Eco. Env. & Cons. 29 (4) : 2023; pp. (1479-1489)
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ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2023.v29i04.003

Zeolite Amendment for Enhanced Onion Growth with Reduced Mineral Nitrogen Fertilization: A Promising Approach

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(Received 2 September, 2023; Accepted 30 October, 2023)

ABSTRACT

Onion, as one of the strategic crops, is a heavy feeder for nitrogen (N) nutrient. Despite the remarkable progress in the manufacturing of synthetic mineral nitrogen fertilizers, their excessive use with plants negatively affects human health after eating. So, the current research aims to reduce the onion mineral nitrogen requirement with keeping acceptable bulb yield without quality decline. So, a field trial was carried out aiming to assess different doses of mineral N [Usual dose of N and low dose of N (75% of the usual N dose)] as main plots. While zeolite [in the presence of zeolite and the absence of it] was evaluated as subplots. Also, the treatments of bio-stimulants i.e., yeast extract and algae in addition to control treatment represented the sub-sub plots. The maximum values of parameters expressing growth performance as well as onion yield and it's quality were recorded with the combined treatment of zeolite + biostimulants extract under the usual N dose, noting the superiority of yeast extract to seaweed extract. Also, zeolite combined with a low N dose in the presence of both studied biostimulants recorded the best onion performance and productivity compared to that under the usualN dose without both zeolite and biostimulants. Also, there was an increase in the values of soil available nitrogen and soil WHC after harvest compared to the initial soil. Generally, this research work concludes that soil addition of zeolite combined with the exogenous application of biostimulants extracts will lead to the achievement of sustainability via raising N fertilizer efficiency. Based on these findings, we recommend further research to optimize the application rates of zeolite and biostimulants and investigate the long-term effects of these treatments on soil health and onion productivity. Furthermore, farmers and growers could benefit from incorporating zeolite and biostimulants into their fertilizer programs to reduce the use of synthetic mineral nitrogen fertilizers and promote sustainable onion production.

Key words: *Zeolite, Seaweed, Yeast, Sustainability, Onion.*

Introduction

In order for plants to meet human needs, humans must also fulfil needs plants' needs for nutrients and water. In recent decades, synthetic fertilizers have emerged as a prominent feature of modern agriculture aiming to maximize agricultural production and enrich nutrients in the soil, which is subject to intensive cultivation throughout the year. In light of the expected population increase, the use of synthetic fertilizers is likely to contribute to raising the productivity of agricultural crops, to keep pace with the increased demand for food in light of the decline in agricultural soil, the increase in desertification, drought and the deterioration of agricultural soils in many regions. In order for the synthetic fertilizers to achieve the desired benefit, they are added according to a well-thought-out program in terms of dose, quality and timing of application, in proportion to the plant's growth stage and its requirements for nutrients. However, their excessive use causes great damage, sometimes to the soil itself, and at other times to the biosphere and the environment. This confirms the need for a balanced use of synthetic fertilizers to avoid these damages (Horrigan *et al*., 2002; Savci, 2012).

The danger of synthetic fertilizers and their derivatives lies in their possibility of entering the components of the food chain (plant, animal, human) and their cumulative concentration in successive nutritional levels (Sabry, 2015). Nitrogen fertilization, for example, is one of the most important agricultural applications that contribute to the pollution of water, food and air (Suhag, 2016). On the one hand, the leaching of nitrates into groundwater is one of the most important risks of nitrogen fertilizer pollution in some countries, in which groundwater is the main source of drinking. Some reports indicate that groundwater pollution leads to an increase in the incidence of stomach cancer in adults, and blue baby syndrome in children (Van der Ploeg *et al*., 2001). In other words, despite the remarkable progress in manufacturing mineral nitrogen fertilizers, their excessive use with plants negatively affects human health after eating those (Baweja *et al*., 2020).

Organic farming is considered the best solution to avoid any environmental damage resulting from the continuous use of synthetic fertilizers, but currently, it has become a solution for rich countries only without developing countries that are characterized by continuous population increase (Reddy, 2010). Therefore, raising the efficiency of mineral fertilization by reducing its dose is the closest thing to realism, especially in developing countries as well as entering simultaneously the bio-stimulants in fertilizing programs.

There are many recent studies that talked about the possibility of raising the efficiency of mineral fertilization of the nitrogen element by mixing it with zeolite conditioner (Bernardi *et al*., 2009; Azarpour *et al*., 2011; Khalifa *et al*., 2019; El-Sherpiny *et al*., 2020). Zeolite is among the most hydrated minerals on the surface of the earth and is found in a myriad of environments, including soils.

Zeolite is a crystalline, hydrated aluminosilicate having selective capabilities for the adsorption of metals (Polat *et al*., 2012). It is one of the clay miner-

Abbreviation: WHC, Water-holding capacity als elevating the effectivity use of mineral nitrogen fertilizers (NH-N and NO-N), thus reducing leaching losses (Mahabadi *et al*., 2007). as nicely as appearing as a slow-release fertilizer (Tran *et al*., 2019). Zeolites are characterised by cation exchange with stability in the crystal structure (Chadwick *et al.,* 2020). Its structure approves the formation of channels (mesopores) Mohammed *et al.* (2020). This mesoporous structure affords an excessive surface area (8.0 to 72.0 $m^2 g^{-1}$ for clinoptilolite zeolite) (Riyanto *et al*., 2022). However, the aluminosilicate ionic charge is not impartial it requires cations to stabilize it. These cations related to the excessive surface area, furnish one of the most vital properties of these minerals: the excessive cation exchange capacity of 2.6 meq g^{-1} (stilbite) and 3.0 meq g^{-1} (clinoptilolite) (Shen *et al*., 2020). Zeolite stilbite has the capacity to preserve 1/2 of the volume of ammonium held via the clinoptilolite kind (Jarosz *et al*., 2022).

Foliar application of bio-stimulants to the leaves of plants can be one of the ways of supplying the plant with its nutrient requirements. Yeast extract is one of the natural biostimulants which has a positive impact on plant growth performance, where it is an excellent source of pyridoxine, cytokinins, niacin, vitamins, thiamine, riboflavin protein, carbohydrates, nucleic acid, lipids and many minerals such as nitrogen, phosphorus, potassium and magnesium (El-Desouky *et al*., 2011; Hammadand Ali, 2014; Mannino *et al*., 2020). Seaweed extract also is one of the natural biostimulants, which has a positive impact on plant growth performance. Seaweed extract also known as seaweed or marine macroalgae is regarded as a supply of organic matter as well as mineral nutrients. It performs a function as an activator of cell division and offers a rise to antioxidant rates for safety towards any environmental stress (Seif *et al*., 2016; Ashour *et al.,* 2023; Krawczuk *et al*., 2023).

Onion (*Allium cepa* L), as one of the strategic crops, belongs to the Amaryllidaceae family (Wakchaure *et al*., 2023). It is a heavy feeder for nitrogen element, where the N application enhances production significantly (Gererufael *et al*., 2020). It several researches have been done about reducing mineral nitrogen fertilizer doses, however, to our knowledge, little research has been done to evaluate the role of zeolite in raising N efficiency with onion. So, the specific objectives of the current study were to assess different doses of mineral nitrogen combined with zeolite conditioner in raising the efficiency of mineral N fertilizers used with onion plants. Simultaneously some bio-stimulant extracts i.e., yeast extract and seaweed extract as the foliar application was evaluated.

Materials and Methods

Location coordinates and date of the experiment

A field trial was implemented during two successive cropping seasons (2020/2021 and 2021/2022) at a private farm located at El-Mansour District, El-Dakahlya Governorate, Egypt (31°32003E longitude and 31°22259.883 N latitude).

Initial soil properties

The characteristics of the initial soil before onion transplanting was taken at depth of 0.0-30 cm are ýpresented in Table 1 according to the standerd methods described by Dane and Topp, (2020), Richards, (1954) and Sparks *et al*. (2020).

Substances studied

- Zeolite

Zeolite was purchased from Alex Zeolite Company, Egypt. It contains 6.00 % FeO, 12.50 % AlO_3, 9.00 %

Table 1. Traits of initial soil depending on the standard analytical techniques

Particle size distribution	Sand, %	Silt, %	Clay, %	Clayey texture
	20. 89	30.6	48.51	
Hydro physical measurements	Water holding capacity, %	Wilting point, %	Saturation, %	
	45.0	22.5	90.00	
Chemical parameters	EC, dSm^{-1}	pH	O.M, %	
	5.79	7.92	1.09	
Available nutrients	N, mg kg^{-1}	P, mg kg^{-1}	K, mg kg^{-1}	
	53.00	9.99	275.8	

CaO, 5.20 % K_2O, 64.75 % SiO_2, 1.05 % P_2O_5, 1.50% Na_2O, 160.0 cmol kg^{-1} CEC.

- **Seaweed extract**

Seaweed extract was purchased from Tiba Company for Trading. It contains 6.00 % N, 3.05 % P_2O_5, 4.80 % K_2O, 0.150% B, 21.0 % algae, 6.50% algenic acids.

- **Yeast extract**

Yeast extract was prepared as mentioned by El-Ghamriny *et al*., (1999). It contains 50 % protein, 30% carbohydrates, 8.0 % Minerals, 8.0 % Nucleic acid and 4.0 % Lipids.

Onion seedling

The onion cultivar "Cv. Giza Red, 65 days old " was examined, where it was obtained from the nurseries of Egyptian MASR (Ministry of Agricultural and Soil Reclamation).

Experimental setup

A field research experiment was carried out using a split split-plot design by three replicates to assess different doses of mineral nitrogen using ammonium sulfate (20.5% N) as main plots [100% of usual dose of N and 75% of usual dose of N (as low dose)]. While rates of zeolite substance [0.00 and 15.0 Mg ha^{-1}] was evaluated as subplots. Also, the treatments of bio stimulants extracts [yeast extract (2.5 gl^{-1}) and seaweed extract (2.5 gl^{-1}) in addition to control treatment (without bio stimulants)] were devoted to the sub-sub plots. Each subplot contained three rows, having 7.0 m as long and 0.80 m as wide, where each sub-sub plots contains two rows. After soil irrigation by flood regime, the seedlings were transplanted on 20th November on two sides of the ridges with a spacing of 20.0 cm among plants. Except for nitrogen, which was done according to the studied treatments, other mineral and organic fertilization processes as well as traditional agricultural practices were executed. A month before transplanting, both compost and calcium super-phosphate (15.5% P_2O_5) were added at a rate of 15.0 and 0.72 Mg ha^{-1}, respectivly at the same time. The usual recommended nitrogen dose for onion is 216 N unit ha^{-1}. It was added depending on the studied treatments, where the N fertilizer was divided into three equal quantities applied starting after 3 weeks from transplanting to maturity with 20 days interval. On the other hand, with the second N dose, potassium sulfate (48% K_2O) was added at rate of 60 unit K_2O ha^{-1} before the 3rd irrigation event. Foliar treatments of the studied biostimulants were done three times during the growth period (30, 50 and 70 days after transplanting) with a volume of 900 L ha^{-1} for each.

Harvest

Harvest process was done after 150 days from transplanting.

Measurements

At a period of 90 and 150 (harvest stage) days from transplanting, five onion plants of each replicate were taken for measuring

1. Vegetative growth characters *i.e.*, foliage fresh and dry weights (g), plant height (cm), total chlorophyll (mg g^{-1}) content using organic solvent (methanol 100%) according to Sadasivam and Manickam, (1996).
2. Yield and its components i.e. average bulb diameter (cm) and weight (g), total bulb yield (Mg ha^{-1}), marketable bulb yield (Mg ha^{-1}) and dry matter (%).
3. Chemical contents in leaves and bulb
   - N percentage was determined in leaves and bulb using Micro-kjeldahl method by digesting onion leaves and bulb samples in mixed of $HClO_4 + H_2SO_4$ according to Rukun, (1999).
   - S percentage in onion bulb samples was determined using a Leco sulfur analyzer according to Jones and Isaac, (1972).
4. Onion bulb quality *i.e.*, vitamin C (mg $100g^{-1}$), total dissolved solids percentage (TDS) and total sugars percentage were estimated according to A.O.A.C., (2000), while anthocyanin pigment (mg $100g^{-1}$) was determined as described by Schoefs, (2004).
5. Some soil properties like available nitrogen and water holding capacity were determined at harvest stage as formerly mentioned in initial soil sample.

Statistical analysis

Treatment means were contrasted utilizing Duncan's Multiple Range Test at $P \leq 0.05$ using CoStat computer software package [Version 6.303, CoHort, USA, 1998–2004].

Results

Vegetative growth parameters

Results in Figure 1 illustrate the impact of the studied nitrogen doses, zeolite conditioner and both studied bio-stimulants on parameters expressing growth performance *i.e.,* foliage fresh and dry weights, plant height and total chlorophyll of onion plants during seasons of 2020/2021 and 2021/2022. It can be noticed that the maximum values of vegetative growth creteria significantly affected due to both studied nitrogen rates (low and normal doses of N). The highest values were realized with onion plants treated with the usual dose of N compared to the low dose of N which possessed the lowest values. Concerning the effect of zeolite, results indicate that zeolite conditioner possessed a pronounced promotional effect compared to the corresponding onion plants grown without zeolite. In other words, the maximum values were recorded with plants treated with zeolite compared to that of plants grown without zeolite, which possessed the lowest ones. Moreover, exogenous application of biostimulants had a significant effect on growth performance. The maximum vegetative growth creteria was obtained with onion plants sprayed with yeast extract followed by seaweed extract compared to control. It was mentioning that zeolite combined with a low N dose in the presence of both studied biostimulants recorded the best onion performance compared to that under the usual N dose without both zeolite and biostimulants. The findings illustrate that the maximum values of vegetative growth were achieved with the combined treatment of zeolite and yeast extract under usual dose of N. The same trend was found during both studied seasons.

Yield and its components

According the results shown in Figure 2, the nitrogen dose, zeolite conditioner and both studied biostimulants significantly affected yield and its components *i.e.,* average bulb diameter and weight, total bulb yield, marketable bulb yield, dry matter of onion plants during both seasons. The highest values of yield and its components were obtained from usual dose of N. This enhancement can be estimated as 8.06 and 7.89% in total bulb yield and marketable bulb yield, respectively in the first season as well as 8.02 and 8.89% in the second season.

Concerning the effect of zeolite, results indicate that plants treated with zeolite possessed the highest onion yield compared to the onion plants grown

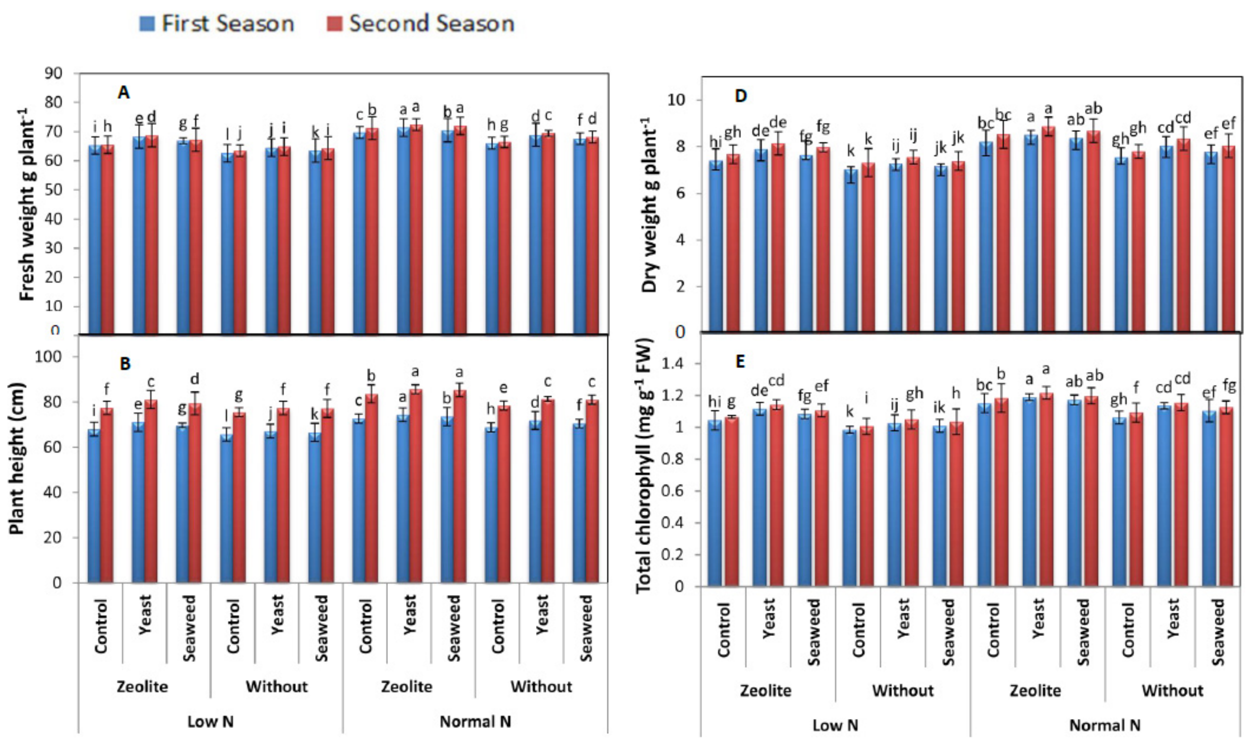

Fig. 1. Effect of nitrogen dose, zeolite conditioner and some bio-stimulants on fresh weight (A), dry weight (B), plant height (C) and total chlorophyll (D) of onion plants during both seasons. Bars indicates standard error (SE) of the means (n = 5). Different letters indicate significant differences between the treatments at according to the Duncan test ($p \leq 0.05$)

without zeolite. Moreover, the exogenous application of biostimulants had a significant effect on onion yield and its components, as a foliar application with yeast extract gave the highest onion yield followed by algae extract compared to the control.

Generally, it can be noticed that the maximum values of yield and its components were recorded with combined treatment of zeolite + bio stimulants extract under 100% of the usual N dose, noting the superiority of yeast extract to algae extract. Also, it can be noticed that zeolite conditioner combined with 75% of the usual N dose in the presence of both studied bio stimulants recorded the best productivity compared to that under treatment of 100% of the usual N dose without both zeolite and both stimulants.

Chemical contents in leaves and bulb

The N contents of onion leaves as well as N and S contents in bulb were significantly (p d" 0.05) reduced by decreasing N dose (Figure 3). The highest values of all aforementioned traits were realized with plants treated with normal dose of N compared to low dose of N. Moreover, adding zeolite to soil enhanced chemical contents in leaves and bulb comparing with plants grown without zeolite. Spraying biostimulantshad a significant effect on chemical contents in leaves and bulb compared to control, noting the superiority of yeast extract to seaweed extract. Also, it can be noticed that zeolite in the presence of both studied bio stimulants recorded the best chemical contents in leaves and bulb under normal dose of N, noting the superiority of the combined treatment of zeolite + 75% of the usual N dose + any studied bio-stimulants to the treatment of 100% of the usual N dose without both zeolite and both stimulants.

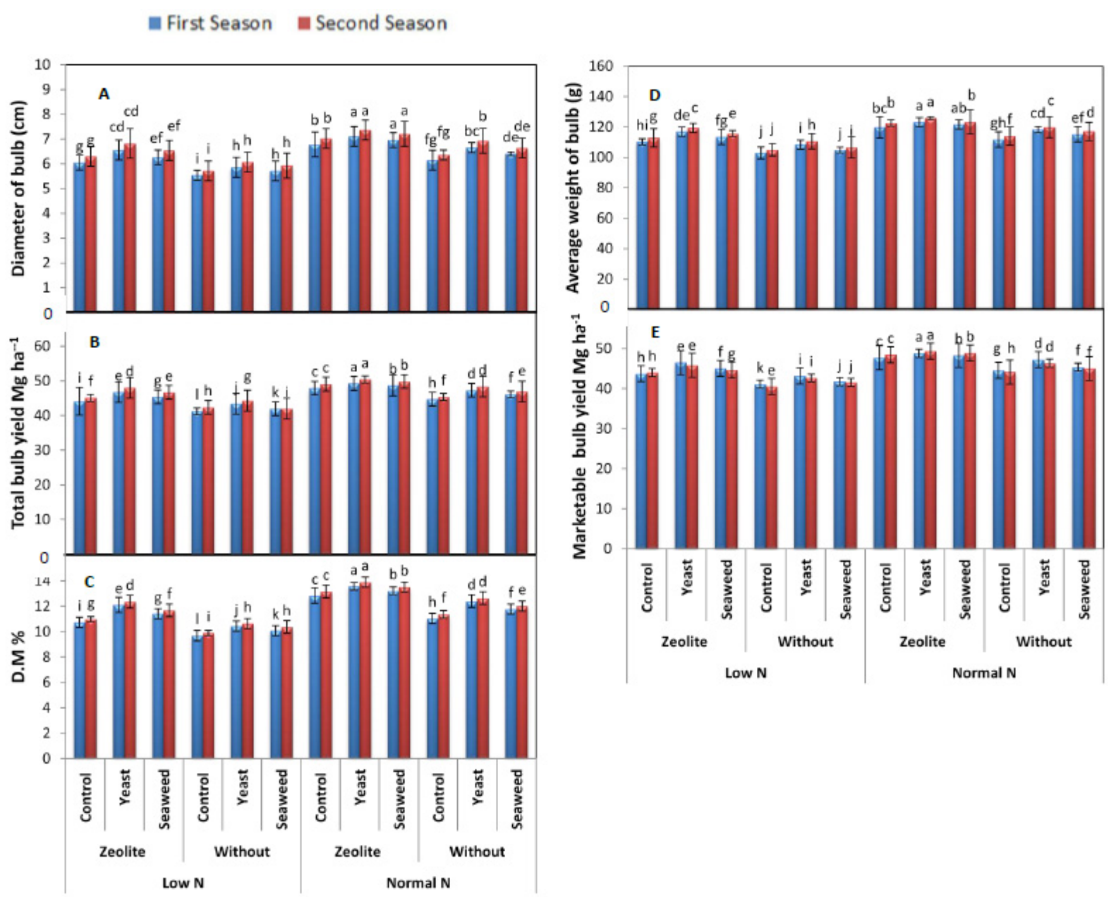

Fig. 2. Effect of nitrogen dose, zeolite conditioner and some bio-stimulants on diameter of bulb (A), total bulb yield (B), dry matter [D.M] (C), average weight of bulb (D) and marketable bulb yield (E) of onion plants during both seasons. Bars indicates standard error (SE) of the means (n = 5). Different letters indicate significant differences between the treatments at according to the Duncan test ($p \leq 0.05$)

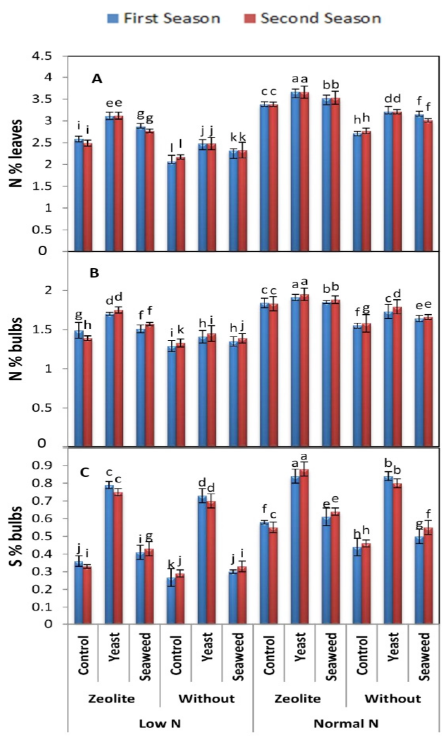

Fig. 3. Effect of nitrogen dose, zeolite conditioner and some bio-stimulants on N in leaves (A), N in bulbs (B) and S in bulb (C) of onion plants during both seasons. Bars indicates standard error (SE) of the means (n = 5). Different letters indicate significant differences between the treatments at according to the Duncan test ($p \leq 0.05$)

Onion bulb quality

N deficit significantly ($p \leq 0.05$) decreased onion bulb quality *i.e.*, vitamin C, anthocyanin, total dissolved solids (TDS), and total sugar (Figure 4). The maximum contents of onion quality were obtained from plants fertilized with normal dose of N compared to low dose of N. Moreover, soil addition with zeolite increase onion bulb quality compared to plants grown without zeolite. Foliar application with yeast extract or seaweed extract enhanced onion bulb quality compared to control. The highest quality was realized with plants sprayed with yeast extract. The best results were obtained in combination from the plants treated with zeolite and sprayed with yeast extract under normal N fertilization. Noting the superiority of the combined treatment of zeolite + 75% of the usual N dose + any studied bio-stimulants to the treatment of 100% of the usual N dose without both zeolite and both stimulants.

Post-harvest soil properties

Table 2 illustrates the effect of the studied nitrogen recommended dose, zeolite conditioner and bio-stimulants on the average values (combined data over both seasons) of some soil properties *i.e.*, available N (mg kg^{-1}) and water holding capacity (WHC, %) at harvest stage. The variation due to the effects of the studied mineral N dose (Low and normal of N dose) on the studied soil properties was unclear. Also, the effect of foliar application of yeast and algae extracts on the studied soil properties was unclear. While, the variation between the treatments of zeolite soil conditioner [once in the presence of zeolite and other in the absence of zeolite] was clear. From the same Table it can be noticed that soil addition of zeolite conditioner led to a pronounced in-

Table 2. Effect of nitrogen dose, zeolite conditioner and some bio-stimulants on some soil properties at harvest stage (combined data over both seasons)

Treatments			Available N mg kg^{-1}	Water holding capacity %
Initial soil before transplanting			53.0	45.0
Low N	With zeolite	Control	56.0	46.8
		Yeast extract	54.0	47.0
		Seaweed extract	55.0	47.1
	Without zeolite	Control	52.5	45.1
		Yeast extract	53.1	45.1
		Seaweed extract	52.9	45.2
Normal N	With zeolite	Control	55.3	47.1
		Yeast extract	53.0	47.3
		Seaweed extract	54.2	47.2
	Without zeolite	Control	52.0	45.2
		Yeast extract	50.1	45.0
		Seaweed extract	51.5	45.1

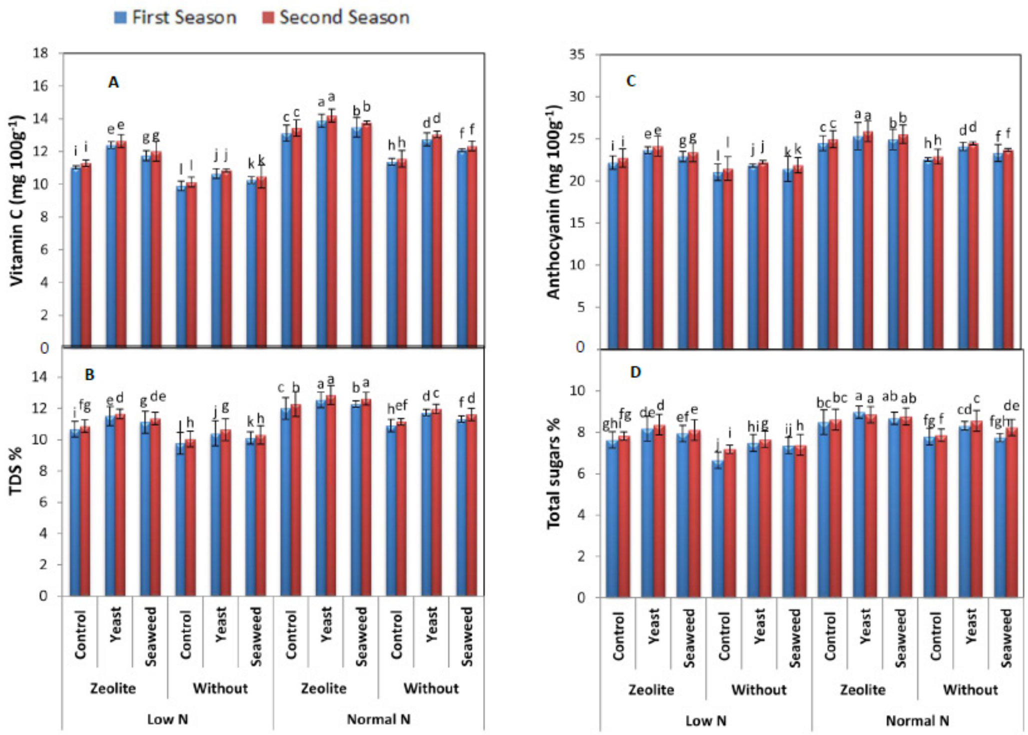

Fig. 4. Effect of nitrogen dose, zeolite conditioner and some bio-stimulants on vitamin C (A), TDS (B), anthocyanin (C) and total sugars (D) of onion bulb during both seasons. Bars indicates standard error (SE) of the means (n = 5). Different letters indicate significant differences between the treatments at according to the Duncan test ($p \leq 0.05$).

crease in the values of soil available N (mg kg^{-1}) and soil water holding capacity (WHC %) at harvest stage.

Discussion

This study intended to reduce the mineral nitrogen requirements for onion using zeolite soil conditioner with foliar spraying with bio-stimulants *i.e.,* yeast and algae extracts. Generally, the obtained results showed that the onion plants treated with the traditional dose of nitrogen (100% of NRD) realized growth and productivity better than that were realized with plants treated with 75%of NRD. This is attributed to the vital role of nitrogen in all vital processes in higher plants. Nitrogen is an essential macronutrient for higher plant function (Ali, 2020), where it is a critical component of amino acids forming the building blocks of plant proteins and enzymes (Kishorekumar *et al.,* 2020).It is also a component of the chlorophyll molecule that enables the higher plant to capture sunlight energy via the photosynthesis process improving plant growth and yield (Yoneyama *et al.*, 2020). Thus, nitrogen deficiency leads to the failure to complete the vital processes that it enters to the fullest. Even though the importance of synthetic nitrogen fertilizers for improving onion plant growth, their continued utilization may be cause environmental hazards *e.g.*, surface and groundwater pollution via leaching nitrate (Sabry, 2015; Suhag, 2016). It is known that a large part of the nitrogen added to the soil is lost either through volatilization in the form of ammonia or leaching with irrigation water. So, reducing the synthetic nitrogen fertilizers amount without nitrogen deficiency (or raising the nitrogen fertilizers efficiency) is a major challenge in field management (Van der Ploeg *et al*., 2001; Baweja *et al*., 2020). The obtained results also confirmed that the zeolite conditioner leads to raising nitrogen fertilizers' efficiency. The zeolite conditioner combined with 75% of NRD recorded the best onion performance and productivity compared to that of plants grown under treatment of 100% of NRD without zeolite and this is due to the vital role of zeolite in holding the mineral nitrogen and thereby raising nitrogen fertilizers efficiency. Zeolite may be supplied onion plants with macro and micronutrients as well as it may act as a slow-release fertilizer and improve nitrogen use efficiency via improving the use of NH_4 and NO_3 (Jarosz *et al*., 2022). Also, it has an important role in preventing soil moisture losses (Khalifa *et al*., 2019). Generally, it can be said that zeolite possesses a vital role in reducing the added synthetic nitrogen fertilizers due to its ability to hold the mineral nitrogen forms as long as possible (El-Sherpiny *et al*., 2020), consequently slow-release of its and increasing efficiency of synthetic nitrogen fertilizers. In other words, zeolite could retain available mineral nitrogen form in the root zone of the onion plant to be used when the plant required it. The pronounced promotional effect of zeolite may be also due to its role in improving soil properties *e.g.*, available N, water holding capacity, cation exchange capacity and total porosity as mentioned byKhalifa *et al*. (2019); El-Sherpiny *et al*. (2020). Generally. It can be said that the superiority of zeolite in raising nitrogen fertilizers efficiency attributes to its natural, where it is a crystalline, hydrated aluminosilicate having selective capabilities for the adsorption of metals (Polat *et al*., 2012). It is one of the clay minerals elevating the effectivity use of mineral nitrogen fertilizers (NH-N and NO-N), thus reducing leaching losses (Mahabadi *et al*., 2007), as nicely as appearing as a slow-release fertilizer (Tran *et al*., 2019). Zeolites are characterised by cation exchange with stability in the crystal structure (Chadwick *et al.,* 2020). Its structure approves the formation of channels (mesopores) (Mohammed *et al.* (2020).This mesoporous structure affords an excessive surface area (8.0 to 72.0 $m^2 g^{-1}$ for clinoptilolite zeolite) (Riyanto *et al*., 2022). However, the aluminosilicate ionic charge is not impartial (Fu *et al*., 2020), it requires cations to stabilize it. These cations related to the excessive surface area, furnish one of the most vital properties of these minerals: the excessive cation exchange capacity of 2.6 meq g^{-1} (stilbite) and 3.0 meq g^{-1} (clinoptilolite)(Shen *et al.,* 2020). Zeolite stilbite has the capacity to preserve 1/2 of the volume of ammonium held via the clinoptilolite kind (Jarosz *et al*., 2022). Using zeolite can permit a significant decrease in N fertilizer, decreasing the losses of N and promoting the plant's physiological status, with significant advantages in terms of agriculture, the environment, the economy, and health. It is crucial to note that these minerals' impacts on the soil are long-lasting because of their long-term structural stability under conditions of normal pressure and temperature. Furthermore, reducing the use of N fertilizers can be done frequently over many years with substantial long-term economic and environmental benefits (Medoro *et al*., 2022). Bio-stimulants *i.e.,* yeast and seaweed extract led to promoting the performance and productivity of onion plants. The superiority of yeast compared to seaweed extracts may be due to its being an excellent source of pyridoxine, cytokinins, niacin, vitamins, thiamine, riboflavin protein, carbohydrates, nucleic acid, lipids, amino acids and many minerals such as nitrogen, phosphorus, potassium and magnesium which led to enhance plant growth and productivity (Abd El-Hady and Shehata, 2019). While the superiority of seaweed extracts compared to control treatment may be attributed to its role as an activator of cell division giving rise to antioxidant levels for protection against any environmental stress such as N deficit as well as it can elevate photosynthetic rates and nutrients uptake which promote plant growth and productivity (Abd El-Hady *et al*., 2016; Shehata *et al*., 2019).

Conclusion

The results of the current research work provide evidence demonstrating the ability of zeolite in raising N fertilizers efficiency. Also, the findings confirm the vital role of biostimulants in improving onion growth performance and yield. According to the obtained results, it can be concluded that soil addition of zeolite combined with the exogenous application of bio stimulants extracts will lead to the achievement of sustainability via raising N fertilizer efficiency. In other words, unlike modern chemical fertilizers, zeolite is a natural soil conditioner, as well as yeast and seaweed extracts come from renewable resources biodegradable, and non-toxic. Thus, they represent an attractive tool for sustainable onion crop management programs as a partial substitute for mineral N fertilizer without occurring deficiency of plant requirements nitrogen, but further research is needed to decrease N fertilizers with different natural methods for saving human health and decreasing costs.

Funding: The current research work was funded by personal efforts of the authors.

Data Availability Statement: Not applicable.

Acknowledgements

The authors would like to thank, **Egypt:** Aswan

University, Matrouh University, Damietta University, Mansoura University, National Research Center, Agriculture Research Centre, El-Nada Misr Scientific Research and Development Projects, **Saudi Arabia:** Shaqra University, University of Tabuk, Al-Baha University, University of Hafr Al Batin, King Saud University.

Conflicts of Interest: "The authors declare no conflict of interest."

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