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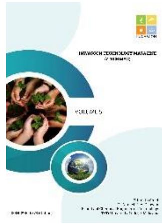

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RESEARCH ARTICLE

AN ECONOMIC STUDY OF THE IRRIGATION PERIODS' EFFECTS ON SOME SOIL PROPERTIES AND FABA BEAN CROP PRODUCTIVITY

Khaled A. H. Shaban[a], Samia E. A. Hatem[b], Rama T. Rashad[a,*], Rania G.M . Hleal[b]

[a]Soils, Water and Environment Research Institute, Agricultural Research Center, Giza, Egypt. P.O. Box: 175 Orman,
[b]Agricultural Economics Research Institute -Agricultural Research Center, Giza, Egypt
****Corresponding Author Email:rama.mostafa@arc.sci.eg***

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ABSTRACT

This study aims to economically evaluate the water use efficiency at three rates of irrigation (1, 2, and 3) with the comparison between using 11.9 ton ha^{-1} application rate of the biochar and/or compost along with the mineral fertilization on the yield and quality of the faba bean crop. Two field experiments were conducted at El-Qantara Sharq farm Ismailia Governorate, Egypt, (winter seasons of 2020/2021 and 2021/2022) in a split-plot design with three replicates. The main factor F1 was the irrigation rates: rate 1 (3571.43 m^3 ha^{-1}), rate 2 (4761.90 m^3 ha^{-1}), and rate 3 (5952.38 m^3 ha^{-1}) while the sub-factor F2 was the type of the soil additive (biochar, compost or mineral). The soil-available N (mg kg^{-1}) has increased relative to that before cultivation in the range 11.3 – 55.5% that was non-significant due to the irrigation rates (main factor F1) but a significant due to the soil additives (sub-factor F2). The studied irrigation rates as well as the soil additives have increased the soil-available concentration (mg kg^{-1}) of K, Mn, and Zn significantly and the available P, and Fe but non-significantly at $p < .05$. The most significant relative increase compared to the soil-available content (mg kg^{-1}) before cultivation was found for the compost at the irrigation rate 3 by 6.9% for K, 78.3% for Mn, and by 44.1% for Zn. The increase in the available nutrients followed the order irrigation rate 1 (3571.43 m^3 ha^{-1}) < rate 2 (4761.90 m^3 ha^{-1}) < rate 3 (5952.38 m^3 ha^{-1}) and the order mineral < biochar < compost. The increased yield (ton ha^{-1}) of pods and seeds at the rate 3 relative to rate 1 was by 6.1% and 28.4% for the mineral fertilization, by 11.6% and 13.4% for the biochar, and by 15.0% and 26.1% for the compost, respectively. This increase was dependent on both factors F1 and F2 since their interaction was highly significant. At the irrigation rate 3, the total costs increased in the direction biochar (13095 LE) < compost (13333 LE) < mineral (14404 LE). The maximum net return was at the irrigation rate 2 for the compost (36837 LE) followed by the biochar (34010 LE) then at the rate 3 for the mineral fertilization (28326 LE). The return and net return with respect to the costs were also increased in the same order: rate 2 (compost) > rate 2 (biochar) > rate 3 (mineral). The application of the compost and/or the biochar is more efficient at the rate 2 than the single use of the mineral fertilization that need greater level of the irrigation water otherwise the yield decreases. The maximum water unit return has increased by 32.3% and 21.9% for the compost and biochar at rate 2, respectively, relative to the mineral at rate 1.

KEYWORDS

Biochar; Compost; Irrigation rates; Faba Bean; Water use efficiency (WUE)

1. INTRODUCTION

The climate changes leading to the drought and desertification are severely affecting the agricultural sector. The elevated evapo-transpiration rates of plants in the arid regions cannot be replenished by rains making the irrigation is a fundamental practice**.** The water resources worldwide and particularly in Egypt have been decreased from ~ 2500 to 700 m^3 capita/year during the years 1950's/2015 and is expected to be 250 m^3 by the year 2050 due to the continuously increasing population. The irrigated agriculture along with the water deficit is a challeng in Egypt being more than 95% of its area is a desert soil (El-Habashy et al 2021; Min et al., 2016).

Agriculturally, the water stress negatively affects the plant metabolic processes and the most sensitive cellular expansion and development that lead to morphological traits like the reduced leaf area and stem diameter (Efeoglu et al., 2009). Developing policies and technologies for an advanced irrigation-saving knowledge are required to improve the use efficiency of the irrigation water with the quantitative and qualitative keeping of crop production (Pereira et al., 2012; Abd El-Mageed et al., 2021).

Surface irrigation is the traditional irrigation method applied in about 80% of the irrigated area in Egypt with greater water losses. The farmers usually pump irrigation water from the Nile River and its tributaries so that the water pricing is a complicated topic due to economic and political reasons. The economists think about the value of the secondary products of the irrigation water as good cost estimation and a measure of a firm's returns obtained by the last unit of a productive factor employed. For the studied crops, the value can be derived from the previously estimated linear and double logarithmic production functions (El-Shahat et al., 2013).

Recycling of the agricultural wastes such as crops residues has produced two types of the effective soil amendments that enhance the soil fertility, quality and productivity, which are the compost and biochar. Compost has been prepared by a long-time (>90 days) bio-oxidative processes in which the microorganisms play an essential role to mineralize the organic matter producing a stabilized final product containing humic substances (complex organic molecules) that is free of pathogens and toxics. Biochar has been made by the slow pyrolysis ~ 350 °C with a short-residence time of few hours in which the start organic residues become more mineral-like upon heating. Such mineral transformations create a skeletal structure looks like a carbon sponge (Liu et al., 2021). The organic carbon in the biochar is from the re-condensed vapours along with the incompletely carbonized char prepared at low temperature. It is the black carbon produced due to the incomplete combustion of the organic matter (OM) resistant to the decomposition and degradation because of its condensed aromatic structure (Schulz and Glaser, 2012). Biochar is a highly hydrophobic carbonaceous residue produced by the thermal breakdown of organic materials under limited conditions of oxygen. It is characterized by hydrophobic groups such as acid anhydrides (C-C and C-O); carboxylate (CO_2), aromatic ketones (C=O), silanol (Si-O-H), and carbonates (C-O) (Duarte et al., 2019).

Some agricultural soils may lose between 25% to 75% of their original organic carbon because of the nitrogen (N) fertilization along with the tillage that accelerates the microbial respiration and burn up the soil carbon faster than it is replaced. These soils need repeated feed with irrigation water, mineral nutrients, and pesticides to produce crops. Both the compost and biochar can remediate the soil providing some benefits like reducing the bulk density, increasing the water holding capacity and support the microbial life and biodiversity. They enrich the soil organic carbon, increase the retention of nutrients dissolved from the fertilizer for the absorption by plant with decreasing their leaching loss that increase the crop yield (Rosenani, et al., 2014).

The soil amendments such as the biochar and compost can be used to reduce the applied water quantities. Biochar improves the water retention by soil and its available water AW. This is commonly observed in the coarse-textured soils (El-Habashy et al., 2021). The biochar application rates of 5 and 10 tons ha^{-1} had significantly increased the seed yield by 25.8 and 38.7%, respectively, compared to the control. It had improved the soil properties, plant growth, physiological response, N, P and K contents in soil and faba bean plant under deficit irrigation (Abd El-Mageed et al., 2021).

Compost applied to a desert soil improves the organic matter (OM) and reduces the evaporation from the surface that maintains the soil moisture available for the plant (Curtis and Claassen 2005). Combined application of compost with mineral nitrogen fertilizers slightly decreased the pH in the tested soil and increased the available N, P , K , Fe , Mn and Zn content of saline soil and uptake in straw and grain (Taha et al ., 2016; Ibrahim et al., 2011).

Faba bean (*Vicia faba* L.) is one of the most important legume food crops being a source of plant protein and as a good break crop in the intensive cereal farming systems. The planted area in Egypt during the recent five years perhaps is more than 270 ha producing about 3504.8 kg ha^{-1} (~9.2 ardab/feddan) with a continuous demand and need to improve its quality and productivity (FAO, 2019). This study aims to evaluate economically the water use efficiency at three rates of irrigation (1, 2, and 3) with the comparison between using the biochar and compost along with the mineral fertilization on the yield and quality of the faba bean crop.

2. Materials and Methods

Two field experiments have been carried out at El-Qantara Sharq, Ismailia governorate, Egypt, during the winter seasons of 2020/2021 and 2021/2022. The main factor F1 was the irrigation rates: rate 1 (3571.43 m^3 ha^{-1}), rate 2 (4761.90 m^3 ha^{-1}), and rate 3 (5952.38 m^3 ha^{-1}) while the sub-factor F2 was the type of the soil additive (biochar, compost or mineral). Triplicate treatments were distributed in a split-plot design.

The irrigation water was from El-Salam canal (Nile water mixed with agriculture daring 1:1) applied via a surface-flow irrigation system consists of line pipes connected to a meter for measuring the applied water volume. The available water (AW) in soil was calculated as the difference between the field capacity (FC) and the wilting point (WP) assuming that the extracting depth of the faba bean roots is from 0.15 to 0.30 m.

Biochar and compost additives were prepared from some plant sources such as the straw of rice, wheat, maize, and faba bean along with the trees' leaves then applied to soil 15 day before the sowing at 11.9-ton ha^{-1} application rate.

Air-dried surface soil samples (0–30 cm) were crushed and sieved by a 2 mm sieve then kept for analysis before cultivation. Some properties of the experiment soil before sowing, irrigation water, biochar, and compost were presented in Table 1 according to the standard methods described by (Klute, 1986; Cottenie et al., 1982; Page et al., 1982; Brunner and Wasmer, 1978).

Table 1: Main characteristics of the experiment soil at EL-Qntara Sharq, the irrigation water from El-Salam Canal, biochar and compost

Soil	Coarse sand (%)	Fine sand (%)	Silt (%)	Clay (%)	Texture	Moisture content (%) FC	WP	AW	OM (%)	$CaCO_3$ (%)
	15.62	62.50	8.30	13.58	Loamy sand	20.80	10.55	13.55	0.67	4.88

Chemical analysis	pH	EC ($dS\ m^{-1}$)	Cations ($meq\ L^{-1}$) Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	Anions ($meq\ L^{-1}$) HCO^{-}_3	Cl^{-}	SO^{-2}_4
Soil	7.95*	5.30	10.62	17.90	23.63	0.85	7.40	19.84	25.78
Water	7.98	1.59	2.10	5.19	8.10	0.51	1.66	7.58	6.66
Biochar	7.99	4.20	(C/N = 20.64)			Moisture = 20%			
Compost	7.22	3.50	(C/N = 21.85)			Moisture = 20%			

	Nutrients N	P	K	Fe	Mn	Zn
Soil (Available, $mg\ kg^{-1}$)	33.70	7.39	175.00	3.44	1.20	0.59
Water (Soluble, $mg\ L^{-1}$)	7.40** 14.88***	6.39	10.44	1,22	0.86	0.24
Biochar ($g\ kg^{-1}$)	14.0	19.8	29.5	0.259	0.088	0.050
Compost ($g\ kg^{-1}$)	18.2	8.8	24.5	0.124	0.079	0.044

*(1:2.5) soil: water suspension ** NO3-N *** NH4-N

Faba Bean (*Vicia faba* L.) seeds Giza 843 were obtained from the Legume Department, Field Crops Research Institute, Agricultural Research Center, Giza, Egypt and sown on the 20th of November (2020/2021 and 2021/2022). The area of the experimental unit was 5 × 4 m^2 divided into 75 cm separated rows. Three to four seeds were sown in holes of 5 cm depth and 25 cm distance. After 31 day of sowing, the plants in each hole were thinned to one plant.

Mineral fertilization has included the super phosphate (15.5% P_2O_5 - 476.19 kg ha^{-1}) applied during the soil tillage, urea (46% N – 71.43 kg ha^{-1}) three equal doses applied 31, 45 and 65 days after sowing, in addition to the potassium sulphate (48% K_2O – 178.57 kg ha^{-1}) two equal doses applied 31 and 45 days after sowing. The three irrigation rates (rate 1 = 3571.43 m^3 ha^{-1}, rate 2 = 4761.90 m^3 ha^{-1}, and rate 3 = 5952.38 m^3 ha^{-1}) were applied during the planting seasons.

Some climatic elements of the experiment location like the air temperature (T, C°), mean relative humidity (RH, %), wind speed (U_2, m sec^{-1}), evaporation pan (Ep, mm d^{-1}) and rainfall (Rf, mm) during the two growing seasons are presented in Table 2. The climatic data were recorded by El-Quantara Sharq climatic Station The water use efficiency (WUE) was calculated according as follows: The crop yield (Y, Kg ha^{-1}) / the applied rate of the irrigation water (m^3 ha^{-1}) to (FAO, 1982).

Table 2: Some climatic elements of the experiment location like the air temperature (T, C°), mean relative humidity (RH, %), wind speed (U2, m sec^{-1}), evaporation pan (Ep, mm d^{-1}) and rainfall (Rf, mm)

Month	Temperature (°C)			Relative humidity (%)	Wind speed (mm sec^{-1})	Evaporation pan (mm d^{-1})	Rainfall (mm month^{-1})
	Mix	Min	Mean				
Nov	23.45	13.88	18.70	72.90	0.85	3.10	00.00
Dec	18.90	9.80	14.35	78.30	0.66	5.29	75,89
Jan	17.44	7.40	12.42	81.40	0.58	4.22	88.40
Fab	19.20	5.40	12.30	82.10	0.77	2.18	90.49
Mars	22.88	12.88	11.92	79.44	0.85	3.50	77.40
Apr	28.40	17.25	22.82	73.98	1.08	5.12	35.87
May	31.86	20.18	26.02	78.60	1.02	3.66	00.00

At harvest, ten plants from each plot were selected randomly as a representative sample to measure the plant height (cm), number of branches/plant, weight of pods/plant (g), weight of seeds/plant (g), 100 seed weight (g), yield of pods and seeds (ton ha^{-1}).

2.1 Plant Analysis

Faba bean seeds and straw were oven-dried for 48 h at 70 ºC and ground. A half gram of the powdered seeds and/or straw was acid digested using the mixed $H_2SO_4/HClO_4$ (4:2) (Chapman and Pratt, 1961). The N, P, K, Fe, Mn and Zn concentrations in the plant extracts were measured using the Kjeldahl apparatus, colorimetrically by the UV-Vis. Spectrophotometer, by flame photometer, and by the ICP Spectrometry (ICP-*Ultima 2 JY* Plasma), respectively (Cottenie et al., 1982; Page et al., 1982). All results were the average values of the two seasons.

The photosynthetic pigment Chlorophyll (a, b) as well as the carotenoids were estimated in the fresh leaves as described by (Witham et al., 1071). The total carbohydrates were determined in the dry leaves according to (Dubois et al., 1956). The seeds' protein (%) was calculated as the N (%) × 6.25 (Hymowitz et al., 1972).

The obtained data were statistically analysed to calculate the treatments statistical significance (LSD) at $P \leq .05$ using the COSTAT program (Gomez and Gomez, 1984).

3. Results

3.1 Effect of The Irrigation Rates and Soil Additives on The Soil-Available Nutrients

The soil-available N (mg kg^{-1}) has increased relative to that before cultivation in the range 11.3 – 55.5% that was non-significant due to the irrigation rates (main factor F1) but a significant due to the soil additives (sub-factor F2) according to the Table 3. The studied irrigation rates as well as the soil additives have increased the soil-available concentration (mg kg^{-1}) of K, Mn, and Zn significantly and the available P, and Fe but non-significantly at $p < .05$. The most significant relative increase compared to the soil-available content (mg kg^{-1}) before cultivation was found for the compost at the irrigation rate 3 by 6.9% for K, 78.3% for Mn, and by 44.1% for Zn. The increase in the available nutrients followed the order irrigation rate 1 (3571.43 m^3 ha^{-1}) < rate 2 (4761.90 m^3 ha^{-1}) < rate 3 (5952.38 m^3 ha^{-1}) and the order mineral < biochar < compost. The factors F1 and F2 showed an independent effect on the available N, P, K, Fe, and Zn since the F1 × F2 interaction was non-significant. The significant increase of the Mn available in soil may be dependent on both the irrigation rate and the soil additives.

Table 3: Soil-available concentrations (mg kg^{-1}) of the macro- and micro-nutrients after harvesting

Irrigation rates (m^3 ha^{-1})	Treatments	Available nutrients (mg kg^{-1})					
		N	P	K	Fe	Mn	Zn
3571.43	**Mineral**	37.50	7.95	176.40	3.77	1.67	0.63
	Biochar	39.59	8.06	179.40	3.80	1.75	0.69
	Compost	41.33	8.54	180.57	3.93	1.83	0.72
4761.90	**Mineral**	44.39	8.12	177.12	3.86	1.86	0.67
	Biochar	45.84	8.16	182.55	3.98	1.95	0.77
	Compost	46.40	8.95	185.30	4.09	2.09	0.78
5952.38	**Mineral**	45.72	8.33	178.75	3.94	1.99	0.72
	Biochar	48.50	8.66	184.70	4.07	2.05	0.79
	Compost	52.40	9.13	187.10	4.15	2.14	0.85
$LSD_{5\%}$ Irrigation levels		**ns**	**ns**	**2.31**	**ns**	**1.06**	**0.009**
$LSD_{5\%}$ Soil additives		**1.41**	**ns**	**1.37**	**ns**	**1.06**	**0.019**
Significance of Interaction		**ns**	**ns**	**ns**	**ns**	*******	**ns**

Similar studies have mentioned that the compost and biochar application may increase the fertilizer efficiency and the available N, P and K in soil under different levels of irrigation water by decreasing the nutrients loss (Cong et al., 2022; Adugna, 2016). It had been found that the increased irrigation water period from El-Salam canal gave increments in the micronutrients content in a saline soil (Abou Hussien and Shaban, 2008; Mousa and Shaban, 2017; Ibrahim et al., 2011).

3.2 The effect of the irrigation rates and soil additives on the Faba bean productivity

ata presented in Table 4 indicate that both the studied irrigation rates and soil additives significantly increased the plant height (cm), number of branches/plant, weight of pods/plant (g), weight of seeds/plant (g), weight of 100 seeds (g) as well as the yield of pods and seeds (ton ha^{-1}). The significant increase in the mentioned parameters at $p < .05$ followed the order irrigation rate 1 (3571.43 m^3 ha^{-1}) < rate 2 (4761.90 m^3 ha^{-1}) < rate 3 (5952.38 m^3 ha^{-1}). The increased yield (ton ha^{-1}) of pods and seeds at the rate 3 relative to rate 1 was by 6.1% and 28.4% for the mineral fertilization, by 11.6% and 13.4% for the biochar, and by 15.0% and 26.1% for the compost, respectively. This increase was dependent on both factors F1 and F2 since their interaction was highly significant. These results are in consistence with previous studies (Atta et al., 2002; Mousa and Shaban 2017; Poormansour and Razzaghi, 2018; Poormansour et al., 2019; Rezaie et al., 2019).

Table 4: The effects of the irrigation rates and/or soil additives on the Fababean productivity

Irrigation rates (m³ ha⁻¹)	Treatments	Plant height (cm)	No. branches /plant	Weight of pods /plant (g)	Weight of seeds /plant (g)	Weight of 100 seeds (g)	Yield of Pods (ton ha⁻¹)	Yield of seeds (ton ha⁻¹)
3571.43	**Mineral**	79.40	4.30	85.30	55.30	70.22	3.93	2.50
	Biochar	85.40	5.88	88.00	58.33	74.20	4.48	2.69
	Compost	94.30	6.88	93.22	63.20	77.50	4.60	2.83
4761.90	**Mineral**	87.10	5.29	89.40	59.30	75.40	4.02	2.74
	Biochar	96.30	7.34	99.60	65.30	83.00	5.07	3.48
	Compost	104.98	8.10	105.20	74.60	88.40	5.33	3.71
5952.38	**Mineral**	93.90	5.88	90.39	62.49	77.40	4.17	3.21
	Biochar	110.00	6.29	96.34	63.90	77.60	5.00	3.05
	Compost	115.30	7.55	99.10	69.00	82.50	5.29	3.57
$LSD_{5\%}$ Irrigation levels		**1.18**	**0.46**	**2.62**	**0.007**	**2.57**	**0.070**	**0.068**
$LSD_{5\%}$ Soil additives		**1.46**	**0.49**	**2.85**	**1.19**	**1.45**	**0.028**	**0.044**
Significance of Interaction		***	ns	ns	**	**	***	***

3.3 The effect of the irrigation rates and soil additives on the total concentration of the macro- and micro-nutrients in the faba bean seeds

As the irrigation rate increased from the rate 1 (3571.43 m³ ha⁻¹) to the rate 3 (5952.38 m³ ha⁻¹), the nutrients' concentration in the faba bean seeds was increased significantly (except for the N that was non-significant respecting the irrigation) for the studied soil additives as presented in Table 5. The seeds' N content (g kg⁻¹) was increased at rate 3 relative to rate 1 by 18.2%, 38.3%, and 46.1% for the mineral, biochar, and compost, respectively. Also, the seeds' P and K contents (g kg⁻¹) were increased by 28.9 and 18% for the mineral, 26.2 and 7.3% for the biochar, and by 28.9 and 8.5% for the compost, respectively.

Table 5: Total concentration of the macro- and micro-nutrients in the faba bean seeds

Irrigation rates (m³ ha⁻¹)	Treatments	Total concentration					
		Macronutrients (g kg⁻¹)			Micronutrients (mg kg⁻¹)		
		N	P	K	Fe	Mn	Zn
3571.43	**Mineral**	27.5	3.8	24.4	75.70	43.20	24.90
	Biochar	29.8	4.2	27.5	77.80	45.30	27.50
	Compost	31.0	4.5	28.3	79.00	48.50	28.94
4761.90	**Mineral**	29.7	4.4	27.5	79.30	44.99	25.39
	Biochar	32.8	4.8	27.9	82.60	46.40	30.22
	Compost	39.5	5.3	29.5	84.30	53.80	35.89
5952.38	**Mineral**	32.5	4.9	28.8	81.40	46.30	27.80
	Biochar	41.2	5.3	29.5	85.30	49.20	35.10
	Compost	45.3	5.8	30.7	87.40	55.30	39.00
$LSD_{5\%}$ Irrigation levels		**ns**	**0.013**	**0.015**	**0.44**	**1.15**	**0.49**
$LSD_{5\%}$ Soil additives		**4.5**	**0.008**	**0.017**	**1.74**	**1.68**	**1.47**
Significance of Interaction		ns	ns	***	ns	ns	**

The micronutrients in the faba bean seeds in Table 5 showed a similar behavior under the effect of the studied factors. Their concentrations (mg kg⁻¹) have increased at the irrigation rate 3 relative to rate 1 as follows: the Fe, Mn, and Zn were increased by 7.5, 7.2, 11.6% for the mineral, by 9.6, 8.6, 27.6% for the biochar, and by 10.6, 14, and 34.8% for the compost, respectively. The K and Zn concentration in seeds was dependent on both the irrigation rates and soil additives as their statistical interaction was significant at $p < .05$. In contrast, the individual effect of the irrigation rates was independent of that of the soil additives for the N, P, Fe, and Zn content in seeds since their interaction was non-significant.

It had been found that biochar and compost application significantly increased the uptake of the N, P, and K by the Stover and grains. The uptake was significantly affected by the irrigation regimes (Abd El-Kader et al., 2010; Awadalla et al., 2018; Abdel Azeem, 2020; Gomaa and Afifi, 2021).

3.4 The effect of the irrigation rates and soil additives on the protein (%), carbohydrate (%) and chlorophyll (mg g f.w⁻¹) in the faba bean seeds

The faba bean seeds' contents of the protein (%); carbohydrate (%) and chlorophyll (mg g f.w⁻¹) shown in Figures 1, 2, and 3 respectively were almost significantly increased in the direction mineral < biochar < compost affected by the irrigation rates 1, 2, and 3. The protein has increased at rate 3 relative to rate 1 by 18.2%, 38.2%, 46.1% for the mineral, biochar, and compost, respectively. The increase in the carbohydrates was by 7.9%, 7.8%, 9.9% and the chlorophyll by 19.1%, 6.9%, and 10.7% for the mineral, biochar, and compost, respectively. The interactive effect of the irrigation rates and soil additives was complementary for the seeds protein as their interaction was significant but independent for the carbohydrates and chlorophyll with non-significant interaction.

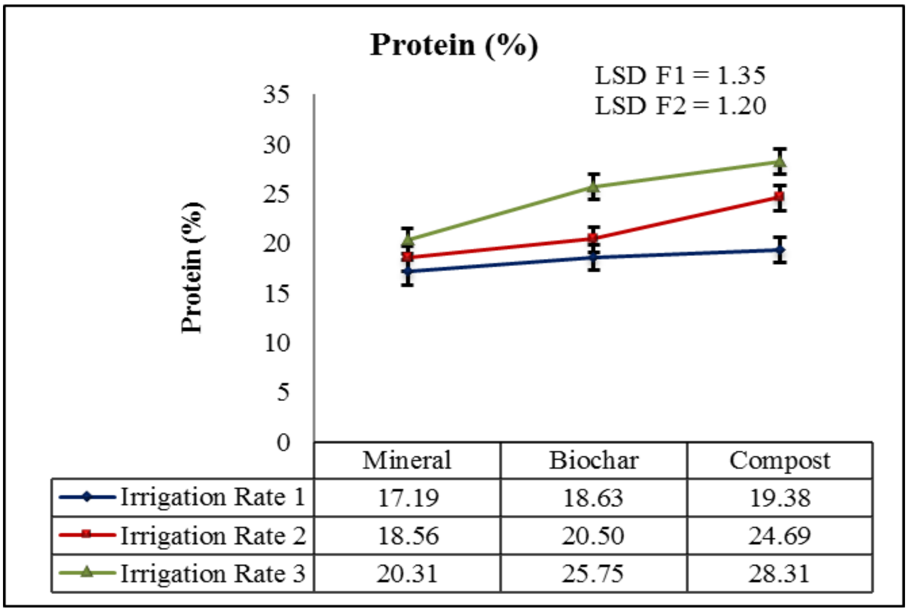

Figure 1

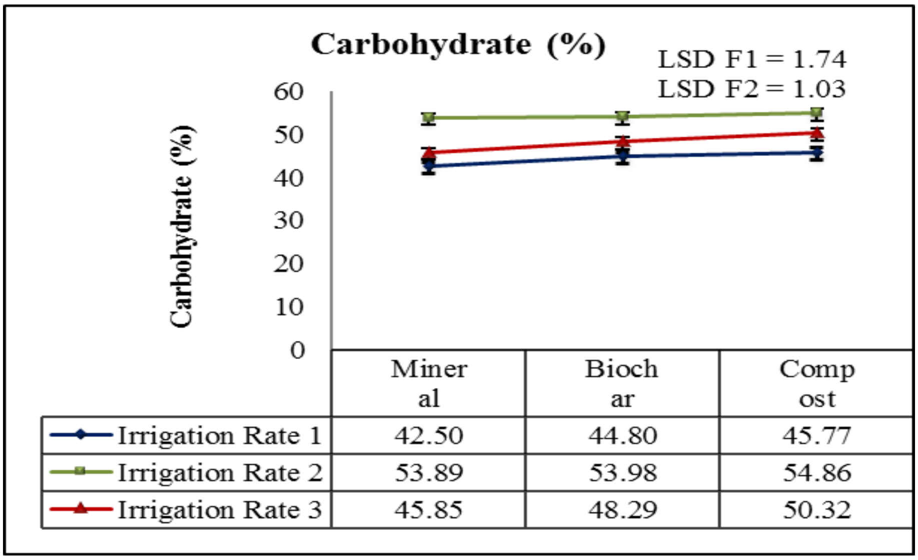

Figure 2

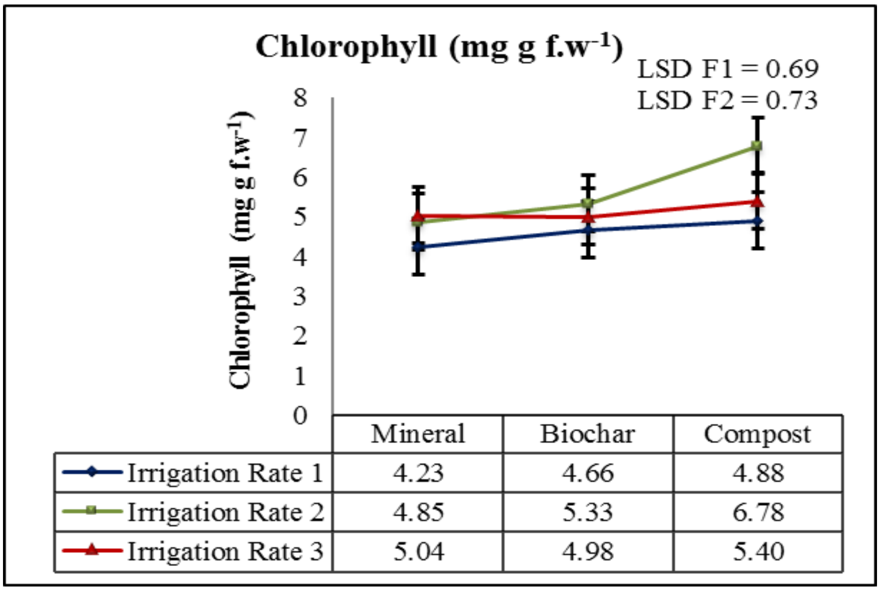

Figure 3

It has a reported tha chloropt the increased amount of irrigation water during the vegetative and reproductive growth of faba bean enhances the photosynthesis resulting in more synthesis and accumulation of food material which leads to higher yield and its components (Awadalla et al., 2018).

3.5 Water use efficiency (WUE)

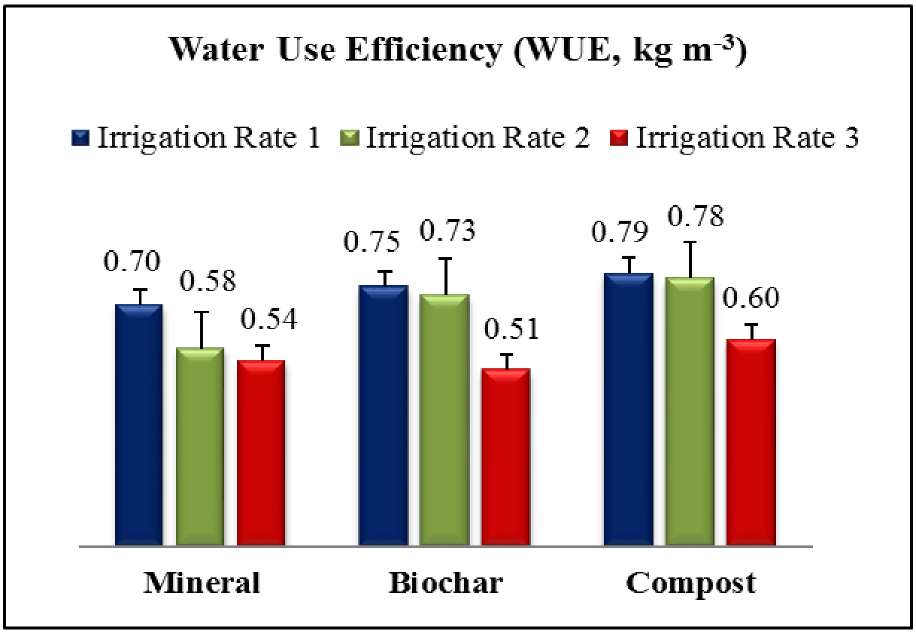

Figure 4

The WUE (kg m^{-3}) was decreased as the irrigation rate increased as mentioned by the Figure 4 for the mineral, compost, and biochar applications. At the rate 3, the WUE was decreased by 22.86%, 32%, and by 24.05% relative to the rate 1 for the mineral, biochar, and compost, respectively (Fayed et al., 2018; Noah et al., 2010; Dong et al., 2019; Aly 2020).

3.6 An economic evaluation of the Faba Bean productivity under the effect of the studied irrigation rates combined with the applied soil additives

Table 6: The most important economic variables for the Faba bean cultivation and harvesting

Treatments	Mineral			Biochar		Compost			
Irrigation rates (m^3 ha^{-1})	3571.4	4761.9	5952.4	3571.4	4761.9	5952.4	3571.4	4761.9	5952.4
Tillage Costs (L.E. ha^{-1})	1785.7								
Sowing Costs (L.E. ha^{-1})	2381.0								
Employment Costs (L.E. ha^{-1})	3571.4								
Fertilizers Price (L.E.)	2381.0								
Fuel price (L.E.)	2857	3571	4285	2261	2619	2976	2357	2857	3214
Total costs	12976	13690	14404	12381	12738	13095	12476	12976	13333
Productivity of Seeds (ton ha^{-1})	2.50	2.74	3.21	2.69	3.48	3.05	2.83	3.71	3.57
Productivity of Pods (ton ha^{-1})	3.93	4.02	4.17	4.48	5.07	5.00	4.60	5.33	5.29
Seeds price (L.E.)	12065								
Pods price (L.E.)	948								
Revenue (L.E.)	33888	36869	42681	36701	46792	41538	38504	49813	48086
Net Return (L.E.)	20912	23179	28326	24320	34010	28443	26028	36837	34753
Return/Cost (L.E.)	2.61	2.69	2.96	2.96	3.67	3.17	3.09	3.84	3.61
Net Return/Cost (L.E.)	1.61	1.69	1.97	1.96	2.67	2.17	2.09	2.84	2.61
Water productivity (kg m^{-3})	0.70	0.58	0.54	0.75	0.73	0.51	0.79	0.78	0.60
Water unit Return (LE/1000 m^3)	5855	4863	4759	6810	7142	4774	7298	7747	5841

The economic calculations of the present study are based on the average costs during the recent three years. Of course, it shall be continually updated to match the annual rising in prices on local and international scales. From cultivation to harvesting the faba bean crop, there are constant and variable costs as mentioned in Table 6. Increasing the irrigation rates from rate 1 (3571.4 m^3 ha^{-1}) to rate 3 (5952.4 m^3 ha^{-1}) lead to an increase in the variable fuel costs in addition to the constant costs of the tillage, sowing, employment, and fertilizers that increase the total costs during the cultivation season. At the irrigation rate 3, the total costs increase in the direction biochar (13095 LE) < compost (13333 LE) < mineral (14404 LE). Calculating the revenue from multiplying the prices of the seeds and pods by their yield has indicated that the maximum net return was at the irrigation rate 2 for the compost (36837 LE) followed by the biochar (34010 LE) then at the rate 3 for the mineral fertilization (28326 LE). The return and net return with respect to the costs were also increased in the same order: rate 2 (compost) > rate 2 (biochar) > rate 3 (mineral). Since the WUE expressed as the water productivity decreases as the irrigation rate increases, it can be said that the application of the compost and/or the biochar is more efficient at the rate 2 than the single use of the mineral fertilization that need greater level of the irrigation water otherwise the yield decreases. The maximum water unit return has increased by 32.3% and 21.9% for the compost and biochar at rate 2, respectively, relative to the mineral at rate 1.

4. Conclusion

The WUE (kg m^{-3}) was decreased as the irrigation rate increased for the mineral, compost, and biochar applications. At the rate 3, the WUE was decreased by 22.86%, 32%, and by 24.05% relative to the rate 1 for the mineral, biochar, and compost, respectively. the application of the compost and/or the biochar is more efficient at the rate 2 than the single use of the mineral fertilization that need greater level of the irrigation water otherwise the yield decreases. The maximum water unit return has increased by 32.3% and 21.9% for the compost and biochar at rate 2, respectively, relative to the mineral at rate 1.

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References

Abbas, Z.M., Khalil, F.A.F., and El-Etr, W.M.T., 2013. Influence of water regimes and soil conditioners on yield, yield components and water utilization efficiency of Egyptian clover (variety fahl). J. Plant prod., Mansoura, Univ., 4(11): Pp. 1675- 1690.

Abdel-Azeem, S. M., 2020. Effect of soil amendments on soil fertility and maize productivity in a newly reclaimed soil.Alexandria Sci. exchange j. 41, (1): Pp. 15 – 25..

Abd El-Kader, A. A., Shabaan, S.M., and Abd El-Fattah, M. S., 2010. Effect of irrigation levels and organic compost on okra plants (Abelmoschusesculentus L) grown in sandy calcareous soil.Agric. Biol. J. N. Am. 1(3):Pp. 225-231.

Abd El-Mageed, T.A., Abdelkhalik, A., Abd El-Mageed, S.A., Semida, W.M., 2021.Co-composted poultry litter biochar enhanced soil quality and eggplant productivity under different irrigation regimes. J. Soil Sci. Plant Nutr. 2021, Pp. 1–17.

Abd El-Mageed, T. A., Belal, E. E., Rady, M. O., Abd El-Mageed, Sh. A., Mansour, E., Awad, M. F., and Semida, W. E., 2021.Acidified biochar as a soil amendment to drought stressed (*viciafaba* l.) plants: influences on growth and productivity, nutrient status, and water use efficiency. Agronomy J. 11 (7): Pp. 1290- 1300).

AbouHussin, E. A., and Shaban,Kh. A., 2008. Trace elements status in the saline soils leached by using low quality water. Twelfth International Water Technology Conference, IWTC12 . Alexandria, Egypt.Pp. 1031 -1043.

Adugna, G., 2016. A review on impact of compost on soil properties , water use and crop productivity. Acad. Res. J. Agri. Sci. Res. 4 (3): Pp. 93 – 104.

Ali, E. M., 2020. Effect of water regimes and polyvinyl alcohol on faba bean yield, chemical compostion and water use efficiency.J. of Soil Sciences and Agricultural Engineering, Mansoura Univ., 11 (12): Pp. 769 – 777.

Ali, L.K.M., 2011. Significance of Applied Cellulose Polymer and Organic Manure for Ameliorating Hydrophysico-chemical Properties of Sandy Soil and Maize Yield. Australian Journal of Basic and Applied Sciences, 5(6): Pp. 23-35.

Atta, Y.E.M., Abou El-Fotouh, N. Z., and Shaalan, W.M., 2002.Response of faba bean to soil moisture stress in Eastern Delta. Zagazig J. Agric. Res. 29 (5), Pp. 1429–1442

Awadalla, A., Morsy, A. S. M., and Sherif, M. M. M., 2018.Performance of Faba Bean Plants under different Irrigation Regimes and Foliar Application of Certain Growth Regulators in Toshka Area, Egypt. J. Plant Production, Mansoura Univ. 9 (10): Pp. 821 – 831.

Chapman, H.D., and Pratt, P.F., 1961. Methods ofAnalysis for Soils, Plants and Water".Agric. Publ.Univ., of California, Riverside.

Cong, X., Zhou, S., Wang, T., Pang, G., and Xu, Z., 2022.Effects of biochar application and irrigation on soil preferential flow and wainter wheat productivity. Pol. J. Environ. Stud. 31 (1): Pp. 625- 635.

Cottenie, A., Verloo, M., Kikens, L., Velghe, G., Camerlynck, R., 1982.Analytical Problems andMethod in Chemical Plant and Soil Analysis. Handbook Ed. A. Cottenie, Gent, Belgium

Curtis, M. J., Claassen, V. P., 2005. Compost incorporation increases plant available water in a drastically disturbed serpentine soil. Soil Science 170 (12):939–953.

Dong,D., Wang ,C., Zwieten, L.V., Wang, H.L., and Wu,W.X., 2019. An effective biochar-based slow-release fertilizer for reducing nitrogen loss in paddy fields.Journal of Soil and Sediment, 20: Pp. 3027-3035.

Dubois, M., Gilles, A., Hamelton, J.K., Robersand Smith, P.A., 1956.A colorimetric method fordetermination of sugar and related substances.Annal.Chem., 28: Pp. 350- 356.

Edwards, S., Hailu, A., 2011. How to make compost and use. In: Ching L L, Edwards S and Nadia H S (Eds), Climate Change and Food Systems Resilience in Sub-Sarahan Africa. FAO, Italy. Pp. 379- 436.

Efeoglu, B., Ekmekçi, Y., Çiçek, N., 2009.Physiological responses of three maize cultivars to drought stress and recovery.S. Afr. J. Bot. 75: Pp. 34–42.

El-Habashy, H.M., Sobh, M. M., Mohamed, M. M., and Amer, M. H., 2021.Effect of irrigation treatments on some hydrophysical parameters of sandy soil under different rates of biochar. J. Product and Dev, 26 (4): Pp. 887- 902.

El-Shahat, A. A. I., Dhehibi, B., and Hassan , A., 2013. The impacts of irrigation water on the productivity of main crops in Egypt. International Conference "Water in the Arab World", Status, Challenges and Opportunities, Pp. 25-27 February 2013 - Amman – Jordan

FAO. 1982.Crop water requirements irrigation and drainage. Paper No. 24,Rome Italy

FAO. 2019.Food and Agriculture Organization Statistics, FAOSTAT. www.fao.org/faostat.

Fayed, T. B., Abdrabbo, M. A. A., Hamada, M. M. A., Hashem, F. A., and Hegab, A. S. A., 2018. Irrigation requirements of faba-bean under two climatic locations in EGYPT.Egypt. J. Agric. Res. 96 (2): Pp. 653 – 664.

Fouda, S. S., El-Shazely, M. A., and Victor, M. D. M., 2020.Evaluation of biochar and charcoal as amendments and their effect on sandy soil fertility and wheat productivity. J. of Soil Sciences and Agricultural Engineering, Mansoura Univ., 11 (10): Pp. 531-539.

Gomaa, I. M., and Afifi , M.M., 2021. Effect of organic fertilizers on growth and yield of Faba Bean (Viciafaba L.).Al-Azhar Journal of Agricultural Research. 46.(1) : Pp. 139-152

Gomez, K.A., and Gomez, A.A., 1984. StatisticalProcedures of Agricultural Research. Second Ed.Wiellyinter Science Publ. John Wiley and Sons.New York, Pp. 357-423.

Hymowitz, T.F., Collins, P., and Walker, W.M., 1972. Relationship between the content of oil , protein and sugar in soybean seed. Agron. J., 64: Pp. 613-616.

Ibrahim, P., Ebrahim,P., Payam,N., Abdolamir, M., and Kourosh,O., 2011.The effect of compost leachate on pH, EC and soil organic matter in the gavart region of Isfahan. Adv. Environ. Biol., 5(4): Pp. 624-630.

Di Liu, Zheli Ding, Esmat, F., Ali, Ahmed M. S., Kheir, Mamdouh, A., Eissa Omer, H. M., Ibrahim, 2021. Biochar and compost enhance soil quality and growth of roselle (*Hibiscus sabdariffa* L.) under saline conditions. Scientific Reports, 11:Pp. 8739

Min, W., Guo, H.J., Zhang, W., Zhou, G.W., Ma, L.J., Ye, J., and Hou, Z.A., 2016. Irrigation water salinity and N fertilization: Effects on ammonia oxidizer abundance, enzyme activity and cotton growth in a drip irrigated cotton field. J. Integr. Agric. 15, Pp. 1121–1131.

Mostafa, F. A., and Shaban, Kh. A. H., 2019. Effect of different types of biochar on soil chemical properties, microbial community, pathogenic fungi and faba bean productivity.Scientific Journal of Agricultural Sciences 1 (2): Pp. 72-87.

Mousa, W. E., and Shaban, Kh. A., 2017. Influence of irrigation rates , bio-fertilizer and compost on forge yield , quality and seed production of EgyptianClover verity (Fahl) under saline soil condition. Egypt. J. of Appl. Sci. 32 (1): 51- 74.

Noah, A., Olufunke, C., Ofosu-Budu, K. G., Ofosu-Animc, J., Laryea, K. B., and Dionys. F., 2010. Effect of N-enrichedco-compost on transpiration efficiency and water-use efficiency of maize (*Zea mays* L.) under controlled irrigation.Agricultural Water Management97 (7):Pp. 995–1005.

Page, A.L., Miller, R.H., Keeney, D.R., 1982. Methods of Chemical Analysis, Part 2: Chemicaland microbiological properties (Second Edition).American Society of Agronomy, Inc. and Sci. Soc.of America, Inc. Publishers, Madison, WisconsinU.S.A.

Pereira, L.S., Cordery, I., Iacovides, I., 2012. Improved indicators of water use performance and productivity for sustainable water conservation and saving. Agric. Water Manag. 108, Pp. 39–51.

Poormansour, S., Razzaghi, F., Sepaskhah, A., Moosavi, A. A., 2019. Different levels of biochar and irrigation influence on faba bean growth, yield and yield components. Iranian Journal of Field Crop Science. 50(2): Pp. 89 – 99.

Poormansour, S., Razzaghi, F., 2018. Effect of biochar and irrigation levels on fababean .J .ActaHorticulturea.1190 : Pp. 157 – 162.

Rezaie, N., Razzaghi, F., Ali, R. S., 2019. Different levels of irrigation water salinity and biochar influence on faba bean yield, water productivity, and ions uptake. J. Communications in Soil Sci. and plant Analysis, 50 (5): Pp. 611 – 625.

Schulz, H., Glaser, B., 2012. Effects of biochar compared to organic and inorganic fertilizers on soil quality and plant growth in a greenhouse experiment. J. Plant Nutr. Soil Sci., 175, Pp. 410–422

Taha, M., Salama,A., El-Seedy, M., El-Akhdar, I., Islam, M. S., Barutcuar, C. and El-Sabagh, A., 2016. Potential impact of compost tea on soil microbial properties and performance of radish plant under sandy soil conditions greenhouse experiments. Aust. J. Basic Applied Sci. 10: Pp. 158 – 165.

Witham, F.H., Blaydes, D.F., and Devin, P.M., 1971. Experiments in plant physiology. Van Nosland Reihold. Co. New York, Pp. 55-58.