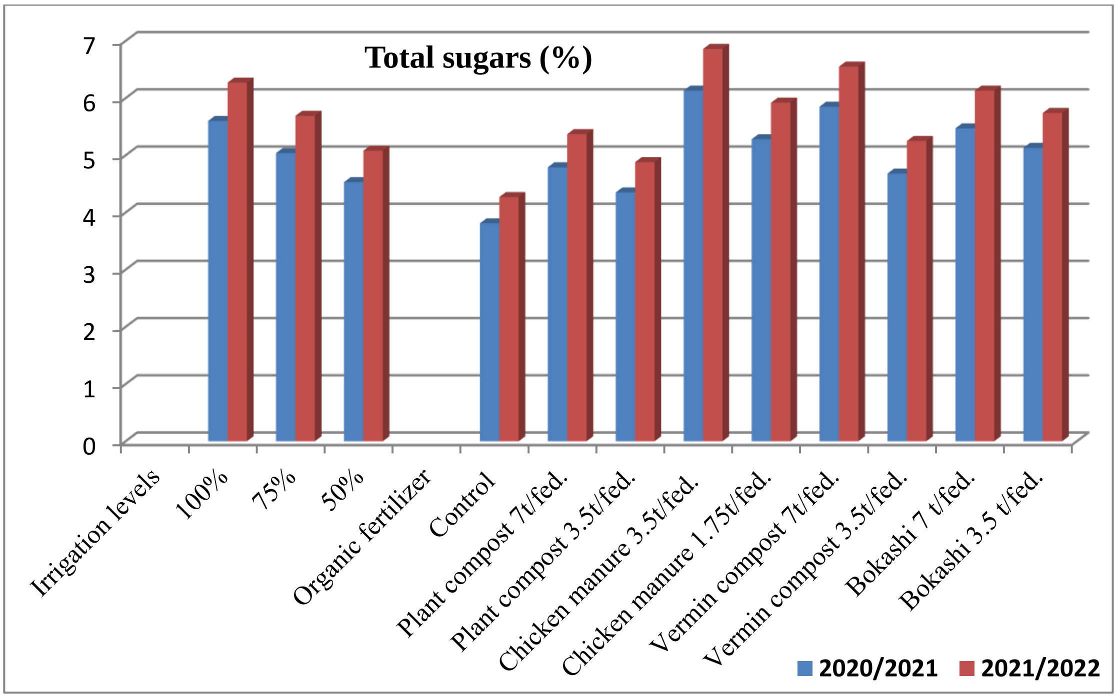

Fig. (7): Effect of irrigation levels and different organic fertilizer rates on total sugar (%)during the 2020/2021 and2021/2022 seasons.

Table (5) and Figs. (8-10) show the effect of irrigation levels and different organic fertilizer rates on chemical composition (Acidity (%), TSS (%), VC (mg/100g f.w.) and total sugars percentage). However, the results showed that the highest mean values of all the traits studied increased gradually by increasing irrigation levels to 100% (0.518 and 0.582%, 5.35 and 6.00%, 56.66 and 63.46 mg/100g f.w. and 5.60 and 6.27%), as opposed to 50%, which recorded the lowest mean values of these traits during both seasons.

These findings are consistent with, who showed that large concentrations of elements in fruits were caused by NH4+ ion adsorption on the surface of compost and became available for plant uptake. Similarly, said that applying organic fertiliser with organic manures increased both N mineralization and nitrification, which improved access to NH4+ and resulted in a greater number of viable cells of nitrifying bacteria, particularly when chemical fertilisation was used. Furthermore, chicken manure has an indirect effect on growth and mineral content by improving soil physical, chemical, and biological qualities, resulting in more vigorous squash development **(Abou El-Goud and Yousry 2019).**

Organic material is utilised to avoid or enhance the negative effects of stress on plants and yield reduction. It is a substance used to reduce soil salinity. Root development in soil increases organic matter, improves soil structure, and increases water and air permeability. It is a popular fertilizer **(Hassanpanah and Azimi, 2012).**

Mona *et al.* 2021 discovered that varied amounts of irrigated water influenced the growth, productivity, and pod properties of Faba bean genotypes in different ways, indicating that Faba bean genotypes differed in their ability to survive different rates of water scarcity. This would aid in the discovery of additional growth and physiological markers associated with water deficit sensitivity. Due to the scarcity of irrigation water in semi-arid countries such as Egypt, advanced irrigation systems such as the drip irrigation system are required.

The interaction effect between irrigation levels and different organic fertilizers rates was highly significantly on potassium, while not significant on nitrogen and posphorus, during both seasons.

Table (5): Effect of irrigation levels and different organic fertilizer rates on NPK percentages in leaves of strawberries during the 2020/2021 and 2021/2022 seasons.

Treatments	In leaves					
	N (%)		P (%)		K (%)	
	2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022
A) Irrigation levels						
100%	2.90a	3.24a	0.49a	0.55a	2.94a	3.29a
75%	2.61b	2.92b	0.44b	0.49b	2.65b	2.96b
50%	2.35c	2.63c	0.40c	0.44c	2.38c	2.67
$LSD_{(0.05)}$	**0.01**	**0.01**	**0.01**	**0.001**	**0.003**	**0.002**
B) Organic fertilizer						
Control	1.99f	2.23f	0.30g	0.33g	2.26i	2.53i
Plant compost (7t/fed.)	2.32e	2.60e	0.35f	0.39f	2.53e	2.84e
Plant compost (3.5t/fed.)	2.11f	2.36f	0.39e	0.43e	2.38g	2.67g
Chicken manure (3.5t/fed.)	3.26a	3.66a	0.57a	0.64a	3.38a	3.79a
Chicken manure (1.75t/fed.)	2.76c	3.09c	0.52b	0.58b	2.63d	2.94d
Vermin compost (7t/fed.)	3.00b	3.36b	0.56a	0.63a	3.10b	3.47b
Vermin compost (3.5t/fed.)	3.06b	3.42b	0.49c	0.54c	2.50f	2.80f
Bokashi (7 t/fed.)	2.61bc	2.92cd	0.42d	0.47d	2.82c	3.16c
Bokashi (3.5 t/fed.)	2.45de	2.75de	0.40e	0.44e	2.31h	2.59h
$LSD_{(0.05)}$	**0.16**	**0.18**	**0.02**	**0.02**	**0.03**	**0.03**
Interaction (AXB)	**ns**	**ns**	**ns**	**ns**	**	**

*Means in the same column within a treatment that followed by the same letter(s), are not significantly different at P = 0.05.

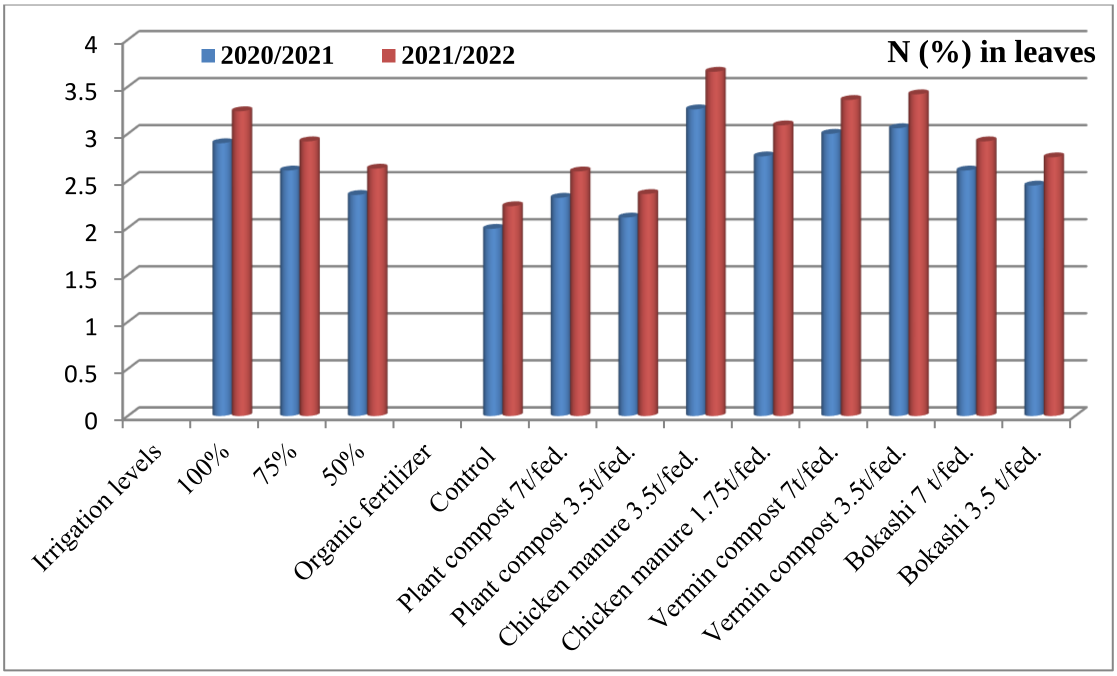

Fig. (8): Effect of irrigation levels and different organic fertilizer rates on N (%) in leaves during the 2020/2021 and2021/2022 seasons.

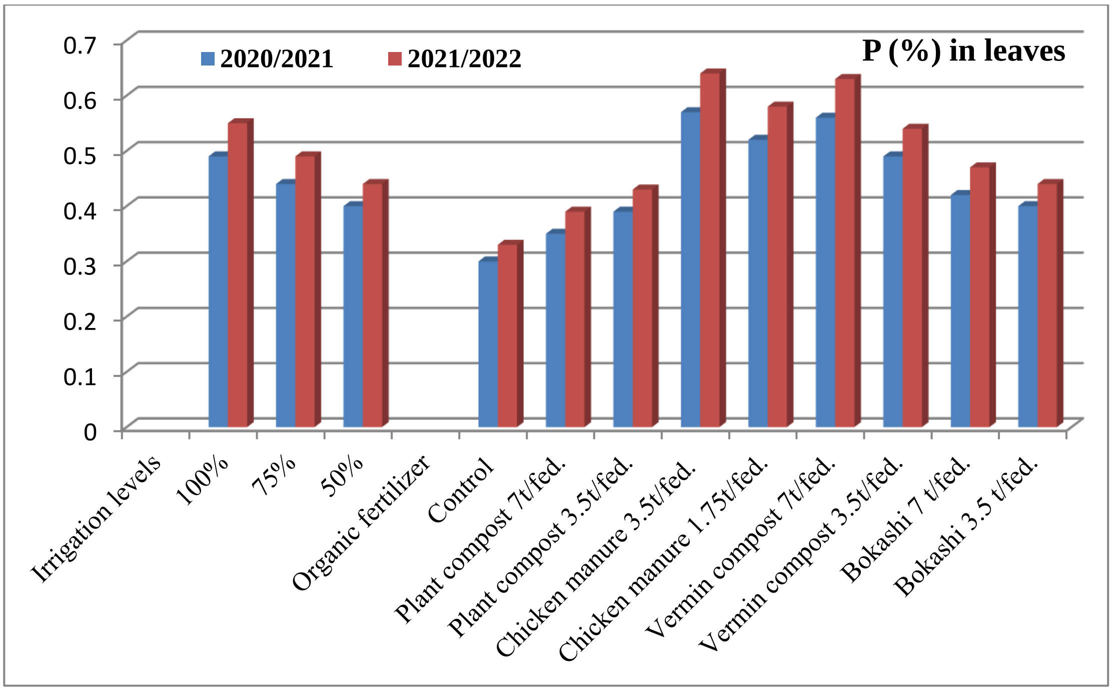

Fig. (9): Effect of irrigation levels and different organic fertilizer rates on P (%) in leaves during the 2020/2021 and2021/2022 seasons.

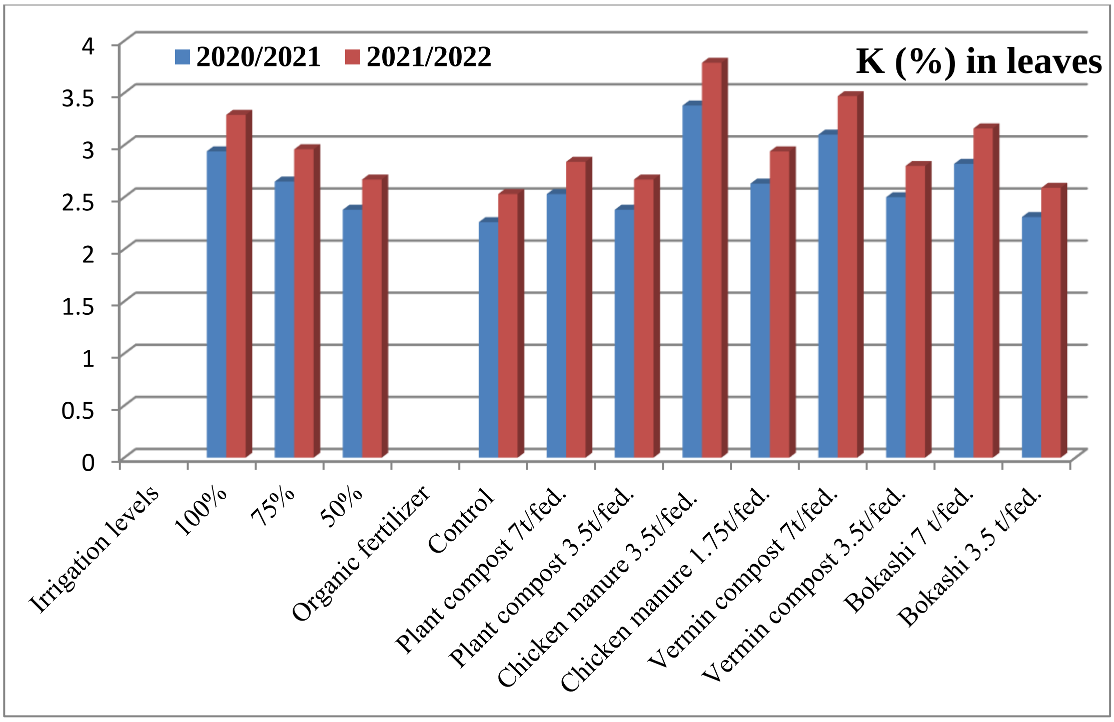

Fig. (10): Effect of irrigation levels and different organic fertilizer rates on K (%) in leaves during the 2020/2021 and2021/2022 seasons.

REFERNCES

Abou El-Goud, A.R.; Al-Masood, Fahd, R.; Elzopy, Karam A., Mona M. Yousry. (2021). „Performance Potato Cultivars in an Organic Farming System using Organic Fertilizers, Vermicompost and Azolla", Australian J. of Crop Science, 15(07), pp. 1081-1088, ISSN: 1835-2707, ESSN, 1835-2693.

Abou El-Goud, A.K. and, Mona M. Yousry. (2019). Organic summer squash production using chicken manure, compost and AMF for enhancing soil fertility. Current Science International. Vol. 08, No. 04, ISSN: 2077- 4435, EISSN:2706-7920, pp. 711-720.

Abou El-Gould AK (2020a). Efficiency response of Vermicompost and Vermitea levels on growth and yield of Eggplant *Solanum melongena*. Alexandria Sci Exchange J. 41(1): 69 -75.

Abou El-Gould AK (2020b). Organic cowpea *"Vigna unguiculate"* production by Smart Agritechnique of Organic Fertilizers Mixture" OFM" and Vermitea levels and Beneficial Microbes "BM". J Plant Prod.11(5): 399-405.

Abou El-Gould AK (2020c). Organic Watermelon Production by Smart Agri technique Using Organic Fertilizers, Vermitea levels and AMF in poor nutrients soil. Plant Arch. 20(2): 4107-4116.

Abou Kamer M. E., G. Abdel-Nasser2 , Mona M. Yousry (2022). Yield and Quality Performance of Some New Sweet Melon Lines Under Water Stress Conditions. Journal of the Advances in Agricultural Researches (JAAR) Volume: 27 (1): 148-161.

Ahmed, M.S. and S.M.K. Quadri (2009). Decision support systems: concepts, progress and issues, a review. In: Lichtfouse, E. (Ed.), Climate change, intercropping pest control and beneficial microorganisms, Sustainable agriculture review 2. Springer Science + Business Media B.V. Dordrecht, Netherlands, 373-399.

Al-Balikh, K. (2008). The Influence of kind and quantity of manure on productivity and quality characteristics for spring potato in raqqa province raqqa research center alfurat university, Faculty of Agriculture.

Al-Hisnawy, E. A. K. (2011). The effect of spraying organic fertilizer (LIQ Humus) on the growth and yield of three cultivars of potato plant *Solanum tubersum* L. M.Sc. Thesis. College of Agric. Univ. Kufa. Iraq. (in Arabic).

AOAC (1985). Official methods of analysis pp 490-510. Association of Official Analytical Chemists Washington, D.C.

Arash N., F. Golam and R. Kamaludin (2015). The impact of drought stress on morphological and physiological parameters of three strawberry varieties in different growing conditions. Pak. J. Agric. Sci., 52 (1), 79-92

Audi, W., J.N. Aguyoh and L. Gao-Qiong. (2013). Yield and quality of watermelon as affected by organic and inorganic nitrogen sources. Asian Journal of Agriculture and Food Science, 1:180–185.

Avetisyan, A., M. Hokhanyan, K. Herdt, L. Lund, A.L. Hykkerud, L. Jaakola and I. Martinussen (2021). Effect of organic fertilizer on growth of strawberry cultivar 'Sonata'. Acta Hortic. 1309: 629-634

Bhattacharyya, P., K. Chakrabarti and A. Chakraborty (**2003**). Effect of MSW compost on microbiological and biochemical soil quality indicators Compos Science and Utilization., 11(3): 220-227.

Chagas, K. L., T. V. A. Viana, D. V. Vasconcelos, G. G. Sousa and J. V. P. Filho (2018). Agronomic performance of strawberry plants under growing environments and organomineral fertilization. Pesq. Agropec. Trop., Goiânia, v. 48(4): 331-339

Chapman, H. D. and P.F. Pratt (1978). Method of Analysis for Soil and Water. 2nd Ed., Chapter, 17pp: 150-161. Uni. Calif. Div. Agric. Sci. USA**.**

Chen, B.M. and W.M. Mellenthin (1981). Effect of harvest date on ripening capacity and post-harvest life of Anjou pears. J. Amer. Soc. Hort. Sci., 106: 38-42.

EI Hamid, A.A.S., A.A. Abbou, S.A. Mansour and E.I. Sayed (2006). Effect of some biofertilizer on yield and fruit quality of strawberry. J. Agric. Sci., 10: 251-264.

FAO. (2020). Available online: https://www.fao.org/faostat/en/#data/QCL (accessed on 12 December 2020).

FAO. (2012). FAOSTAT. http://faostat.fao.org/site/339/default.aspx.

(FAO) (2019). Statistical Data Base. Crops; FAO: Rome, Italy,.

Gomes, E.D., F. Broetto, J.O.G..T. Queluz and D.F. Bressan (2015). Efeito da fertirrigação com potássio sobre osolo e produtividade do morangueiro. Irriga, 1: 107. **Gomez, K. A. and A. A. Gomez (1984).** Statistical Procedures for Agricultural Research. John Wiley and Sons. Inc., New York.

Grant O.M., A.W. Johnson, M.J. Davies, C.M. James and D.W. Simpson (2010). Physiological and morphological diversity of cultivated strawberry *(Fragaria × ananassa)* in response to water deficit. Environ. Exp. Bot., 68:264-272.

Hassanpanah, D. and J. Azimi (2012). Evaluation of 'Out Salt' anti-stress material effects on mini-tuber production of potato cultivars under in vivo condition. J. food Agric. Environ., 10(1): 256-259

Jackson, M.L. (1973). Soil chemical analysis, Prentice Hall of India private limited, New Delhi, P. 498.

Kachwaya, D. S., J.S. Chandel, N. Chauhan, V. S. Kuchi and M.C. Singh (2016). Performance of strawberry grown in open field conditions in relation to differential irrigation scheduling. J. Pharma. Phytochem., 7(2): 1977-1980.

Kumar, **R., P. Bakshi, M. Singh, A.K. Singh, V. Vikas, J.N. Srivatava, V. Kumar and V. Gupta, (2018).** Organic production of strawberry: A review. Int. J. Chem. Stud., 6: 1231–1236.

Sri Anjar Lasmini* 1 , Burhanuddin Nasir2 , Nur Hayati1 , Nur Edy (2018). Improvement of soil quality using bokashi composting and NPK fertilizer to increase shallot yield on dry land. AJCS 12(11):1743-1749 (2018) ISSN:1835-2707

Li W, Bhat SA, Li J, Cui G, Wei Y, Yamada T, Li F (2020). Effect of excess activated sludge on vermicomposting of fruit and vegetable waste by using novel vermireactor. Bioresource Technol. 302: 122816.

Malik, C.P. and M.B. Singh (1980). Plant enzymology and histoenzymology. Atext manual, kalyani publishers, New Delhi**.**

Martínez-Ferri, E., C. Soria, M.T. Ariza, J.J. Medina, L. Miranda, P. Domíguez and J.L. Muriel (2016). Water Relations, Growth and Physiological Response of Seven Strawberry Cultivars *(Fragaria × Ananassa Duch.)* to Different Water Availability. Agricultural Water Management, Enhancing plant water use efficiency to meet future food production, 164(1): 73–82.

Mona, M. Yousry and Amal K.Abou El-Goud .(2020). Response of watermelon (*Citrullus lanatus*) to plant compost, kitchen wastes and chicken manure composted with PGPR microbes as Bio-Organic fertilizers. Scientific Journal of Agricultural Sciences 2 (2): 29-37.

Mona, M. Yousry , Sameh A. M. Moussa , and G. Abdel-Nasser (2021). Response of Some Faba Bean Genotypes to Irrigation Water Deficit Grown in Sandy Soil. Alex. Sci. Ex. J., 42(3): 677-693.

Morales-Quintana, L., M. Moya, R. Santelices-Moya, A. Cabrera-Ariza, C. Rabert, S. Pollmann and P. Ramos (2022). Improvement in the physiological and biochemical performance of strawberries under drought stress through symbiosis with Antarctic fungal endophytes. Front. Microb., 13: 939955.

Najar IA, and Khan AB (2013). Effect of vermicompost on growth and productivity of tomato (*Lycopersicon esculentum*) under field conditions. Acta Biol Malaysiana. 2(1): 12-21.

Odongo, T., D.K. Isutsa and J.N. Aguyoh (2008). Effects of integrated nutrient sources on growth and yield of strawberry grown under tropical high altitude conditions. Afr. J. Hort. Sci., 1: 53–69.

Piya S, Shrestha I, Gauchan DP, Lamichhane J (2018). Vermicomposting in organic Agriculture: Influence on the soil nutrients and plant growth. Int J Res. 5(20): 1055-1063.

Perin, E. C., R. S. Messias, V. Galli, J. M. Borowski, E. R. Souza, L.O. Avila, A. L. Bamberg and C. V. Rombaldi (2019). Mineral content & antioxidant compounds in strawberry fruit submitted to drought stress. Food Sci. Technol. Compinas, 39 (1): 245-254.

Tandon, H. (1995). Methods of Analysis of soil, plants, waters and fertilizer, p: 144. Fertilizers development and consultation organization, New Delhi, India.

Wang, S.Y. (2014). Antioxidants and Health Benefits of Strawberries. Acta Hortic., 1049: 49–62

Yuan, B.Z., J. Sun and S. Nishiyama (2004). Effect of Drip Irrigation on Strawberry Growth and Yield inside a Plastic Greenhouse. Biosys. Eng., 87(2): 237-245

Zaman, A., A. Sarkar, S. Sarkar and W.P. Devi (2011). Effect of organic and inorganic sources of nutrients on productivity, specific gravity and processing quality of potato (*Solanum tuberosum*). Ind. J. Agric. Sci., 81(12): 1137–1142.

Zuo, Y., J. Zhang, R. Zhao, H. Dai and Z. Zhang (2018). Application of vermicompost improves strawberry growth and quality through increased photosynthesis rate, free radical scavenging and soil enzymatic activity. Scientia Horti., 233:132–140

الملخص العربي

استجابة الفراولة لإضافات الأسمدة العضوية المختلفة تحت تأثير مستويات الري

كرم الزوبى[1]، مبارك جمال[3]، آمال كرم [2]، سيد منصور [3] ، منى محمد يسرى[4]

1 قسم الأراضي والكيمياء الزراعية – كلية الزراعة (سابا باشا) – جامعة الاسكندرية

2 قسم بحوث البطاطس والخضر خضرية التكاثر – معهد بحوث البساتين – مركز البحوث الزراعية

3 قسم النبات الزراعى– كلية الزراعة – جامعة دمياط

4 قسم الإنتاج النباتي– كلية الزراعة (سابا باشا)– جامعة الأسكندرية

أجريت تجربتان حقليتان بمزرعة خاصة بمنطقة (عبد السلام عارف - مركز بدر - محافظة البحيرة) - مصر، خلال موسمي الزراعة الشتوية (2021/2020 و2022/2021), لدراسة إنتاج الفراولة عضوياً تحت مستويات الري المختلفة المنزرعة في أرض رملية. صممت التجربة بتصميم القطع المنشقة بثلاث مكررات، حيث تم ترتيب مستويات الري الثلاثة (100، 75 و 50٪) في القطع الرئيسية، بينما الأسمدة العضوية الأربعة الأخرى (الكنترول ، الكمبوست النباتي (3.5 و7 طن / فدان)، سماد الدواجن (1.75 و 3.5 طن / فدان) ، سماد الفيرمى كمبوست (3.5 و7 طن / فدان)، والبوكاشي (3.5 و 7 طن / فدان) في القطع تحت الرئيسية. أظهرت النتائج أن مستويات الري 100٪ سجلت أعلى قيم للنمو الخضري (ارتفاع النبات– وزن النبات الطازج – عدد الأوراق ومساحة الورقة والكلوروفيل الكلي)، وأيضًا، سجلت مستويات الري عند 100٪ أعلى متوسط قيم لخصائص المحصول (طول الثمرة ، وزن الثمرة ، المحصول / نبات والمحصول / فدان) كما أعطت زيادة معنوية في المحتوى الكيميائي للصفات المدروسة مثل المواد الصلبة الذائبة الكلية، الحموضة الكلية والسكريات الكلية وفيتامين سي في الثمار ونسبة النيتروجين والفوسفور والبوتاسيوم في الأوراق مقارنة بالمعاملة الأخرى خلال الموسمين ، ومن ناحية أخرى، أدى استخدام الأسمدة العضوية المختلفة إلي زيادة معنوية لهذه الصفات، حيث وجد إن الفيرميكومبوست بمعدل 7 طن / فدان. سجل زيادة معنوية في طول النبات، الوزن الطازج للنبات، مساحة الأوراق والكلوروفيل الكلي، طول الثمرة في الموسم الثاني، وزن الثمرة، المحصول / نبات والمحصول / فدان (في الموسم الأول) ، النسبة المئوية للمواد الصلبة الذائبة ، محتوى فيتامين سي، بينما روث الدجاج 3.5 طن/ فدان سجل زيادة معنوية في عدد الأوراق، طول الثمرة في الموسم الأول، المحصول/ نبات والمحصول/ فدان (في الموسم الثاني) ، النسب المئوية للنيتروجين والفوسفور والبوتاسيوم في الأوراق، خلال الموسمين مقارنة بالمعاملات العضوية الأخرى والكنترول، كما سجلت معاملة الكنترول أعلي القيم للنسبة المئوية للحموضة الكلية خلال كلا الموسمين.