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Biochar and Chicken Manure Impact on Growth and Yield of Globe Artichoke

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THA consequences of biochar and chicken manure either singly or together with three levels of NPK-recommended fertilizers on the growth, early and total yield, quality, and chemical components of Globe artichoke (Cynara scolymus L.) cv. Herous were investigated in a field trial performed for two consecutive seasons in 2022/2023 and 2023/2024. The experiment employed three replications in a split-plot design where, the main plots were filled with control, 5 tons of biochar per hectare, 10 tons of chicken manure, and a mixture of chicken manure and biochar (1:1) treatments. The sub-plots focused on NPK fertilizer levels, specifically 100%, 75%, and 50% of the recommended dose. When the chicken manure applied with 75% NPK of the recommended fertilizer dose, vegetative growth; plant height, number of leaves per plant, and chlorophyll content tended to increase. The fresh weight and diameter of the flower heads and receptacles were also noticeably higher with this treatment, yielding better over both seasons. Additionally, compared to the other organic fertilizers, the chicken dung mixed with 75% NPK of the recommended rate had resulted in greater levels of inulin, total phenolic and NPK in leaves. According to these findings, the addition of chicken manure produced the highest yield, quality, and chemical components of artichoke plants. This is probably because of raising the soil organic matter content, available NPK, and consequently the microorganisms, which have a positive impact on plant growth and yield components, beside it reduced the required chemical fertilizers for artichokes by 25%.

Keywords: Soil health, Organic fertilizer, Crop yield, Productivity, and Chemical components.

1. Introduction

Globe artichoke is a perennial herbaceous plant that is among the members of the Asteraceae family. It is grown for its young inflorescences, health advantages, and medicinal properties, which are connected to the presence of minerals, fiber, inulin, and cynarin (1,3-O-dicaffeoylquinic acid). These compounds promote the plant's nutrition, industry, and bioactivities, which shield the human heart, liver, and blood vessels and lessen inflammation (Lattanzioa et al., 2009, and Zayed et al., 2020).As indicated by Noriega-Rodríguez et al. (2020), they thought to be among the primary natural sources of cynarine, a phenolic antioxidant with a promising anti-proliferative impact on cancer cells. It is therefore, among the most acknowledged vegetable crops in the Mediterranean basin's neighboring countries.

Egypt planted approximately 60.67 hectares to produce 308,844 tons of globe artichokes (Cynara scolymus L.) annually, according to statistics for 2020/2021 (MALR, 2021). Egypt is the world's second-largest nation in artichoke production, which is one of its most important exported crops. The country exports both fresh and processed artichoke buds to countries in Europe and the Arab world.

Organic fertilizer is, generally used in agriculture to replace chemical fertilizers, which become more expensive and somehow harmful to the public health. Produced by carefully regulating the pyrolysis of biomass, biochar is, primarily utilized for soil properties enhancement in horticultural, agricultural, and environmental contexts (Lehmann, 2009). Researchers are now interested in using biochar as a co-ingredient in compost-based growth media (Steiner and Harttung, 2014 and Melebari, 2025). Lehmann and Joseph (2015), claimed that biochar is a stable C by product that produced when the organic feedstock is thermos chemically decomposed at a high temperature with little to no oxygen present. Biochar enhances the quality of soil by raising the soil pH, cation exchange capacity, nutrient retention capacity, microbial biomass activity and soil moisture retention capacity

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(Lehmann et al., 2011, Gao et al., 2016, Phares et al., 2017 and Abdel-Motaleb et al., 2025). Furthermore, Barracosa et al. (2020) stated that biochar and mineral fertilizers used in order to mitigate pathways for agro-environmental objectives, as they lowered the potential for global warming and may boost cardoon plant biomass production. Moreover, applying biochar in addition to mineral fertilizer increased biomass production by 50% compared to only mineral fertilizer. On the other hand, biochar that made from crop residues such as rice husk and maize cob frequently has low levels of phosphate (P) and nitrogen (N) (Deenik and Cooney, 2016, and Liu et al., 2019).

Chicken manure is full of nutrients from the nutritional supplements that chickens consume to promote rapid growth, so it contains macro- and micronutrients and is therefore very suitable for use as fertilizer. It is recommended to apply 60 tons of chicken manure per hectare since this has been linked to increased yields of lettuce besides higher numbers, areas and fresh weights of leaves (Masarirambi et al., 2012).The soil physiochemical characteristics, soil quality, plant growth and agricultural output can all be enhanced using chicken manure and corn cob biochar (Yuniwati, 2018). Additionally, in plots which was treated with 10 tons ha^{-1} of chicken manure, as equivalent to 60 kg N ha^{-1}, it was found outstanding in terms of growth, yield and dry matter, sunflower seed production and oil quality (Abumere et al., 2019). Furthermore, the application of cow dung (4 t/ha) plus mustard oil cake (0.25 t/ha) and chicken manure (2 t/ha) in combination with BARI Fulkopi-2, yielded the greatest marketable cauliflower growth and yield (Yeasmin et al., 2021). Younas et al. (2022) found that adding 10% bentonite and 15% chicken manure had a significant impact on the productive qualities shown by Bougainvillea growth. Eglous et al. (2023) also, concluded that adding poultry manure to marsh soil boosted the number of flowers and fruits, height of the plants, length of the roots, fresh and dry weight, concentration of potassium in the shoots of cherry tomato plants and the production of biomass. Certainty exists regarding the potential of CMFE treatments to partially replace chemical fertilizer to reduce its usage without lowering cucumber output (Yao et al., 2023).

The goal of the experiment is to find out the impact of adding biochar and chicken manure dung on the globe artichoke cv. Herous's growth, its early and total yield, plant quality and chemical composition. Furthermore, it investigates to which degree it may help to lessen the input of chemical fertilizers and maintain soil health.

2. Material and Methods

2.1. Experiment and treatments

The field experiment was implemented over two-seasons; 2022/2023 and 2023/2024 in EL-Qanater Research Station Farm at Qaluibia Governorate, which belongs to the Horticulture Research Institute, ARC, Egypt. It is located at latitudes 30° 11′ 38.90″ N and longitude 31° 6′ 56.10″ E. The experiment aimed at examining the impact of biochar (BC) and chicken manure (ChM) with three levels of NPK fertilizers applied to the soil before planting on the growth, early and total yield, chemical components, and nutrient contents of globe artichoke (*Cynara scolymus*) cv. Herous.

A split-plot design, in three replicates, was selected to carry out the concerned field experiment. The design was constructed of twelve plots, where the main plots are three of them set as control treatment, three plots were repeated and treated with 5 tons/hectare of biochar (BC), another three plots received 10 tons/hectare of chicken manure (ChM) and the last three plots treated with biochar and chicken manure at a ratio of 1:1 (2.5 tons of biochar + 2.5 tons of chicken manure per hectare). The sub-plots were received with 100, 75 and 50% of NPK recommended fertilizers. Ministry of Agriculture and Land Reclamation (2013) recommended the NPK fertilizer requirements for the globe artichoke crop as follows:

84 kg/hectare of N as ammonium nitrate (33.5% N), 39.5 liters/hectare of P in form of phosphoric acid (10%) and 63 kg/hectare of K as potassium sulphate (48% K). The recommended NPK required rates were applied in the current field experiment with soil content of available NPK considered, where the amount of available nutrients in the soil was calculated and subtracted from the amount of mineral fertilizers added.

The crown sections, or stumps, were soaked in fungicide for 20 minutes before being planted on August 22 and August 14 of the two seasons, respectively, in raised beds that were 15-20 cm high and 100 cm broad with furrows spaced 75 cm apart. Each experimental plot was 25 m^2 in size and had five rows that were each of 5 m long and 1 m wide. Using a drip irrigation system, plants fertilized with five doses of NPK at intervals of 45 days during their life cycle. All farming practices, including managing pests and diseases and pulling weeds, executed in compliance with directives from the Egyptian Ministry of Agriculture. Table 1 lists the physicochemical analyses of the soil used in the field trial and the irrigation water's chemical analysis.

Soil analyses: Before planting and after first and second season's samples of the experiment plots' topsoil (0–30 cm) were collected. The soil samples were sieved through a 2 mm sieve after being lightly crashed and allowed to air dry. Then, using the techniques outlined by Soil Survey Staff (2014), laboratory analyses were conducted to identify the primary physicochemical properties of the soil, including the particle size distribution, pH, OM contents, $CaCO_3$, EC, and soluble ions in the soil past extract (Ca^{2+}, Mg^{2+}, Na^+ and K^+, Cl^-, HCO_3^-, and CO_3^{2-}). The flame photometer measured the available K, and the Kjeldahl method was used to determine the available N (Page et al., 1982). Using a spectrophotometer, available P was extracted by Olsen et al. (1954) methodology, (Table 1).

Water analysis: A sample from the source of irrigation water was analyzed to determine its chemical characteristics pH, EC, cations, anions and SAR according to USAD methodology (USDA, 2004), (Table 1).

Soil treatments analysis: Biochar and chicken manure physicochemical properties namely; bulk density, pH, EC, moisture content, organic matter, organic carbon, Ash, C/N ratio, and total NPK were determined using standard methods (Black, 1982; Cottenie et al., 1982 and A.O.A.C., 2016). Table 2 shows the properties of biochar and chicken manure were applied to the soil.

2.2. Data recording

Vegetative growth: Midway through December, which means at 120 days following planting, the vegetative data were collected from a randomized sample of seven plants from every trial plot. Then, the plant's height and leaf count per plant were recorded. A portable chlorophyll meter (SPAD-502, Konica Minolta Sensing, Inc., Japan) was used to quantify the chlorophyll content as relative values of the youngest fourth fully developed leaf (Khan et al., 2003).

Yield and its components: Harvesting took place until mid-May. The first harvest season (2022-2023) started on November 21st, and the second (2023-2024) started on December 15th. Both seasons ended by mid-May and the harvest along this period was considered as total yield. However, for economic consideration the harvest period, which ended at mid- February of each year was called an early harvest. Seven flower heads randomly selected from each plot to determine both early and total yield. Similarly, the number of heads per plant and hectare for early and total yield were counted.

Globe artichoke quality: The fresh weight (g) and diameter (cm) of the flower heads and receptacles for early and total yield were measured using a random sample of seven plants.

2.3. Chemical plant analyses

Dry matter content: From each experimental plot, 100 g of fresh edible portions were weighed and dried out at 70 °C till the weight remained constant, then the dry matter weight/100g fresh weight of the edible parts was calculated (A.O.A.C., 2016).

Inulin content of heads: Applying the method of Winton and Winton (1958), the inulin content (mg/100 g dry weight) of the edible portion of the heads was determined.

Total phenolic content: Montedoro et al. (1992) described the Folin Ciocalteu method, which was used to quantify total phenolic contents (TPC). One hundred microliters of either the standard solution or the sample extract were incubated with 500 liters of freshly diluted 10-fold Folin Ciocalteure agent in water and one milliliter of 20% Na_2CO_3 solution. For one hour, under dark conditions, a reaction mixture was maintained at ambient temperature. Next, absorbance against a prepared blank was measured at 760 nm. A standard curve of gallic acid was constructed, and TPC was reported as milligrams of gallic acid equivalent (GAE) per gram of starting plant material.

Nutrient contents: A.O.A.C. (2016) was followed to digest 0.5 g of the dry samples using a mixture of H_2SO_4 and $HCLO_4$. leaves were randomly selected from each plot and then crushed to fit through a 1 mm sieve after being oven-dried at 70 C˚ till their weight remained constant. In the digested product, N was measured using a micro-Kjeldahl device, P by a spectrophotometer, and K by a flame photometer (Page et al., 1982). Proteins were calculated by multiplying the N content by 6.25, per A.O.A.C. (2016).

2.4. Statistical analysis

According to Di Rienzo et al. (2012), InfoStat modeling software (V. 2014) was used for the statistical analyses of the current study. The results of the various experimental treatments were compared via Duncan's Multiple Comparisons Test to determine their respective means. Additionally, the Duncan multiple range tests at the 5% level indicate that values within the column or rows followed by the same capital or small letter(s) do not substantially differ from one another.

Table 1. Physicochemical soil properties before planting and chemical analyses for irrigation water.

Physiochemical properties of the soil										
Particle Size Distribution (%)				Chemical properties			Available macronutrients (mg kg^{-1})			
Sand	Silt	Clay	Texture (Class)	pH (1:2.5)	OM (g kg^{-1})	Total $CaCO_3$ (g kg^{-1})	N	P	K	
20.11	23.70	56.19	Clay	7.78	10.11	40.97	64.14	6.20	457.34	
Soluble cations and anions (mmolc L^{-1})										
ECe (dSm^{-1})	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Cl^{-}	HCO_3^{-}	CO_3^{2-}	SO_4^{2-}	SAR	
5.30	14.74	10.35	26.65	2.08	23.62	4.38	---	25.82	7.52	
Chemical analyses of irrigation water										
		Soluble ions (mmolc L^{-1})								
pH	ECe (dSm^{-1})	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Cl^{-}	HCO_3^{-}	CO_3^{2-}	SO_4^{2-}	SAR
7.70	0.86	2.86	2.04	3.61	0.16	4.52	0.61	---	3.54	2.31

Table 2. Some Physicochemical properties of the applied biochar and chicken manure.

Parameters	Bulk density (g cm^{-3})	pH	EC (dSm^{-1})	Moisture content	Organic matter	Organic carbon	Ash	C/N ratio	Total N	Total P	Total K
				(%)							
Biochar (BC)	0.36	8.15	1.10	5.20	67.97	40.48	30.21	52.0:1	0.78	0.41	0.56
Chicken manure (ChM)	0.58	6.27	3.21	10.18	60.64	35.17	39.36	23.9:1	1.47	0.60	1.32

3. Results

3.1. The field experiment

3.1.1. Soil analysis before planting

Table 1 displays the soil physicochemical properties of selected site for the field study. The data revealed that the soil had a clayey texture with 56.19% clay. SAR of 7.52, pH of 7.78, and EC of 5.30 dSm^{-1}. Therefore, the soil was slightly saline and non-alkaline. It was non-calcareous soil as it had total carbonate content of 4.1%. Additionally, its organic matter content was low (1.0%) and its available macronutrient contents, N and P, were of moderate class (64.14 and 6.20 mg kg^{-1}), while K was of high class (457.34 mg kg^{-1}).

3.1.2. Irrigation water analysis

Drip irrigation was employed to irrigate the current field experiment. Table 1 contains the analytical data of the irrigation water. The water was very slightly saline (0.86 dSm^{-1}) and non-alkaline (SAR of 2.31) therefore, it was suitable for irrigation with percussions where, FAO (1985) stated that the water of EC values between 0.75-3.00 dSm^{-1} has an increasing problem for irrigation.

3.2. Vegetative growth

3.2.1. Plant height and number of leaves

Data in table 3 indicated that the artichoke plants supplemented with organic manure had higher plant height in the first season however, in the second season all treatments showed the highest plant height except the control treatment. Number of leaves of globe artichoke was significantly different across the application of chicken manure or chicken manure with biochar in both seasons.

Plant height and number of leaves were significantly different under the three rates of NPK, fertilizing with 75% of the required mineral fertilizers gave the highest plant height and number of leaves in the two-seasons. There were three significant interactions for plant height and number of leaves in both years under the chicken manure and chicken manure plus biochar treatments both with the addition of 75% NPK rate. The same relationship existed for the chicken manure treatment and 100% NPK rate.

Table 3. Plant height, leaves number and chlorophyll content of globe artichoke plants under biochar, chicken manure and biochar plus chicken manure treatments with three levels of NPK in 2022/2023 and 2023/2024 seasons.

Treatments		Plant height (cm)		Number of leaves		Chlorophyll content (SPAD)	
		1st	2nd	1st	2nd	1st	2nd
Biochar and chicken manure (A)							
Control		91.97 a	97.40 b	69.50 b	51.83 c	47.77 d	46.95 d
Biochar		93.44 a	106.44 a	66.11 b	56.11 b	50.56 c	53.66 c
Chicken manure		98.33 a	104.47 a	86.22 a	64.67 a	54.86 b	58.37 b
Biochar+Chicken		99.00 a	109.44 a	86.56 a	64.44 a	55.77 a	59.28 a
Levels of NPK (B)							
L 1 (100% NPK)		96.22 b	111.13 a	79.96 b	61.71 a	57.01 a	58.68 a
L 2 (75% NPK)		102.33 a	107.08 a	90.50 a	62.42 a	55.57 b	58.36 a
L 3 (50% NPK)		88.50 c	95.08 b	60.83 c	53.67 b	44.14 c	46.65 b
Interaction (AxB)							
Control	L1	87.57 d	105.87 ab	78.83 d	54.83 ef	53.27 d	52.02 e
	L 2	99.33 ab	101.33 bc	75.00 de	54.00 f	49.35 e	50.67 f
	L 3	89.00 cd	85.00 d	54.67 fg	46.67 g	40.67 g	38.17 h
Biochar	L1	88.00 d	115.00 a	50.00 g	61.00 cd	56.38 c	57.31 d
	L 2	105.00 a	110.33 ab	85.00 cd	61.33 c	54.14 d	58.20 c
	L 3	87.33 d	94.00 cd	63.33 ef	46.00 g	41.16 g	45.47 g
Chicken manure	L1	103.67 a	110.00 ab	104.33 ab	69.00 a	59.71 ab	62.14 b
	L 2	106.33 a	110.00 ab	93.67 bc	67.33 ab	58.53 b	62.63 ab
	L 3	85.00 d	93.33 cd	60.67 fg	57.67 de	46.35 f	50.33 f
Biochar + Chicken	L1	105.67 a	113.67 a	86.67 cd	62.00 c	58.69 b	63.26 a
	L 2	98.67 abc	106.67 ab	108.33 a	67.00 ab	60.24 a	61.95 b
	L 3	92.67 bcd	108.00 ab	64.67 ef	64.33 bc	48.39 e	52.62 e

3.2.2. Chlorophyll content

The addition of mix of biochar with chicken manure led to the highest chlorophyll content as SPAD relative values (55.77 and 59.28) in both years in contrasted with the other various treatments (Table 3). The optimal chlorophyll level of 58.68 (SPAD) obtained under the 100% NPK treatment in the first season. The maximum chlorophyll content as expressed by SPAD relative value (58.36) was gained in 100% and 75% NPK treatments for the second season. The highest significant differences of chlorophyll content were found under the chicken manure and biochar plus chicken manure of both 100 and 75% NPK treatments (Table 3).

3.3. Yield and its components

3.3.1. Heads number per plant of early and total yield

It is evident from the data presented in Table 4 that the application of organic fertilizer made a significant difference in early and total yield. In the first year, chicken manure treatment had a significant increment in the number of heads per plant of early and total yield followed by chicken manure + biochar treatment. However, the biochar or chicken manure fertilizer gave the highest heads number of early yield in the second season.

Moreover, the application of chicken manure or chicken manure with biochar gave a significant increase in the heads number of total yield compared with the control treatment in the second season.

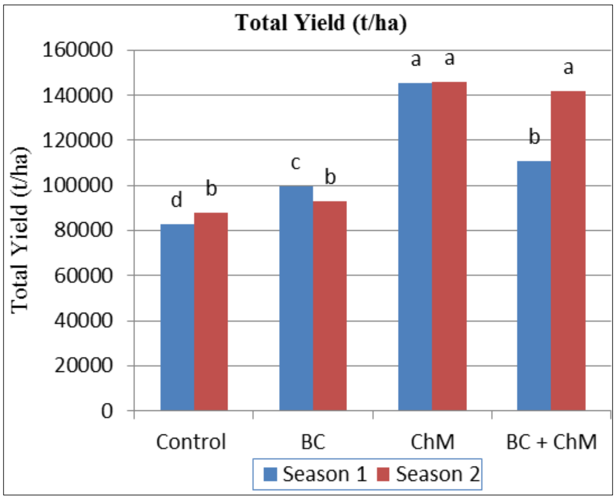
Table 4 show that number of heads/plant of early and total yields of globe artichoke differed significantly under the NPK treatments in both tested seasons. Fertilizing the artichoke plants with 100% and 75% of NPK rates produced the highest number of heads of early and total yield. While the lowest head number of the early and total yield were obtained under the 50% NPK rate in both seasons. The best treatments which significantly produced the highest number of early heads per plant were the chicken manure treatment under 100% and 75% NPK levels and chicken manure plus biochar under 100% NPK rate for all seasons. In contrary, the lowest early yield was recorded for the control treatment of 50% NPK rate in both seasons. The number of total yield heads per plant significantly increased under chicken manure treatment with 100 and 75% NPK rate and biochar plus chicken manure under 75% NPK in the two growing seasons.

3.3.2. Early and total yield in ton/hectare

Adding chicken manure produced the greatest early and total yield ton/hectare, followed by applied biochar plus chicken manure in both tested seasons (Table 4 and Figures 1). The highest early and total yield ton/hectare gained under the 100 and 75% NPK treatment (Table 4 and Figures 2). In addition, the best interaction for early and total yield ton/hectare was achieved by applying chicken manure under 75 and 100% of NPK rates (Table 4 and Figures 3).

Table 4. Heads number per plant of early and total yield, and early yield per hectare of globe artichoke plants under biochar, chicken manure and biochar plus chicken manure treatments with three levels of NPK in 2022/2023 and 2023/2024 seasons.

Treatments		Heads number per plant (Early yield)		Heads number per plant (Total yield)		Early yield (t/ha)	
		1st	2nd	1st	2nd	1st	2nd
Biochar and chicken manure (A)							
Control		1.76 d	2.13 c	9.89 d	9.31 c	16022 d	18904 d
Biochar		2.02 c	3.18 a	11.38 c	10.69 b	18345 c	27437 c
Chicken manure		2.88 a	3.04 ab	15.10 a	15.58 a	28467 a	31047 a
Biochar+Chicken		2.59 b	2.87 b	11.67 b	15.55 a	25611 b	29084 b
Levels of NPK (B)							
L 1 (100% NPK)		2.66 a	3.15 a	14.07 a	13.82 a	25116 a	27380 b
L 2 (75% NPK)		2.51 a	3.16 a	14.03 a	13.67 a	25040 a	31195 a
L 3 (50% NPK)		1.72 b	2.11 b	7.81 b	10.86 b	16177 b	21280 c
Interaction (AxB)							
Control	L1	1.83 cd	2.44 c	11.69 d	10.24 cd	18581 c	20180 h
	L 2	1.92 c	2.50 c	11.71 d	10.03 d	16760 d	22667 f
	L 3	1.34 e	1.46 e	6.26 g	7.65 e	12726 f	13868 k
Biochar	L1	2.09 c	2.92 b	13.14 bc	10.69 c	16855 d	19295 j
	L 2	1.98 c	3.59 a	13.02 c	10.71 c	19199 c	33284 d
	L 3	1.99 c	3.13 b	7.73 f	10.67 c	18978 c	29731 e
Chicken manure	L1	3.42 a	3.75 a	18.17 a	17.16 a	33449 a	35712 a
	L 2	3.19 ab	3.59 a	17.97 a	16.96 a	33384 a	35591 b
	L 3	2.03 c	1.78 d	9.16 e	12.62 b	18566 c	21837 g
Biochar + Chicken	L1	3.32 a	3.57 a	13.27 bc	17.18 a	31575 b	34336 c
	L 2	2.94 b	3.03 b	13.42 b	16.98 a	30821 b	33237 d
	L 3	1.52 de	2.07 d	8.13 f	12.50 b	14439 e	19678 i



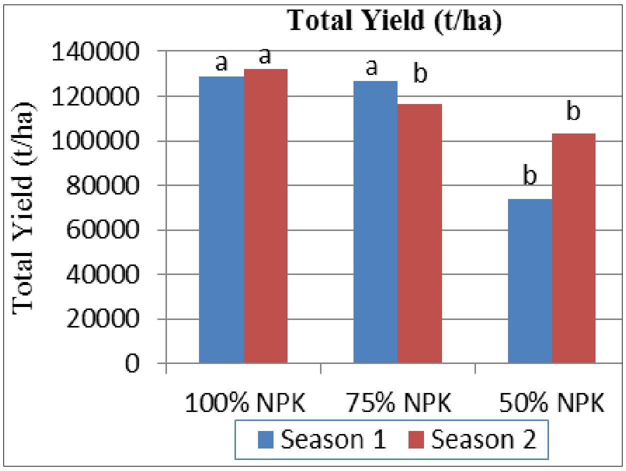


Fig.1. Total yield per hectare for globe artichoke plants under biochar (BC), chicken manure (ChM) and biochar plus chicken manure in 2022/2023 and 2023/2024 seasons.

Fig.2. Total yield per hectare for globe artichoke plants under three levels of NPK in 2022/2023 and 2023/2024 seasons.

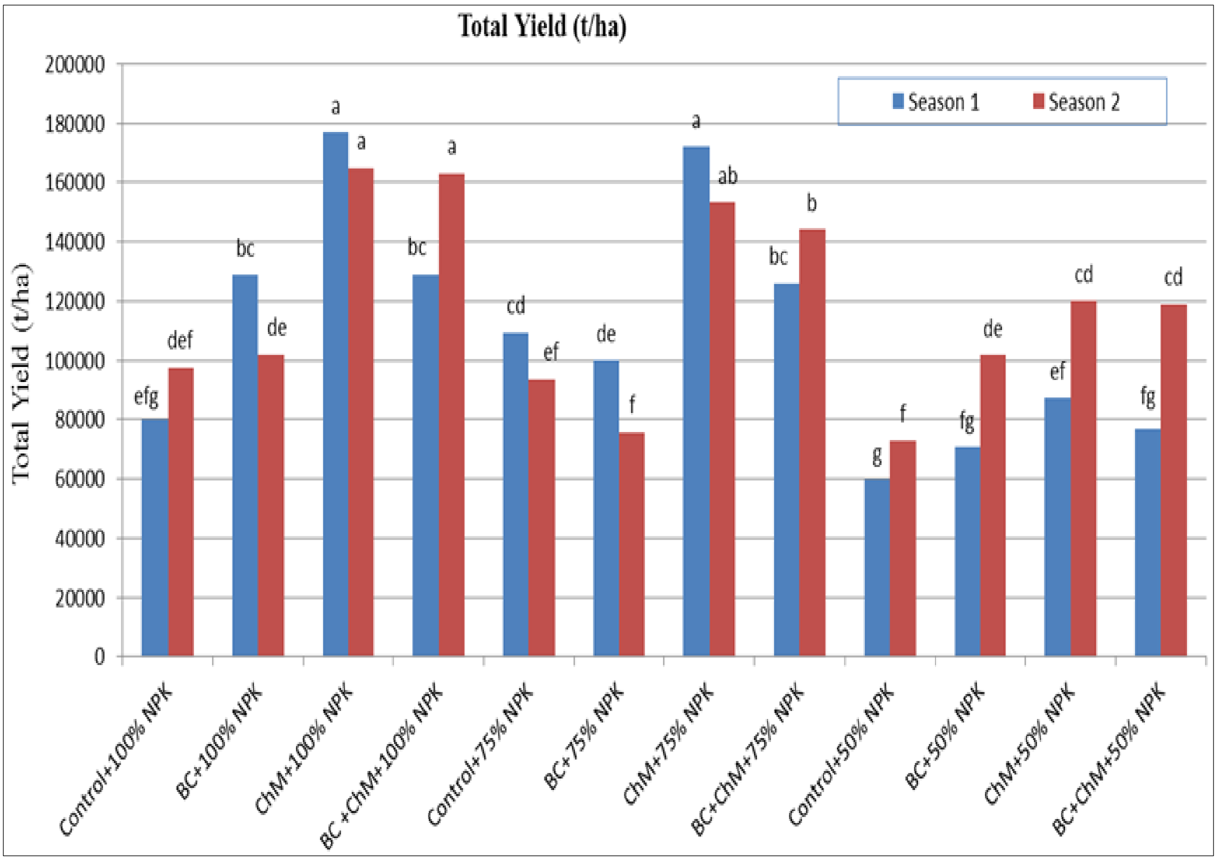


Fig.3. Total yield per hectare for globe artichoke plants interactions between biochar (BC) and chicken manure (ChM) with three levels of NPK in 2022/2023 and 2023/2024 seasons.

3.4. Globe artichoke quality

3.4.1. Head weight and diameter of early yield

The quality parameters; average weight and diameter of head of the early yield were significantly maximized by applying chicken manures before planting the globe artichoke as compared by the alternative treatments in both growing seasons. Average head weight and diameter of early yield increased in response to NPK at 100 and 75% levels (Table 5). The best head weight and diameter of early yield was achieved under chicken manure treatment with 100% and/or 75% NPK rates in both growing seasons.

3.4.2. Receptacle weight and diameter of early yield

As presented in Table 5, applying chicken manure resulted in the highest average receptacle weight and diameter of early yield in both tested seasons. Furthermore, the fertilizer at 100%, or 75% of NPK, had a positive effect on the average receptacle weight of globe artichoke of early yield in both growing periods. The average receptacle diameter of early yield was maximally enhanced under 100% NPK rate as compared to the other treatments in the two growing seasons, and there was insignificant with 75% NPK rate in the last season. As shown in Table 5, the average receptacle weight of early yield was increased by the occurred interaction between chicken manure and mineral fertilizers either of 100% or 75% NPK rates in the two growth seasons. However, the chicken manure treatment with 100% NPK rate maximized the average receptacle diameter of early yield in both seasons.

3.4.3. Heads weight and diameter of total yield

The application of organic fertilizers significantly enhanced the globe artichoke quality (Table 6). Average head weight and diameter of total yield notably increased under chicken manure treatment in both seasons. Although, the average head weight and diameter of total yield under 100% and 75% NPK rates were the highest in the two growing seasons. On the other side, the average head diameter of total yield was insignificant under 100% NPK and 75% NPK rates in the second season.

The average head weight and diameter of total yield were increased by the interaction between chicken manure treatments with 100% NPK rate in the both growing seasons (Table 6). Also, the highest value of average head weight of total yield was obtained with chicken manure with 75% NPK rate in the second season. Whereas, the addition of biochar plus chicken manure with 75% NPK rate maximized the average head diameter of total yield in the second season.

3.4.4. Receptacle weight and diameter of total yield

The application of chicken manure gave the highest average receptacle weight of total yield (Table 6) in the two tested seasons and as well, the maximum receptacle weight of total yield was gained under 100% and 75% NPK rates. The greatest interaction of receptacle weight achieved under chicken manure treatment with both 100% and 75% NPK rates in the two seasons. On the other hand, there were insignificant differences of the average receptacle diameter of total yield under organic fertilizers in the first season, while it statistically influenced by the application of chicken manure and biochar plus chicken manure as well as control fertilizers and the lowest value was under biochar treatment in the second season (Table 6). The receptacle diameter of total yield was insignificantly different under the three NPK levels in the last season, but the lowest value obtained with 50% NPK rate in the first season. Table 6 show a positive effect between the combined chicken manure and 75% NPK rate on receptacle diameter in both tested seasons.

Table 5. Average of weight and diameter for head and receptacle of early yield of globe artichoke under biochar, chicken manure and biochar plus chicken manure treatments with three levels of NPK in 2022/2023 and 2023/2024 seasons.

Treatments		Average head weight for early yield (g)		Average head diameter for early yield (cm)		Average receptacle weight for early yield (g)		Average receptacle diameter for early yield (cm)	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd
Biochar and chicken manure (A)									
Control		206.37 d	207.28 d	7.12 d	6.59 d	56.59 c	58.33 d	5.24 c	5.48 c
Biochar		231.89 c	271.28 c	7.53 c	7.12 c	59.79 c	70.89 b	5.97 b	5.51 c
Chicken manure		263.67 a	327.67 a	8.43 a	8.43 a	84.79 a	82.00 a	6.54 a	7.09 a
Biochar+Chicken		237.67 b	294.94 b	7.82 b	7.51 b	65.49 b	63.78 c	6.54 a	6.33 b
Levels of NPK (B)									
L 1 (100% NPK)		251.95 a	291.77 a	8.12 a	7.97 a	71.94 a	75.62 a	6.56 a	6.55 a
L 2 (75% NPK)		242.58 a	284.31 a	7.90 a	7.26 b	69.76 a	72.38 a	6.16 b	6.45 a
L 3 (50% NPK)		210.17 b	249.79 b	7.16 b	7.02 b	58.30 b	59.00 b	5.50 c	5.47 b
Interaction (AxB)									
Control	L1	214.12 e	218.52 f	7.36 d	6.81 def	60.17 cde	67.16 cde	5.65 de	5.88 de
	L 2	217.00 e	214.00 f	7.33 d	6.60 ef	59.63 de	62.50 def	5.43 e	5.60 e
	L 3	188.00 e	189.33 g	6.67 e	6.37 f	49.97 f	45.33 g	4.63 f	4.97 f
Biochar	L1	236.67 cd	270.00 de	7.87 bc	7.53 bc	59.67 de	70.00 bc	6.30 c	6.23 cd
	L 2	242.33 c	283.50 cd	7.53 cd	7.07 cde	62.40 cde	73.00 c	5.70 de	5.83 de
	L 3	216.67 e	260.33 e	7.20 d	6.77 def	57.30 e	69.33 bcd	5.90 d	5.07 f
Chicken manure	L1	292.67 a	364.92 a	9.20 a	9.53 a	95.33 a	90.00 a	7.30 a	7.47 a
	L 2	274.33 ab	345.08 a	8.73 a	8.10 b	92.00 a	90.67 a	6.80 b	7.60 a
	L 3	188.00 f	273.00 cde	7.37 d	7.67 bc	67.03 bc	65.33 cde	5.53 e	6.20 cd
Biochar + Chicken	L1	264.33 b	313.67 b	8.07 b	8.00 b	72.59 b	75.33 b	7.00 ab	6.60 bc
	L 2	236.67 cd	294.67 bc	8.00 b	7.27 cd	65.00 cd	60.00 ef	6.70 b	6.77 b
	L 3	212.00 e	276.50 cde	7.40 d	7.27 cd	58.90 e	56.00 f	5.93 d	5.63 e

Table 6. Average of weight and diameter for head and receptacle of total yield of globe artichoke under biochar, chicken manure and biochar plus chicken manure treatments with three levels of NPK in 2022/2023 and 2023/2024 seasons.

Treatments		Average head weight for total yield (g)		Average head diameter for total yield (cm)		Average receptacle weight for total yield (g)		Average receptacle diameter for total yield (cm)	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd
Biochar and chicken manure (A)									
Control		221.52 d	261,09 c	8.03 b	8.10 c	62.45 c	74.28 d	6.85 a	6.99 ab
Biochar		271.87 b	250.33 d	7.93 b	8.30 bc	72.38 b	82.97 c	6.36 a	6.80 b
Chicken manure		298.34 a	297.82 a	8.39 a	8.83 a	81.17 a	108.76 a	6.91 a	7.56 a
Biochar+Chicken		264.70 c	284.83 b	7.94 b	8.59 ab	75.57 b	101.01 b	6.74 a	6.98 ab
Levels of NPK (B)									
L 1 (100% NPK)		278.34 a	281.93 a	8.62 a	8.63 a	78.62 a	92.11 a	7.23 a	7.28 a
L 2 (75% NPK)		273.12 a	280.85 a	7.94 b	8.59 a	74.23 a	93.86 a	6.84 b	7.22 a
L 3 (50% NPK)		240.86 b	257.77 b	7.65 c	8.14 b	65.83 b	89.29 b	6.26 c	6.83 a
Interaction (AxB)									
Control	L1	228.64 f	271.23 c	8.33 bc	8.30 bc	71.53 c	78.01 e	7.24 a	7.33 abc
	L 2	229.83 f	270.40 c	8.10 c	8.47 bc	60.43 d	77.16 e	6.93 ab	7.30 abc
	L 3	206.10 g	241.63 d	7.67 d	7.53 d	55.40 d	67.68 f	6.37 bcd	6.33 d
Biochar	L1	273.47 de	269.17 d	8.37 bc	8.40 bc	72.30 c	84.33 e	6.80 abc	6.80 bcd
	L 2	266.33 de	251.67 d	7.73 d	8.33 bc	69.67 c	81.68 e	5.83 d	6.57 cd
	L 3	277.80 cd	245.33 d	7.70 d	8.17 c	75.17 bc	82.90 e	6.43 bc	7.03abcd
Chicken manure	L1	323.67 a	309.16 a	9.23 a	9.40 a	86.03 a	112.33 a	7.19 ab	7.57ab
	L 2	306.67 b	309.33 a	8.20 c	8.73 bc	82.60 ab	111.1 ab	7.47 a	7.77 a
	L 3	264.70 e	274.97 c	7.73 d	8.37 bc	74.87 bc	102.83 c	6.17 cd	7.33 abc
Biochar + Chicken	L1	289.60 c	293.34 b	8.60 b	8.43 bc	84.60 a	93.75 d	7.07 ab	7.10abcd
	L 2	289.67 c	292.00 b	7.73 d	8.83 ab	84.20 a	105.5 abc	7.10 ab	7.23 abcd
	L 3	214.83 g	269.17 c	7.50 d	8.50 bc	57.90 d	103.77 bc	6.07 cd	6.60 cd

3.5. Chemical properties

3.5.1. Dry matter of early and total yield

Addition of chicken manure to globe artichoke recorded the maximum value of its dry matter of early and total yield. Application of 75% NPK rate resulting in the highest edible parts of dry matter of early and total yield compared to 100 and 50% of an in both tested seasons (Table 7). The best interaction of dry matter content for early and total yield obtained under chicken manure treatment with 75% NPK level in both growing seasons (Table 7).

3.5.2. Inulin content of early yield

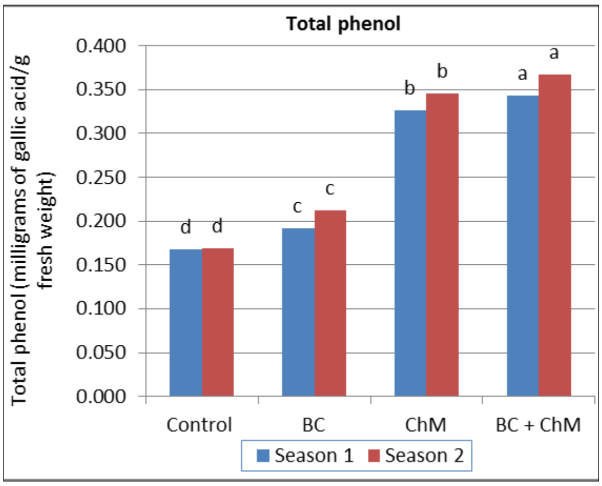
As presented in Table 7, the application of chicken manure treatment significantly increased the inulin content of globe artichoke head, under 75% NPK rate, resulting in the highest values of inulin content compared to the other two NPK levels in both tested seasons. Previous soil augmentations with either biochar with chicken manure or only chicken manure at 10 t/ha. and 75% NPK rate influenced the inulin content of heads in the first season. Moreover, it was noticed that the inulin content value was higher in the second season due to the residual effect of previously applied chicken manure under 75% NPK fertilizer on globe artichoke, which had a significant influence on the inulin content of globe artichoke heads of early yield.

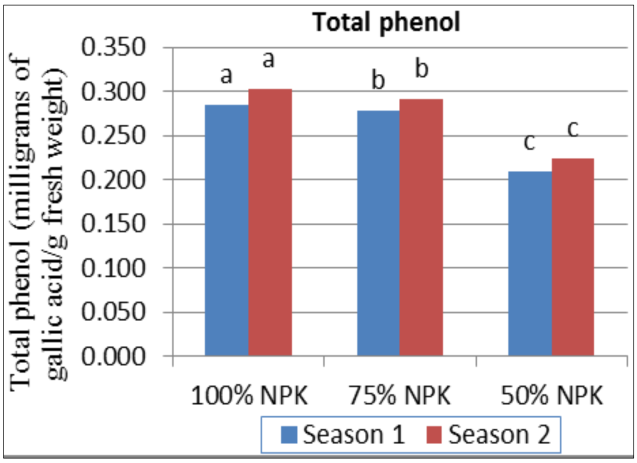
3.5.3. Total phenolic compounds percentage of early yield

The results in Figures 4, and 5 indicate that adding a mixture of biochar and chicken manure, as well as applying 100% NPK, resulted in the highest total phenol compounds percentage in the receptacle of globe artichoke compared to all different treatments in both seasons. The interaction of combining chicken manure with 75% NPK level had resulted in the highest phenol content, with insignificant difference from biochar plus chicken manure under 100% NPK rate in the first season (Figure 6). Whereas, in the second season, the maximum phenol percentage was achieved by combining chicken manure with 100% NPK rate as well as biochar plus chicken treatment under 75% NPK level.

Table 7. Dry matter of early and total yield, and Inulin content of early yield in globe artichoke under biochar, chicken manure and biochar plus chicken manure treatments with three levels of NPK in 2022/2023 and 2023/2024 seasons.

Treatments		Dry matter of early yield (%)		Dry matter of total yield (%)		Inulin content of early yield (mg/100 g dry weight)	
		1st	2nd	1st	2nd	1st	2nd
Biochar and chicken manure (A)							
Control		13.78 ab	16.62 a	19.46 a	15.72 b	5.31 d	6.44 b
Biochar		13.39bc	14.93 b	17.74 bc	17.21 ab	6.21 b	5.22 c
Chicken manure		13.87 a	16.24 a	18.18 ab	18.62 a	6.79 a	7.12 a
Biochar+Chicken		13.13 c	15.26 b	16.35 c	15.23 c	5.77 c	6.53 b
Levels of NPK (B)							
L 1 (100% NPK)		13.36 b	15.59 b	16.99 c	16.92 b	5.12 c	5.12 c
L 2 (75% NPK)		13.47 a	16.17 a	19.11 a	17.43 a	7.00 a	7.29 a
L 3 (50% NPK)		13.79 a	15.53 b	17.61 b	15.72 c	5.93 b	6.58 b
Interaction (AxB)							
Control	L1	13.31 cdef	16.04 bcd	19.16 bc	16.58 de	5.62 f	7.06 d
	L 2	13.91 bcd	17.17 a	20.65 a	17.14 cd	5.46 f	7.08 d
	L 3	14.13 abc	16.67 ab	18.58 c	13.44 f	4.87 g	5.18 g
Biochar	L1	12.85 f	14.19 f	16.17 def	18.73 b	4.09 h	4.07 h
	L 2	14.24 ab	15.25 de	18.76 bc	16.82 cd	7.38 b	5.35 g
	L 3	13.17 ef	15.33 de	18.38 c	16.17 de	7.14 c	6.22 e
Chicken manure	L1	14.80 a	16.45 abc	15.12 ef	17.95 bc	6.65 d	5.79 f
	L 2	14.37 ab	16.65 ab	20.39 ab	20.14 a	7.49 ab	8.14 b
	L 3	12.52 f	15.64 cd	18.66 c	17.77 bc	6.21 e	7.45 c
Biochar + Chicken	L1	12.50 f	15.70 cd	17.67 cd	14.51 f	4.13 h	3.57 i
	L 2	13.22 def	15.59 cd	16.63 de	15.63 e	7.69 a	8.57 a
	L 3	13.68 bcde	14.48 ef	14.81 f	15.56 e	5.50 f	7.45 c





Fig, 4. Total phenolic content of early yield in globe artichoke under biochar (BC), chicken manure (ChM) and biochar plus chicken in 2022/2023 and 2023/2024 seasons.

Fig. 5. Total phenolic content of early yield in globe artichoke under three levels of NPK in 2022/2023 and 2023/2024 seasons.

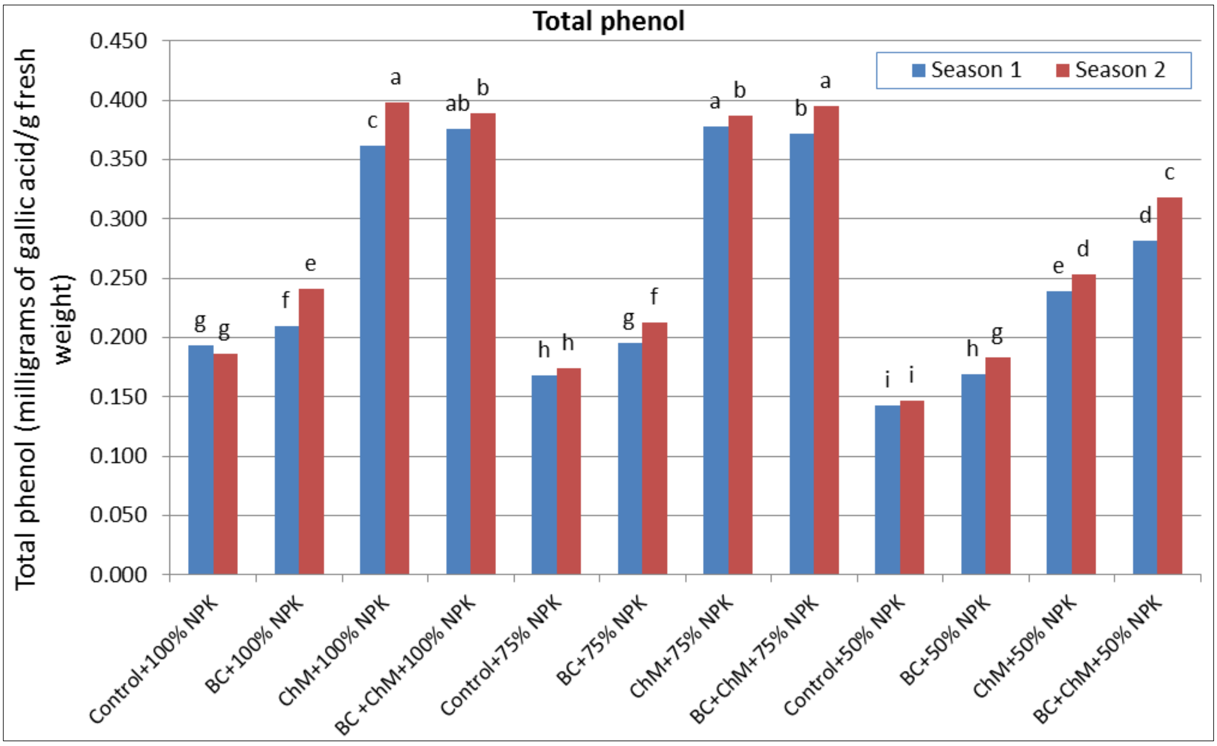


Fig. 6. Total phenolic content of early yield in globe artichoke interactions between biochar (BC) and chicken manure (ChM) with three levels of NPK in 2022/2023 and 2023/2024 seasons.

3.5.4. Nutrient contents in globe artichoke leaves of early yield

Nitrogen and protein contents: Table 8 and Figures 7, 8, and 9 shows that adding chicken manure or 100% NPK to the glob artichoke resulted in the highest protein and nitrogen percentages compared to the other treatment. Furthermore, optimum interactions were reached by applying chicken manure with 100% NPK rate in both tested seasons.

Phosphorus content: The obtained data revealed that chicken manure treatment or 100% NPK rate resulted in the highest value of phosphorus percentage in both tested seasons (Table 8). Additionally, the best interaction was significant for adding chicken manure and applying 100% NPK in the first season, whereas in the second season, the best result was achieved by adding chicken manure and applying 75% NPK, and insignificant differences with biochar plus chicken manure and 100% NPK rate.

Potassium content: Data in Table 8 show that adding chicken manure and/or biochar plus chicken manure or 100% NPK rate achieved the highest level of potassium in both growing seasons. Applying biochar plus chicken manure with 75% NPK level resulted in the highest interaction for potassium levels, with insignificant differences for biochar treatment under 100% NPK in the first season. In the last growing season, adding biochar plus chicken manure under 100% NPK level resulted in an optimal interaction for potassium levels, and insignificant differences with chicken manure treatment under100% NPK rate.

3.5.5. Nutrient contents in the soil

Available nitrogen content: Table 9 display that adding chicken manure with 100% NPK in two seasons or biochar plus chicken manure with 100% NPK in the second season to the soil caused the highest available nitrogen after every season compared to the other treatment.

Available phosphorus content: The analyses conducted confirmed that chicken manure treatment with 100% NPK level leads to the highest value of available phosphorus in the soil after the first season, though after the second season, the best result was attained by adding biochar plus chicken manure and applying 100% NPK (Table 9).

Available potassium content: Table 9 illustrates that applying biochar plus chicken manure with 100% NPK rate gives rise to the highest interaction for the rate of available potassium in the soil after both growing seasons.

Table 8. Nitrogen, phosphorus and potassium contents of early yield in globe artichoke leaves under biochar, chicken manure and biochar plus chicken manure treatments with three levels of NPK in 2022/2023 and 2023/2024 seasons.

Treatments		Nitrogen content (%)		Phosphorus content (%)		Potassium content (%)	
		1st	2nd	1st	2nd	1st	2nd
Biochar and chicken manure (A)							
Control		1.07 d	1.12 d	0.147 d	0.152 c	2.05 b	2.02 c
Biochar		1.81 c	1.92 c	0.152 c	0.162 b	2.31 a	2.25 b
Chicken manure		2.12 a	2.29 a	0.268 a	0.298 a	2.29 a	2.34 a
Biochar+Chicken		2.05 b	2.21 b	0.263 b	0.302 a	2.33 a	2.42 a
Levels of NPK (B)							
L 1 (100% NPK)		2.04 a	2.20 a	0.241 a	0.253 a	2.46 a	2.44 a
L 2 (75% NPK)		1.75 b	1.92 b	0.227 b	0.251 a	2.43 a	2.36 b
L 3 (50% NPK)		1.50 c	1.55 c	0.155 c	0.181 b	1.85 b	1.96 c
Interaction (AxB)							
Control	L1	1.29 i	1.46 i	0.177 d	0.169 gh	2.29 d	2.18 f
	L 2	1.02 j	1.13 j	0.154 e	0.162 h	2.14 e	2.05 gh
	L 3	0.89 k	0.77 k	0.110 f	0.124 j	1.72 g	1.80 j
Biochar	L1	2.12 d	2.26 d	0.179 d	0.181 f	2.56 ab	2.43 d
	L 2	1.76 g	1.91 f	0.160 e	0.172 g	2.45 c	2.36 e
	L 3	1.53 h	1.58 h	0.118 f	0.133 i	1.91 f	1.95 i
Chicken manure	L1	2.42 a	2.57 a	0.314 a	0.327 c	2.47 c	2.54 ab
	L 2	2.19 c	2.33 c	0.293 b	0.340 a	2.53 abc	2.49 cd
	L 3	1.77 g	1.97 e	0.198 c	0.227 e	1.86 f	1.98 hi
Biochar + Chicken	L1	2.31 b	2.51 b	0.297 b	0.336 ab	2.51 bc	2.62 a
	L 2	2.02 e	2.26 d	0.301 b	0.329 bc	2.60 a	2.53 bc
	L 3	1.83 f	1.87 g	0.192 c	0.241 d	1.89 f	2.10 fg

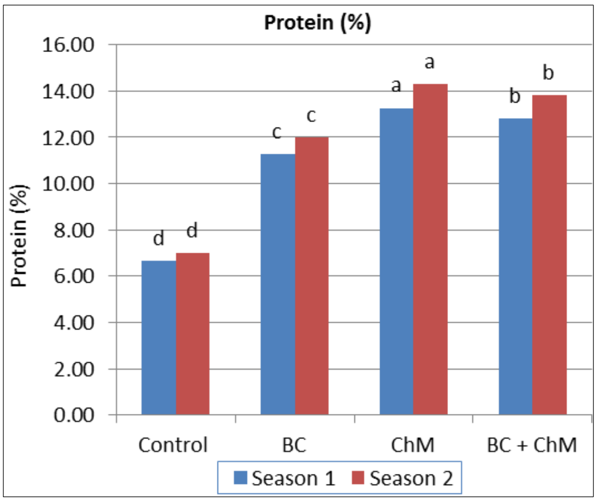


Fig. 7. Protein content of globe artichoke leaves under biochar (BC), chicken manure (ChM) and biochar plus chicken in 2022/2023 and 2023/2024 seasons.

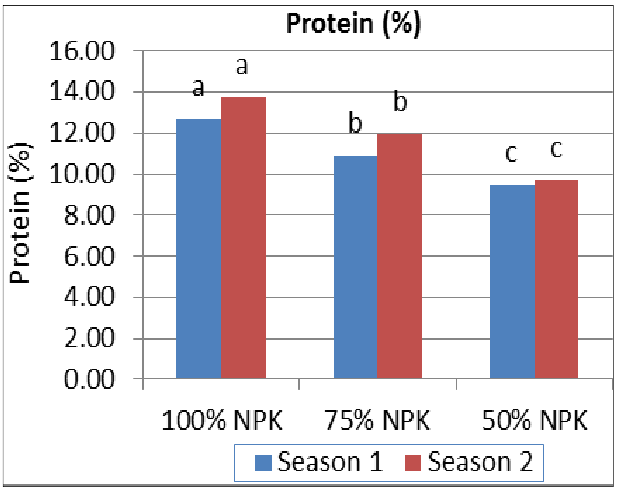


Fig. 8. Protein content of globe artichoke leaves under the effect of three levels of NPK in 2022/2023 and 2023/2024 seasons.

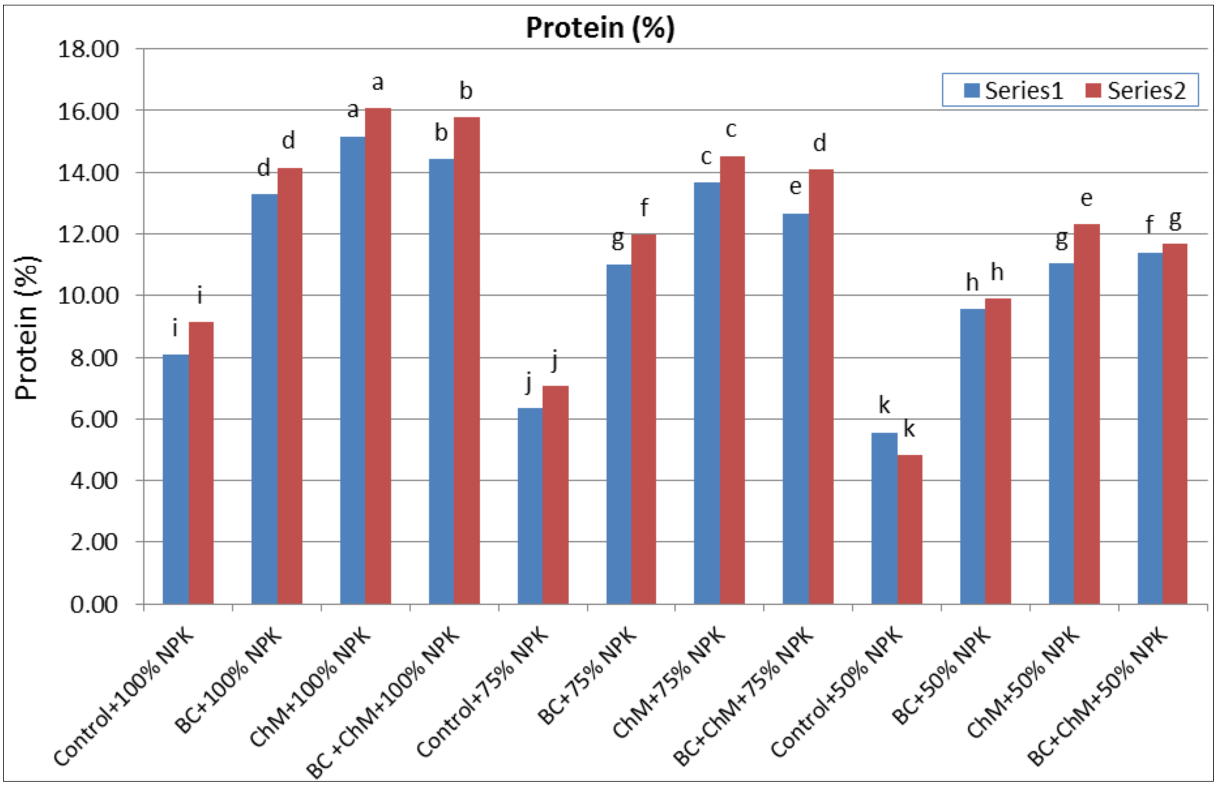


Fig. 9. Protein content in globe artichoke leaves interactions between biochar (BC) and chicken manure (ChM) with three levels of NPK in 2022/2023 and 2023/2024 seasons.

Table 9. Available nitrogen, phosphorus and potassium contents in soil under biochar, chicken manure and biochar plus chicken manure treatments with three levels of NPK after first season (2022/2023) and after second seasons (2023/2024).

Treatments		Available nitrogen (mg kg^{-1})		Available phosphorus (mg kg^{-1})		Available potassium (mg kg^{-1})	
		1st	2nd	1st	2nd	1st	2nd
Biochar and chicken manure (A)							
Control		55.04 d	52.63 c	5.19 c	5.39 c	396.79 c	392.08 d
Biochar		65.74 c	76.09 b	6.49 b	7.05 b	474.78 b	509.77 c
Chicken manure		79.79 a	88.67 a	8.16 a	9.08 a	538.66 a	552.63 b
Biochar+Chicken		76.37 b	89.11 a	8.17 a	9.13 a	542.86 a	560.60 a
Levels of NPK (B)							
L 1 (100% NPK)		75.76 a	83.30 a	7.75 a	8.99 a	577.03 a	599.05 a
L 2 (75% NPK)		69.73 b	79.42 b	7.27 b	7.77 b	527.32 b	544.51 b
L 3 (50% NPK)		62.21 c	67.15 c	5.99 c	6.22 c	360.47 c	367.75 c
Interaction (AxB)							
Control	L1	61.11 h	57.48 g	5.67 e	6.59 f	481.66 f	468.28 f
	L 2	54.29 j	56.33 g	5.39 e	4.88 h	397.37 g	415.41 g
	L 3	49.72 k	44.09 h	4.50 f	4.70 h	311.34 i	292.55 k
Biochar	L1	74.27 d	83.47 d	7.36 c	7.85 d	548.26 d	589.25 d
	L 2	65.85 g	79.47 e	6.86 d	7.46 de	510.48 e	563.61 e
	L 3	57.17 i	65.32 f	5.25 e	5.84 g	365.61 h	376.45 j
Chicken manure	L1	86.22 a	95.76 a	9.38 a	10.34 b	623.34 b	660.65 b
	L 2	80.50 b	89.45 c	8.27 b	9.45 c	597.69 c	586.84 d
	L 3	72.64 e	80.79 e	6.91 d	7.44 de	394.95 g	410.40 h
Biochar + Chicken	L1	81.42 b	96.50 a	8.59 b	11.19 a	654.86 a	678.04 a
	L 2	78.29 c	92.45 b	8.62 b	9.30 c	603.76 c	612.17 c
	L 3	69.39 f	78.38 e	7.37 cd	6.90 ef	369.95 h	391.59 i

4. Discussion

4.1. Vegetative growth and yield components

The globe artichoke showed the best responses to the trial treatments regarding plant height, number of leaves and chlorophyll content, when either chicken manure alone or in combination with biochar was applied. Application of chicken manure was preferred as it was associated with a higher yield, especially the leaf number of lettuce (Masarirambi et al., 2012). Also, Younas et al. (2022) showed that chicken manure considerably influences Bougainvillea's vegetative growth and productive qualities. In addition, Eglous et al. (2023) found that using poultry manure in marsh soil increased plant height, the number of flowers and fruits of cherry tomato plants, and increased biomass production.

Chicken manure is known to improve soil properties namely; water retention capability, pH status, and available nutrient minerals as well as microorganism activities, resulting in improvement of the plant growth and consequently yield (Hossain and Ryu 2017 and El-Shaboury et al., 2024). Thus, chicken manure could lead to higher plant vigor and increase chlorophyll SPAD values if used alone or in combination with biochar treatments to encourage the vegetative growth of globe artichokes. Moreover, addition of chicken dung, as an organic matter, to the soil is basically increase its macronutrients content and therefore, raising yield of the globe artichoke due to the high content of available micro and macronutrients in the chicken manure (Azmi et al., 2019 and Du et al., 2020). These outcomes are consistent with those seen when maize cob and chicken dung were used. These amendments positively affect plant growth because they boost phytohormones and encourage the activity of soil microorganisms (Morsy, 2019). It has been demonstrated that biochar can enhance the growth of corn and cassava plants and cauliflower (Yuniwati, 2018 and Yeasmin et al., 2021). As reported by Al-Omran et al. (2019), Ahmed et al. (2022), and Singh et al. (2025) increased plant growth may also be the consequence of improving the soil physical qualities such as; water retention, soil structure and soil aeration that caused by applied biochar and chicken manure. Also, implementing chicken manure increases chlorophyll levels, which improves the photosynthesis and productivity of Artemisia lactiflora (Taokaenchan et al. 2020).

The present study results revealed that early and total yield of globe artichoke were statistically different by the applied treatments under NPK levels. The highest early and total yield obtained by applying chicken manure or in combination with biochar with 100 or 75% NPK recommended fertilizer doses. These findings are consistent with those published by Merwad et al. (2017) and Yao et al. (2023), who found that chicken manure has potential positive impact on soil available nutrients and consequently can partially substitute the needed chemical fertilizer and subsequently reduces its usage while preserving cucumber yield. Likewise, Mancer et al. (2024) studied the effect of mineral and organic fertilizers on potato yield and revealed that the highest yield observed when just poultry manure was employed.

4.2. Globe artichoke quality

The current experiment demonstrated positive relations between organic fertilizer and three NPK recommended rates on globe artichoke quality. The maximum head quality of early and total yield obtained by the application of chicken manure with 100% or 75% NPK levels. Saleh et al. (2006) reported comparable benefits of organic manures for plant growth and nutrients absorption in general and specifically the improvement of artichoke yield characteristics treated with organic manure. In this context, it may worth to mention that poultry manure is the easiest to get and cheapest to obtain, as organic fertilizer, for low-income agricultural households. According to Mohamed et al. (2017) and Allahdadi and Farzane (2018), globe artichoke yield and its constituents were highest when N, P, and K were increased at the highest rates. Additionally, organic manure-treated soils have the advantage of being able to respond better to crop production and quality output because organic additions raise P availability in acidic soils and buffer acidity issues (Biratu et al., 2018). These supplements improve the activity of soil microorganisms, which raises phytohormones and consequently, artichoke quality (Morsy, 2019).

4.3. Chemical properties

The chemical contents of globe artichoke significantly increased with the utilization of organic fertilizers. Whereas, the chicken manure and its combination with biochar along with 100 or 75% NPK doses significantly increased the artichoke dry matter, inulin, total phenol, protein, nitrogen, phosphorus, and potassium contents, besides increasing available NPK in the soil. Kihanda et al., (2006), confirmed that the highest quality animal dung in terms of nutrient concentration is poultry manure. The addition of poultry manure to biochar could encourage surface oxidation of biochar by raising the temperature, especially at the start of the procedure, which explains the reflection of the interaction of biochar and poultry manure in enhancing soil chemical characteristics. In addition, the dry biomass of cassava root production was noticeably higher as a result of all the manure rates and fertilizers used (Biratu et al., 2018). Comparably, an observation reported by Morsy (2019), declaring that the application of organic manure caused greater contents of inulin in early yield. Applying fertilizer derived from organic sources had a remaining impact on globe artichoke performance, as the current study showed. Compared to inorganic materials, the crop grown in a field that received chicken manure benefited from the previously applied organic material. This is most likely because the soil's microorganisms helped break down the remaining organic matter into a form that could be absorbed promoting the nutrients' gradual release over an extended period. Additionally, the higher amount of macro and micronutrients in the chicken dung may potentially increase globe artichoke production, as Azmi et al., (2019), said that chicken manure is rich in both macro and micronutrients. This conclusion is in line with the findings of Mustafa et al. (2022). The combination of manure and biochar resulted in enhanced dry biomass of lettuce and cassava root. According to Thepsilvisut et al. (2022), white mugwort supplied with chicken manure had a higher total phenolic content than treatment with chemical fertilizers. Antonious (2023) stated that adding chicken manure to the soil greatly elevated the total phenol content of turnips, arugula and mustard plants in comparison to the control treatments. Additionally, Chuong (2023) confirmed that adding chicken manure to peanut seeds substantially improved NPK levels and protein content compared to control. Similarly, in their study on barley Mahmoud et al. (2023) stated that applying chicken manure may promote nutrient release by nutritional supplements and/or by increasing microbial activity that dissolves organic material, hence improving the fertility of the soil. Antonious, (2024) found that the concentration of phenols in the roots of sweet potatoes increased significantly in soil treated with manure. He attributed these results to improved root zone absorption of NPK nutrients, microbial activity and their excretions of enzymes that was mixed with soil enhancing leaf phenol production.

5. Conclusion

Artichokes are on the list of important export crops in Egypt. Therefore, it is essential to work on rationalizing its mineral fertilizers consumption in light of their large-scale production and enhancing their productive qualities, in addition to improving the properties of productive soil and reducing its degradation. By partial replacement of organic fertilizers instead of the mineral ones, the current field experiment concluded that higher globe artichoke yield, yield quality, chemical properties, and nutrient uptake were acquired where the plants treated with chicken manure (10 tons/hectare) and under 75% NPK level followed by biochar plus chicken manure at ratio 1:1 under 75% NPK rate to assist with maintaining soil health and optimum artichoke yield. It, also, reduced the requirement for chemical fertilizers for artichokes by 25%. This is probably because it improved soil organic matter and microorganisms have a positive impact on plant growth and yield components. The research did not include an economic study due to the drastic changes in artichoke prices for export and local markets, from one season to another, as well as significant price fluctuations within the same season. Additionally, there were large differences between export and local prices, along with the instability of the US dollar exchange rate.

Conflicts of interest: The authors have stated that there are no conflicting interests.

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