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Onion Response to Combined Biochar and Compost with Cobalt Spraying under Saline Conditions

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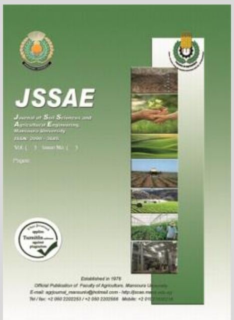

ABSTRACT

This study explores the potential role of combined biochar and compost amendments, along with cobalt spraying on the growth and yield of onion grown on soil with an EC value of 7.42 dSm^{-1}. A field trial was conducted with the main treatments being soil amendments (Without, biochar, compost and biochar + compost) and sub main treatments being different cobalt (Co) rates (0, 5, and 10 mg Co/L). Parameters measured at 80 days post-transplanting included plant height, dry weight, carotene content, nitrogen, phosphorus and potassium. At harvest, yield traits such as bulb diameter, total bulb yield, vitamin C and total sugar content were assessed. Soil nutrient levels, including available NPK, were also determined at harvest. The results indicate that both biochar and compost significantly improved onion growth and yield parameters compared to the control, as the superior treatment was the combined application of biochar and compost followed by compost alone then biochar alone. Also, the cobalt treatments had a positive effect, as this effect increased as the Co rate increased. Specifically, the highest rates of cobalt (10 mg/L) in conjunction with biochar and compost amendments resulted in the greatest increases in plant growth and nutrient content as well as bulb characteristics. Also, the soil available NPK increased due to soil additions, as the highest values were achieved with the combined treatment of boichar plus compost. These findings suggest that integrating biochar and compost amendments with cobalt spraying can effectively enhance onion growth and productivity under saline conditions.

Keywords: Biochar, Compost, Cobalt, Onion .

INTRODUCTION

Soil salinity is a major challenge in agriculture, significantly affecting crop productivity and soil health (Baddour *et al.* 2021). High soil salinity, indicated by elevated electrical conductivity (EC), can impede plant growth and reduce yields (El-Shamy *et al.* 2022). The EC value of 7.42 dSm^{-1} in the studied soil represents a considerable salinity stress for many crops, including onions.

Onions (*Allium cepa* L.) are an essential vegetable crop worldwide, valued for their culinary uses and health benefits. However, their cultivation is highly sensitive to soil conditions, particularly salinity (El-Sherpiny *et al.* 2022). To mitigate the adverse effects of salinity and enhance onion productivity, effective soil amendment strategies are necessary.

Biochar, a carbon-rich product derived from the pyrolysis of organic materials, has gained attention for its potential to improve soil properties and crop performance (El-Sherpiny *et al.* 2023). It enhances soil structure, water retention, and nutrient availability, making it a promising amendment for saline soils. Similarly, compost, a well-decomposed organic matter, enriches the soil with essential nutrients and improves its physical and biological properties (El-Sherpiny and Kany,2023).

Cobalt, though required in trace amounts, plays a vital role in plant growth and development, influencing various physiological processes (Baddour *et al.* 2021; Abd–Elhady *et al* 2023). Its application, in appropriate doses, can potentially enhance plant resilience to stress conditions, including salinity (Ghazi *et al.* 2023).

Therefore, this study aims to evaluate the combined effect of biochar and compost amendments with cobalt spraying on the growth and yield of onions grown under saline conditions. Generally, this research seeks to provide insights into effective strategies for improving onion cultivation in challenging soil environments.

MATERIALS AND METHODS

The field trial was conducted on a private farm located at Met-Antar village, Talkha district, El-Dakahlia governorate, Egypt (coordinates 31°4'54"N - 31°24'4"E). A split-plot design was used with three main soil amendment treatments and three sub-main cobalt rate treatments, each replicated three times.

The main treatments included control (No amendments), biochar (applied at 1.0 ton fed^{-1}), compost (applied at 3.0 tons fed^{-1}) and biochar + compost (combination of biochar at a rate of 1.0 ton fed^{-1} and compost at a rate of 3.0 tons fed^{-1}). While the sub-main treatments involved different cobalt (Co) rates, applied as cobalt sulphate (0, 5 and 10 mg Co/L). Each subplot measured 6.0 m^2. Onion seedlings of the cultivar Cv. Giza Red (60 days old) were transplanted on November 25th in both 2022 and 2023. Mineral fertilization was conducted according to MASR guidelines using urea (46% N), calcium super-phosphate (6.7% P) and potassium sulphate (38% K). Standard agronomic practices for onion cultivation were followed, including irrigation, weeding, and pest control. Biochar and compost were added during soil preparation (one month before transplanting), while foliar application of

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cobalt was conducted four times at 20-day intervals, starting one month after transplanting. The harvest took place on April 29th for both studied seasons.

The initial soil (sampled from a depth of 0-30 cm, before transplanting), along with the biochar and compost, were analyzed using standard methods as described by Tandon (2005), were their properties are shown in Table1.

Table 1. Attributes of initial soil as well as the studied biochar and compost

Initial soil		Biochar	
Characteristics and unit	Values	Characteristics and unit	Values
Sand	17	EC, dSm^{-1}	5.00
Silt	33	pH	8.50
Clay	50	CEC, cmolc kg^{-1}	70.0
Textural class	Clay	Compost	
F.C, %	35.92	Characteristics and unit	Values
Organic matter, %	1.4	C:N ratio	11.8
EC dSm^{-1}	7.42	EC,dSm^{-1}	4.0
pH	7.9	pH	6.25
Available nitrogen, $mgKg^{-1}$	40.28	O.M,%	34.5
Available phosphorus, $mgKg^{-1}$	5.62	Total C, %	20
Available potassium, $mgKg^{-1}$	201.76	Total N, %	1.7

Plant compost was prepared by combining plant residues, such as rice and maize straw, and allowing them to decompose. Biochar was produced by combusting plant residues (soybean stover) in a muffle furnace without oxygen at 400 to 500 °C for 30 minutes (Vijayaraghavan, 2019). At 80 days post-transplanting, several parameters were measured, including plant height (cm) and fresh and dry weights (g/plant). Additionally, chlorophyll content (SPAD) and carotene content (mg/g) were determined following the methods described by Hentschel *et al.* (2002). Also, at 80 days from transplanting, malondialdehyde (MDA, µmol.g^{-1} F.W) was estimated as per the method by Valenzuela (1991), while peroxidase (POX, unit mg^{-1} $protein^{-1}$) and catalase (CAT, unit mg^{-1} $protein^{-1}$) activities were determined according to Alici and Arabaci (2016). Leaf nutrient concentrations (N, P, K, %) were measured at 80 days post-transplanting, and the availability of N, P and K (mg kg^{-1}) in the soil at harvest was determined using the Kjeldahl method, spectrophotometer, and flame photometer for N,P and K, respectively, based on standard methods described by Tandon (2005). Soil field capacity (FC, %) was also measured at the harvest stage. At harvest, additional parameters assessed included average bulb fresh weight (g), bulb diameter (cm), neck diameter (cm), and total bulb yield (ton/ha). Various bulb quality traits were determined according to AOAC (2000), including vitamin C content (mg/100g), total soluble solids (TSS,%), total sugar content (%), dry matter (%), fiber (%), anthocyanin pigment (mg/100g), pyruvic acid (µmol.g^{-1}), carbohydrates (%), and protein (%). Data were analyzed using appropriate statistical methods to determine the significance of treatment effects on the measured parameters as described by Gomez and Gomez (1984). Means were compared using the least significant difference (LSD) test at a 5% significance level.

RESULTS AND DISCUSSION

Onion traits at a period of 80 days from transplanting

Table 2 presents the impact of different soil amendments (none, biochar, compost, biochar + compost) and cobalt treatments((0, 5, and 10 mg Co/L) on various growth parameters and photosynthetic pigments of onion plants 80 days post-transplanting over two study seasons. The combined application of biochar and compost significantly increased plant height, fresh and dry weights, in both seasons compared to other treatments.

Table 2. Impact of the treatments on onion growth performance 80 days after transplanting during both study seasons

Treatments		Plant height cm		Fresh weight $g.plant^{-1}$		Dry weight $g.plant^{-1}$		Chlorophyll SPAD		Carotene $mg.g^{-1}$	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Main factor: Soil amendments											
Without		73.11d	75.37d	72.47d	74.63d	8.78d	9.23d	42.53d	43.84d	0.334d	0.348d
Biochar		77.19c	81.00c	74.82c	76.49c	9.07c	9.53c	43.23c	44.90c	0.354c	0.370c
Compost		81.65b	85.68b	76.96b	78.66b	9.38b	9.86b	44.01b	45.77b	0.372b	0.387b
Biochar+compost		83.02a	87.28a	78.68a	80.35a	9.68a	10.15a	44.58a	46.50a	0.386a	0.401a
LSD at 5%		1.07	1.11	0.96	0.94	0.08	0.13	0.39	0.38	0.009	0.009
Sub main factor: Cobalt treatments											
0.0 mg Co L^{-1}		77.77c	81.33c	75.04b	76.80b	9.11b	9.57b	43.37a	45.00b	0.355c	0.370c
5.0 mg Co L^{-1}		78.74b	82.18b	75.77ab	77.66a	9.20b	9.67b	43.56a	45.26ab	0.361b	0.376b
10.0 mg Co L^{-1}		79.72a	83.49a	76.39b	78.14a	9.36a	9.84a	43.83a	45.50a	0.368a	0.384a
LSD at 5%		0.70	0.73	0.84	0.76	0.11	0.11	N.S	0.48	0.003	0.003
Interaction											
Without	0.0 mg Co L^{-1}	72.16	74.47	71.36	73.35	8.66	9.13	42.33	43.62	0.327	0.340
	5.0 mg Co L^{-1}	72.98	75.24	72.64	74.93	8.77	9.20	42.49	43.88	0.335	0.350
	10.0 mg Co L^{-1}	74.18	76.41	73.42	75.59	8.91	9.35	42.75	44.02	0.340	0.355
Biochar	0.0 mg Co L^{-1}	75.08	78.76	74.10	76.00	8.98	9.41	43.02	44.68	0.348	0.363
	5.0 mg Co L^{-1}	77.06	80.76	74.90	76.39	9.06	9.53	43.09	44.82	0.352	0.366
	10.0 mg Co L^{-1}	79.44	83.49	75.47	77.09	9.18	9.66	43.59	45.21	0.364	0.381
Compost	0.0 mg Co L^{-1}	81.05	85.03	76.26	77.89	9.27	9.71	43.78	45.52	0.366	0.382
	5.0 mg Co L^{-1}	81.84	85.77	76.96	78.96	9.36	9.88	44.06	45.80	0.372	0.387
	10.0 mg Co L^{-1}	82.05	86.24	77.68	79.14	9.49	9.98	44.18	45.99	0.377	0.392
Biochar + compost	0.0 mg Co L^{-1}	82.78	87.08	78.45	79.96	9.54	10.02	44.35	46.17	0.381	0.395
	5.0 mg Co L^{-1}	83.06	86.97	78.59	80.34	9.62	10.06	44.61	46.56	0.387	0.402
	10.0 mg Co L^{-1}	83.22	87.80	79.00	80.75	9.87	10.38	44.79	46.76	0.392	0.408
LSD at 5%		1.41	1.45	1.68	1.52	0.21	0.21	1.17	0.95	0.005	0.005

Means within a row followed by a different letter (s) are statistically different at a 0.05 level

This increase can be attributed to improved soil structure, moisture retention, and nutrient availability provided by the amendments (El-Sherpiny *et al.* 2023). Higher cobalt rates (10 mg Co/L) resulted in the highest values of plant height, suggesting that cobalt, as a micronutrient, plays a role in promoting plant growth by enhancing physiological processes (Baddour *et al.* 2021). The highest values of plant height were observed with the combined biochar and compost treatment, along with spraying cobalt at 10 mg /L, indicating a synergistic effect of organic amendments and cobalt on plant height.

Chlorophyll and carotene contents were highest in the biochar and compost treatment as combined, indicating better photosynthetic efficiency and antioxidant properties. Improved soil fertility and structure likely enhance chlorophyll synthesis and carotene accumulation. Higher cobalt rates increased chlorophyll and carotene contents, with 10 mg Co/L showing the highest values. Cobalt may be involved in chlorophyll synthesis and protecting chloroplasts from oxidative damage. The combination of biochar and compost with 10 mg Co/L cobalt resulted in the highest chlorophyll and carotene contents, suggesting a synergistic effect enhancing the plant's photosynthetic and antioxidant capacities. The results are in harmony with those of Baddour *et al.* (2021); Abd–Elhady *et al* (2023).

Table 3 shows the effect of the studied treatments on leaf chemical constituents (N, P, K, %) during both studied seasons. The results indicate that both biochar and compost significantly increased the values of NPK in leaves of onion compared to the control, as the superior treatment was the combined application of biochar and compost followed by compost alone then biochar alone. The combined biochar and compost treatment showed the highest concentrations of nitrogen, phosphorus, and potassium in the leaves, indicating improved nutrient availability and uptake due to the amendments. Also, the cobalt treatments had a positive effect on leaves NPK, as this effect increased as the Co rate increased. Specifically, the highest rates of cobalt (10 mg/L) in conjunction with biochar and compost amendments resulted in the greatest increases in leaf chemical constituents (N, P, K, %). Cobalt plays a crucial role in the activation of certain enzymes involved in nutrient uptake and metabolism within plants. Higher cobalt concentrations may enhance the activity of these enzymes, leading to increased uptake and assimilation of nitrogen, phosphorus, and potassium from the soil into the plant tissues (El-Sherpiny *et al.* 2023; El-Sherpiny and Kany, 2023).

Table 3. Impact of the treatments on onion chemical constituents 80 days after transplanting during both study seasons

Treatments		N%		P%		K%	
		1st	2nd	1st	2nd	1st	2nd
Main factor: Soil amendments							
Without		2.86d	2.93d	0.273d	0.287d	2.66d	2.79d
Biochar		3.16c	3.23c	0.298c	0.303c	2.86c	2.94c
Compost		3.42b	3.51b	0.319b	0.324b	3.03b	3.10b
Biochar+compost		3.68a	3.76a	0.336a	0.345a	3.21a	3.28a
LSD at 5%		0.09	0.06	0.008	0.008	0.05	0.04
Sub main factor: Cobalt treatments							
0.0 mg Co L^{-1}		2.86d	2.93d	0.273d	0.287d	2.66d	2.79d
5.0 mg Co L^{-1}		3.16c	3.23c	0.298c	0.303c	2.86c	2.94c
10.0 mg Co L^{-1}		3.42b	3.51b	0.319b	0.324b	3.03b	3.10b
LSD at 5%		3.68a	3.76a	0.336a	0.345a	3.21a	3.28a
Interaction							
Without	0.0 mg Co L^{-1}	2.72	2.78	0.264	0.277	2.57	2.71
	5.0 mg Co L^{-1}	2.90	2.96	0.273	0.287	2.66	2.79
	10.0 mg Co L^{-1}	2.98	3.05	0.283	0.296	2.75	2.88
Biochar	0.0 mg Co L^{-1}	3.08	3.14	0.291	0.297	2.81	2.91
	5.0 mg Co L^{-1}	3.15	3.23	0.297	0.301	2.87	2.93
	10.0 mg Co L^{-1}	3.26	3.32	0.306	0.310	2.92	2.98
Compost	0.0 mg Co L^{-1}	3.35	3.43	0.313	0.318	2.96	3.03
	5.0 mg Co L^{-1}	3.42	3.51	0.320	0.324	3.02	3.10
	10.0 mg Co L^{-1}	3.50	3.59	0.326	0.331	3.12	3.18
Biochar + compost	0.0 mg Co L^{-1}	3.60	3.68	0.334	0.339	3.19	3.25
	5.0 mg Co L^{-1}	3.68	3.76	0.336	0.341	3.21	3.28
	10.0 mg Co L^{-1}	3.75	3.85	0.339	0.356	3.23	3.30
LSD at 5%		0.17	0.08	0.004	0.004	0.07	0.08

Means within a row followed by a different letter (s) are statistically different at a 0.05 level

Table 4 illustrates the impact of the different soil amendments and cobalt treatments on onion oxidative indicators.

Table 4. Impact of the treatments on onion MDA and enzymes 80 days after transplanting during both study seasons

Treatments		MDA (μmol.g^{-1} F.W)		POX (unit mg^{-1} $protein^{-1}$)		CAT (unit mg^{-1} $protein^{-1}$)	
		1st	2nd	1st	2nd	1st	2nd
Main factor: Soil amendments							
Without		12.35a	12.60a	1.81d	1.85d	0.280d	0.294d
Biochar		11.50a	11.74b	2.41c	2.45c	0.305c	0.310c
Compost		10.51b	10.75c	2.74b	2.78b	0.326b	0.332b
Biochar+compost		9.60d	9.79d	2.97a	3.01a	0.342a	0.352a
LSD at 5%		0.06	0.16	0.07	0.07	0.008	0.006
Sub main factor: Cobalt treatments							
0.0 mg Co L^{-1}		11.32a	11.54a	2.38c	2.42c	0.308c	0.315c
5.0 mg Co L^{-1}		10.99b	11.22b	2.50b	2.53b	0.314b	0.322b
10.0 mg Co L^{-1}		10.67c	10.90c	2.58a	2.62a	0.318a	0.329a
LSD at 5%		0.14	0.13	0.06	0.06	0.002	0.003
Interaction							
Without	0.0 mg Co L^{-1}	12.60	12.85	1.69	1.72	0.276	0.290
	5.0 mg Co L^{-1}	12.37	12.64	1.83	1.86	0.279	0.294
	10.0 mg Co L-1	12.09	12.30	1.93	1.97	0.285	0.298
Biochar	0.0 mg Co L^{-1}	11.85	12.07	2.32	2.35	0.301	0.306
	5.0 mg Co L^{-1}	11.61	11.85	2.42	2.45	0.306	0.312
	10.0 mg Co L^{-1}	11.06	11.29	2.50	2.54	0.307	0.313
Compost	0.0 mg Co L^{-1}	10.76	10.98	2.60	2.63	0.317	0.322
	5.0 mg Co L^{-1}	10.50	10.74	2.76	2.80	0.329	0.335
	10.0 mg Co L^{-1}	10.26	10.52	2.86	2.91	0.334	0.341
Biochar + compost	0.0 mg Co L^{-1}	10.06	10.24	2.92	2.96	0.338	0.343
	5.0 mg Co L^{-1}	9.46	9.66	2.98	3.02	0.344	0.349
	10.0 mg Co L^{-1}	9.28	9.47	3.03	3.07	0.346	0.364
LSD at 5%		0.27	0.28	0.13	0.13	0.004	0.006

Means within a row followed by a different letter (s) are statistically different at a 0.05 level

The Table illustrates the effects of studied treatments on the levels of malondialdehyde (MDA) and the activities of peroxidase (POX) and catalase (CAT) enzymes in leaves of onion plants 80 days post-transplanting across both study seasons. Onion plants treated with biochar and compost, either alone or in combination, exhibited significantly lower MDA levels compared to the untreated control. This indicates reduced lipid peroxidation and oxidative stress, possibly due to the antioxidant properties of these amendments. Increasing cobalt concentrations led to a decrease in MDA levels, with the highest cobalt rate (10.0 mg Co L^{-1}) resulting in the lowest MDA levels. Cobalt likely mitigates oxidative damage by enhancing antioxidant defense mechanisms within the plant. POX activity increased with the application of biochar, compost, and their combination. This suggests an induction of defense responses against oxidative stress, as POX is involved in scavenging reactive oxygen species (ROS) in plants. Higher cobalt rates corresponded to increased POX activity, indicating a role for cobalt in stimulating the antioxidant defense system. Elevated POX activity may enhance the plant's ability to detoxify ROS and maintain cellular homeostasis (El-Sherpiny and Kany,2023).Similar to POX activity, CAT activity was higher in onion plants treated with biochar, compost, and their combination.CAT plays a crucial role in detoxifying hydrogen peroxide, a byproduct of oxidative stress, thereby protecting plant cells from damage. Increasing cobalt concentrations resulted in elevated CAT activity, highlighting cobalt's potential to enhance antioxidant enzyme systems. Enhanced CAT activity helps alleviate oxidative stress and maintain cellular redox balance. Cobalt serves as a cofactor for enzymes involved in antioxidant defense, such as POX, and CAT. Higher cobalt concentrations can enhance the activity of these enzymes, thus reducing oxidative stress (Baddour *et al.* 2021; Abd–Elhady *et al.* 2023).

Onion yield and its components

Data in Table 5 show the effect of the studied treatments on yield and its components, including average bulb fresh weight (g), bulb diameter (cm), neck diameter (cm), and total bulb yield (ton/ha) at harvest stage during both study seasons. while, Table 6 illustrates the effect of the studied treatments on various bulb quality traits, including vitamin C content (mg/100g), total soluble solids (TSS,%), total sugar content (%), dry matter (%), fiber (%), anthocyanin pigment (mg/100g), pyruvic acid (µmol.g^{-1}), carbohydrates (%), and protein (%).at harvest stage during both study seasons.

The data in Table 5 reveal significant variations in onion bulb yield and its components across different treatments. Parameters demonstrate a significant response to the applied treatments. Notably, treatments involving biochar, compost, and their combination exhibit notable improvements in bulb size and total yield compared to the untreated control. These findings underscore the potential of organic soil amendments in enhancing onion bulb yield, likely attributed to improved soil fertility, nutrient availability, and overall plant health.

Table 5. Impact of the treatments on onion yield and its components at harvest stage during both study seasons

Treatments		Average bulb F.W		Bulb diameter cm		Neck diameter cm		Total bulb yield ton/ha		Marketable bulb yield ton/ha	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Main factor: Soil amendments											
Without		88.87d	91.64d	4.15d	4.33d	1.33d	1.37d	33.84d	34.90d	32.15d	33.84d
Biochar		97.10c	100.88c	4.63c	4.83c	1.62c	1.67c	36.98c	38.41c	35.07c	36.42c
Compost		103.19b	105.73b	5.04b	5.24b	2.11b	2.16b	39.29b	40.26b	37.65b	37.95b
Biochar+compost		109.10a	111.76a	5.87a	6.11a	2.68a	2.76a	41.55a	42.56a	40.07a	40.79a
LSD at 5%		0.27	1.69	0.05	0.07	0.06	0.06	0.10	0.18	0.11	0.12
Sub main factor: Cobalt treatments											
0.0 mg Co L^{-1}		97.58c	101.04c	4.76c	4.95c	1.81c	1.85c	37.16c	38.48c	35.30c	36.62c
5.0 mg Co L^{-1}		99.54b	102.22b	4.92b	5.12b	1.93b	1.98b	37.91b	38.93b	36.27b	37.42b
10.0 mg Co L^{-1}		101.57a	104.25a	5.10a	5.31a	2.07a	2.14a	38.68a	39.70a	37.13a	37.71a
LSD at 5%		0.40	0.99	0.07	0.06	0.05	0.05	0.16	0.12	0.15	0.18
Interaction											
Without	0.0 mg Co L^{-1}	86.93	89.75	4.01	4.17	1.23	1.28	33.10	34.18	30.86	32.89
	5.0 mg Co L^{-1}	88.84	91.59	4.12	4.30	1.31	1.37	33.83	34.88	32.35	33.86
	10.0 mg Co L^{-1}	90.83	93.60	4.33	4.52	1.44	1.47	34.59	35.64	33.23	34.76
Biochar	0.0 mg Co L^{-1}	95.00	98.77	4.54	4.73	1.52	1.55	36.17	37.61	34.23	35.64
	5.0 mg Co L^{-1}	97.09	100.98	4.62	4.82	1.62	1.66	36.97	38.45	35.05	36.46
	10.0 mg Co L^{-1}	99.23	102.89	4.74	4.96	1.74	1.81	37.78	39.18	35.92	37.16
Compost	0.0 mg Co L^{-1}	101.25	104.70	4.83	5.03	1.97	2.01	38.55	39.87	36.86	37.84
	5.0 mg Co L^{-1}	103.13	105.17	5.04	5.25	2.07	2.12	39.27	40.05	37.59	38.60
	10.0 mg Co L^{-1}	105.18	107.31	5.24	5.45	2.29	2.35	40.05	40.86	38.49	37.40
Biochar + compost	0.0 mg Co L^{-1}	107.16	110.93	5.67	5.88	2.51	2.56	40.80	42.24	39.25	40.09
	5.0 mg Co L^{-1}	109.11	111.14	5.87	6.11	2.71	2.76	41.55	42.32	40.08	40.76
	10.0 mg Co L^{-1}	111.04	113.21	6.08	6.33	2.83	2.95	42.28	43.11	40.88	41.53
LSD at 5%		0.81	1.97	0.14	0.12	0.10	0.10	0.31	0.26	0.31	0.34

Means within a row followed by a different letter (s) are statistically different at a 0.05 level

The observed enhancements in onion bulb yield and its components can be attributed to several scientific factors. Biochar and compost amendments contribute to soil organic matter content, which enhances soil structure, water retention, and nutrient availability. Improved soil structure facilitates root growth and nutrient uptake, leading to increased bulb size and yield. Additionally, these amendments promote beneficial microbial activity in the soil, facilitating nutrient cycling and release. The combination of biochar and compost may further enhance these effects through synergistic interactions, resulting in greater yield improvements. On the other hand, the sequence order of cobalt treatments from more effective to less was 10 mgCo/L then 5.0 mgCo/L and lately 0.0 mgCo/L. the vital role of cobalt was mentioned above. The results are in agreement with those of Aneseyee and Wolde, (2021).

Table 6 shows the effects of treatments on various quality traits which are crucial indicators of onion bulb quality, influencing consumer preferences and market value. Treatments incorporating biochar, compost, and cobalt spraying demonstrate significant enhancements in several quality parameters compared to the control. This suggests that these treatments positively influence the nutritional composition, taste, and shelf-life of onion bulbs.

The improvement in onion bulb quality traits can be attributed to the beneficial effects of the applied treatments on plant physiology and metabolism. Biochar and compost amendments contribute to soil fertility and nutrient availability, promoting the synthesis and accumulation of essential nutrients and bioactive compounds in onion bulbs. Cobalt spraying may also play a role in enhancing nutrient uptake and metabolism, thereby influencing bulb quality traits. Additionally, the reduction of oxidative stress and improvement in antioxidant enzyme activities associated with these treatments may contribute to enhanced nutritional quality and shelf-life of onion bulbs (Baddour *et al.* 2021; El-Sherpiny *et al.* 2023; El-Sherpiny and Kany,2023; Abd–Elhady *et al* 2023; Ghazi *et al.* 2023).

Table 6. Impact of the treatments on onion quality at harvest stage during both study seasons

Treatments		Vitamin C mg/100g		TSS %		Total sugar %		Dry matter %	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd
Main factor: Soil amendments									
Without		10.95d	11.27d	9.63d	9.82d	5.56d	5.84d	9.32d	9.47d
Biochar		11.83c	12.29c	10.40c	10.54c	5.81c	6.10c	9.92c	10.06c
Compost		12.48b	12.81b	11.07b	11.23b	6.00b	6.31b	10.82b	10.97b
Biochar+compost		13.06a	13.37a	11.56a	11.71a	6.16a	6.46a	11.54a	11.70a
LSD at 5%		0.12	0.22	0.19	0.18	0.11	0.15	0.09	0.15
Sub main factor: Cobalt treatments									
0.0 mg Co L^{-1}		11.83c	12.27b	10.47c	10.61c	5.81b	6.11c	10.19c	10.35c
5.0 mg Co L^{-1}		12.07b	12.39b	10.67b	10.84b	5.88ab	6.18b	10.39b	10.54b
10.0 mg Co L^{-1}		12.34a	12.65a	10.85a	11.03a	5.95a	6.25a	10.62a	10.76a
LSD at 5%		0.17	0.15	0.13	0.13	0.07	0.06	0.14	0.12
Interaction									
Without	0.0 mg Co L^{-1}	10.61	10.96	9.55	9.69	5.48	5.77	9.11	9.29
	5.0 mg Co L^{-1}	10.87	11.19	9.58	9.77	5.58	5.85	9.31	9.45
	10.0 mg Co L^{-1}	11.36	11.68	9.77	9.98	5.62	5.89	9.53	9.66
Biochar	0.0 mg Co L^{-1}	11.55	12.02	10.04	10.16	5.74	6.02	9.72	9.86
	5.0 mg Co L^{-1}	11.87	12.33	10.47	10.62	5.79	6.10	9.91	10.05
	10.0 mg Co L^{-1}	12.08	12.53	10.68	10.85	5.88	6.18	10.12	10.25
Compost	0.0 mg Co L^{-1}	12.29	12.77	10.89	11.03	5.93	6.22	10.58	10.75
	5.0 mg Co L^{-1}	12.50	12.76	11.09	11.25	6.00	6.33	10.80	10.95
	10.0 mg Co L^{-1}	12.65	12.90	11.23	11.41	6.07	6.38	11.07	11.21
Biochar + compost	0.0 mg Co L^{-1}	12.87	13.32	11.40	11.55	6.10	6.41	11.32	11.48
	5.0 mg Co L^{-1}	13.03	13.28	11.55	11.70	6.15	6.43	11.55	11.72
	10.0 mg Co L^{-1}	13.27	13.50	11.72	11.88	6.22	6.54	11.76	11.91
LSD at 5%		0.35	0.31	0.26	0.27	0.14	0.12	0.28	0..24

Means within a row followed by a different letter (s) are statistically different at a 0.05 level

Table 6. cont.

Treatments		Fiber %		Anthocyanin mg/100g		Pyruvic acid; πmol.g^{-1}		Carbohydrates %		Protein %	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Main factor: Soil amendments											
Without		3.24d	3.38d	26.25d	26.61d	5.45d	5.72d	15.72d	15.91d	7.34d	7.47d
Biochar		3.56c	3.71c	27.20c	27.59c	6.06c	6.36c	16.73c	16.95c	7.65c	7.79c
Compost		3.88b	4.04b	27.84b	28.22b	6.54b	6.88b	17.45b	17.65b	8.05b	8.21b
Biochar+compost		4.25ba	4.42a	28.45a	28.88a	7.07a	7.42a	18.03a	18.26a	8.36a	8.53a
LSD at 5%		0.04	0.03	0.22	0.36	0.06	0.09	0.14	0.14	0.11	0.19
Sub main factor: Cobalt treatments											
0.0 mg Co L^{-1}		3.62c	3.76c	27.16b	27.57b	6.08c	6.39c	16.74c	16.97c	7.73c	7.89c
5.0 mg Co L^{-1}		3.74b	3.89b	27.47a	27.84ab	6.29b	6.62b	17.00b	17.20b	7.86b	7.99b
10.0 mg Co L^{-1}		3.84a	4.01a	27.68a	28.06a	6.47a	6.79a	17.21a	17.41a	7.96a	8.12a
LSD at 5%		0.04	0.04	0.28	0.31	0.08	0.08	0.18	0.18	0.09	0.08
Interaction											
Without	0.0 mg Co L^{-1}	3.14	3.27	25.80	26.20	5.14	5.40	15.46	15.63	7.26	7.41
	5.0 mg Co L^{-1}	3.26	3.40	26.33	26.64	5.50	5.78	15.77	15.94	7.35	7.46
	10.0 mg Co L^{-1}	3.34	3.47	26.61	27.00	5.71	5.98	15.95	16.17	7.39	7.54
Biochar	0.0 mg Co L^{-1}	3.44	3.58	26.97	27.41	5.89	6.19	16.45	16.71	7.49	7.65
	5.0 mg Co L^{-1}	3.56	3.71	27.21	27.59	6.07	6.39	16.75	16.95	7.62	7.75
	10.0 mg Co L^{-1}	3.66	3.83	27.41	27.77	6.23	6.51	16.98	17.19	7.82	7.98
Compost	0.0 mg Co L^{-1}	3.77	3.93	27.62	28.03	6.38	6.73	17.24	17.46	7.92	8.10
	5.0 mg Co L^{-1}	3.89	4.05	27.89	28.24	6.52	6.86	17.46	17.67	8.07	8.22
	10.0 mg Co L^{-1}	3.99	4.15	28.03	28.39	6.71	7.05	17.64	17.83	8.16	8.31
Biochar + compost	0.0 mg Co L^{-1}	4.12	4.28	28.24	28.65	6.91	7.22	17.80	18.08	8.25	8.40
	5.0 mg Co L^{-1}	4.24	4.41	28.43	28.90	7.06	7.43	18.03	18.23	8.38	8.54
	10.0 mg Co L^{-1}	4.39	4.57	28.69	29.09	7.23	7.59	18.26	18.46	8.45	8.64
LSD at 5%		0.08	0.08	0.56	0.62	0.17	0.15	0.36	0.36	0.18	0.16

Means within a row followed by a different letter (s) are statistically different at a 0.05 level

Soil analysis post-harvest

Table 7 provides an overview of the effects of various treatments on selected soil properties at the harvest stage across both study seasons. The parameters assessed include available nitrogen (N), phosphorus (P), potassium (K) concentrations in soil(mg kg^{-1}), and field capacity (F.C,%). Notably, treatments involving biochar, compost, and their combination demonstrate significant impacts on soil nutrient levels and field capacity compared to the untreated control, while cobalt treatments didn't have a significant effect on available N, P, K and FC of soil after harvest. This suggests that the observed changes in soil properties are primarily driven by the application of soil amendments rather than cobalt supplementation.

The application of biochar, compost, and their combination resulted in notable improvements in soil nutrient concentrations(N, P and K). Among these treatments, the combination of biochar and compost exhibited the most pronounced effects, with higher concentrations of N, P, and K observed compared to individual amendments. These findings suggest that biochar and compost amendments contribute to enhanced soil fertility and nutrient availability, likely through mechanisms such as nutrient retention, microbial activity promotion, and organic matter decomposition. Moreover, it can be noticed that soil FC increased with both compost and biochar either alone or in combination, with superiority of combined treatment followed by biochar alone then compost alone.

Scientifically, biochar is known to act as a stable carbon source in soil, providing a habitat for beneficial microbes and enhancing nutrient retention through its high surface area and porosity. Compost, on the other hand, enriches soil with organic matter, nutrients, and microbial communities, promoting nutrient cycling and availability. The combination of biochar and compost may synergistically enhance these effects, resulting in greater improvements in soil nutrient status (Baddour *et al.* 2021; El-Sherpiny *et al.* 2023; El-Sherpiny and Kany, 2023; Abd–Elhady *et al* 2023; Ghazi *et al.* 2023).

Table 7. Impact of the treatments on some soil properties at harvest stage during both study seasons

Treatments		N mg/kg		P mg/kg		K mg/kg		F.C %	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd
Main factor: Soil amendments									
Initial		40.28		5.62		201.76		35.92	
Without		42.54c	43.01b	7.42d	7.51c	205.02b	208.19a	35.99d	36.10d
Biochar		44.84b	45.39a	8.51c	8.60b	208.63a	212.32a	37.44c	37.62c
Compost		44.95ab	45.48a	8.65b	8.75b	208.73a	212.31a	36.48b	36.62b
Biochar+compost		45.11a	45.66a	8.78a	8.93a	208.91a	212.59a	37.86a	38.07a
LSD at 5%		0.24	0.69	0.03	0.15	0.59	n.s	0.10	0.10
Sub main factor: Cobalt treatments									
0.0 mg Co L^{-1}		44.43a	45.01a	8.40a	8.50a	207.91a	211.32a	36.96a	37.09a
5.0 mg Co L^{-1}		44.37ab	44.86a	8.34b	8.47ab	207.86a	211.53a	36.94a	37.13a
10.0 mg Co L^{-1}		44.27b	44.79a	8.28c	8.38b	207.70a	211.21a	36.93a	37.08a
LSD at 5%		0.15	N.S	0.03	0.10	N.S	N.S	N.S	N.S
Interaction									
Without	0.0 mg Co L^{-1}	42.68	43.12	7.55	7.64	205.25	208.16	36.01	36.07
	5.0 mg Co L^{-1}	42.59	43.02	7.39	7.51	205.06	208.18	35.98	36.09
	10.0 mg Co L^{-1}	42.34	42.91	7.32	7.38	204.74	208.24	35.99	36.13
Biochar	0.0 mg Co L^{-1}	44.86	45.50	8.55	8.63	208.61	212.24	37.47	37.64
	5.0 mg Co L^{-1}	44.85	45.31	8.52	8.64	208.72	212.79	37.42	37.67
	10.0 mg Co L^{-1}	44.80	45.37	8.46	8.54	208.56	211.93	37.42	37.54
Compost	0.0 mg Co L^{-1}	45.03	45.61	8.68	8.77	208.76	212.34	36.52	36.59
	5.0 mg Co L^{-1}	44.95	45.48	8.66	8.77	208.77	212.36	36.47	36.66
	10.0 mg Co L^{-1}	44.89	45.35	8.61	8.70	208.67	212.23	36.45	36.60
Biochar + compost	0.0 mg Co L^{-1}	45.17	45.81	8.81	8.95	209.02	212.53	37.85	38.04
	5.0 mg Co L^{-1}	45.11	45.63	8.78	8.95	208.88	212.81	37.88	38.11
	10.0 mg Co L^{-1}	45.05	45.54	8.74	8.90	208.84	212.43	37.86	38.05
LSD at 5%		0.30	1.10	0.06	0.20	1.69	n.s	0.30	0.30

Means within a row followed by a different letter (s) are statistically different at a 0.05 level

CONCLUSION

This study elucidates the multifaceted impacts of biochar, compost, and cobalt treatments on onion growth, yield, quality, and soil properties. The superior treatment was when plants treated with biochar (1.0 ton fed^{-1}), compost (3.0 ton fed^{-1}) and cobalt (10.0 mg L^{-1}) at the same TIME. These findings demonstrate the significant potential of biochar and compost amendments in enhancing soil fertility, nutrient availability, and crop performance under saline conditions in conjunction with spraying cobalt element. The synergistic effects of combining biochar and compost underscore the importance of integrated soil management practices for sustainable agriculture. However, further investigation into the long-term effects of these treatments on soil health, ecosystem sustainability, and economic viability is warranted. Additionally, optimizing application rates and timing to maximize benefits while minimizing environmental impacts is crucial. Implementing these findings in agricultural practices holds promise for improving crop productivity, soil resilience, and food security in diverse farming systems.

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استجابة البصل للفحم الحيوي وسماد المكمورة مع رش بالكوبالت تحت الظروف الملحية

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الملخص

يقوم هذا العمل البحثي بدراسة الدور المحتمل للفحم الحيوي وسماد المكمورة، جنبًا إلى جنب مع الرش الورقي بالكوبالت،على نمو وإنتاجية البصل النامي بأرض قيمة التوصيل الكهربي لها (الملوحة) ٧,٤٢ ديسيمنز-١ . تم إجراء تجربة حقلية وكانت المعاملات الرئيسية عباره عن الإضافات الارضية (لا شيء، الفحم الحيوي، المكمورة والفحم الحيوي مدمج مع المكموره) والمعاملات المنشقة كانت عبارة عن الرش الورقي بمعدلات مختلفة من الكوبالت (٠، ٥، ١٠ ملجم / لتر). وشملت المدلولات التي تم قياسها بعد ٨٠ يومًا من الشتل طول النبات والوزن الجاف ومحتوى الكاروتين والنيتروجين والفوسفور والبوتاسيوم. عند الحصاد، تم تقييم الصفات المحصولية مثل قطر البصلة، المحصول الكلي، فيتامين C،محتوى السكر الكلي. كما تم تحديد مستويات عناصر التربة، مثل النيتروجين والفسفور والبوتاسيوم المتاح بعد الحصاد. تشير النتائج إلى أن كل من الفحم الحيوي و المكمورة أدى إلى تحسين ملحوظ في نمو البصل ومؤشرات الإنتاج مقارنة بمجموعة الكنترول، حيث كانت المعاملة الأفضل هي الاستخدام المشترك للفحم الحيوي و المكمورة يليها المكمورة وحدها ثم الفحم الحيوي وحده. كما كان لمعاملات الكوبالت تأثير إيجابي حيث اذداد هذا التأثير مع زيادة معدل الكوبلت. على وجه التحديد، أدت أعلى معدلات من الكوبالت (١٠ ملجم/ لتر) بالتزامن مع الاستخدام المشترك للفحم الحيوي و المكمورة إلى أكبرزيادات في نمو النبات ومحتوى العناصر الغذائية و الصفات المحصولية. كما أن المتاح من النيتروجين والفسفور والبوتاسيوم في التربة زاد نتيجة للاضافات الارضية، حيث تم تحقيق أعلى القيم مع الاستخدام المشترك للفحم الحيوي و المكمورة. تشير هذه النتائج إلى أن دمج الفحم الحيوي وسماد المكمورة مع رش الكوبالت يمكن أن يعزز بشكل فعال نمو البصل وإنتاجيته في ظل الظروف المالحة.