Egypt. J. Soil Sci. **Vol. 64**, No. 1, pp: 49-62 (2024)

Egyptian Journal of Soil Science

http://ejss.journals.ekb.eg/

Vegetative Growth, Yield, and Quality of Onion as Influenced by Nitrogen Rates and Natural Stimulators

Refat A. Marey [1] and **Huda M.M. Elmasry**[2]

[1]*Onion Res. Dep., Field Crops Res. Inst., ARC, Giza, Egypt*
[2] *Soils, Water and Environment Res. Inst., ARC, Giza, Egypt*

TO EXPLORE the influence of varied nitrogen rates and foliar spraying of natural stimulants on vegetative growth, yield, and onion quality. This experiment was carried out over the two seasons 2019-2020 and 2020-2021 to investigate nitrogen fertilizer at rates: 144, 216, and 288 kg N ha^{-1} and natural stimulant treatments (yeast extract, fulvic acid, amino acids, and seaweed extract). As well as control. The results clearly demonstrated that raising the nitrogen rate from 144 to 288 kg N ha^{-1} significantly enhanced the leaves number of $plant^{-1}$, fresh plant weight (g), average bulb weight (g), marketable bulb yield (t ha-1), double bulbs%, bulb diameter, TSS%, dry matter%, N%, P%, K%, carbohydrate% and protein content%. Foliar spraying with natural stimulators (yeast extract, fulvic acid, amino acids, seaweed extract) significantly increased plant height (cm), number of leaves/plant, fresh plant weight (g), neck diameter (cm), bulb diameter (cm), bulbing ratio, average bulb weight (g), marketable bulb yield (t ha-1), culls bulb yield (t ha-1), double bulbs%, bulb diameter, TSS%, dry matter%, N%, P%, K%, carbohydrate% and protein content%, during both seasons. The nitrogen at rate of 288 kg N ha^{-1} combined with amino acids spraying appeared the highest mean values of average bulb weight (g) during the 1^{st} season and marketable yield during the two seasons. The highest value of dry matter% was achieved by fertilizing by 216 kg N ha^{-1} when spraying with fulvic acids during both seasons.

Keywords: *Allium cepa* L., Amino acid, Fulvic acid, Nitrogen, Seaweed, Yeast.

1. Introduction

The onion (*Allium cepa* L.), a plant in the Alliaceae family, is one of the vegetables grown commonly for commercial purposes and cultivated worldwide, valued for their versatile culinary applications and nutritional benefits. The successful cultivation of onions heavily depends on the optimization of various agronomic practices to ensure robust vegetative growth, high yields, and superior quality of the harvested bulbs. Among these practices, nitrogen fertilization plays a crucial role as it directly affects plant growth, development, and overall productivity. Nevertheless, the overuse of mineral nitrogen fertilizers has raised environmental concerns, necessitating the exploration of alternative, sustainable approaches to enhance onion growth and yield. In the year 2021, the onion production area in Egypt covered 94,457 hectares, resulting in a total production of 3,312,469 metric tons, having an average yield of approximately 35 tons per hectare (**FAOSTAT, 2023**). Onion is regarded as one of the most economically significant crops, valued for its flavour and health-promoting attributes, which encompass antibiotic actions, anti-asthmatic effects, anti-thrombotic activity, and anticancer effects (**Suleria et al., 2015**). The edible portions of onion plants include sulfur-containing volatile chemicals that give them their distinct flavour and unique pungent odour (**Gîtina et al., 2014**). Furthermore, onions are a rich in essential oils, vitamins, minerals, antioxidants, and carbohydrates (**Sekara et al., 2017; Sarhan and Bashandy, 2021**). In Egypt, onions hold great potential for exportation owing to their early availability in international markets, high pungency, nutritional value, and extended shelf-storage period compared to other onion varieties.

*Corresponding author e-mail: hudaelmasry32006@gmail.com
Received: 13/08/2023; Accepted: 28/09/2023
DOI: 10.21608/EJSS.2023.229168.1638

Nitrogen is a primary plant nutrient required in substantial amounts, and the particular quantity of nitrogen needed by every crop relies considerably on the species of the crop and the conditions of the soil (**El-Morsy et al., 2016; Moursy et al., 2019**). Because amino acids are converted into proteins, which are subsequently utilized in metabolic actions necessary for plant development (**Abdissa et al. 2011**), the administration of the nitrogen fertilizer considerably increased onion height in comparison with the control. Among different fertilizer rates of nitrogen, the most significant rate was 216 kg N ha^{-1} attained the highest mean values in plant height, leaves No., bulbs diameter, bulbing ratio, fresh weight, marketable bulbs yield, total yield of fresh bulbs, and total soluble solid (**El-Hamady 2017**). In comparison to the control treatment, a 17% increase in means of bulbs weight was noticed when nitrogen fertilizer was added at its maximum amount of nitrogen fertilizer (150 kg N ha^{-1}), also, the highest bulbs yield of 17.41 t ha^{-1} recorded in plots that received 150 kg N ha^{-1} of treatment (**Etana et al. 2019**). Nitrogen element is a limiting factor for crop productivity because onions have a shallow root structure and sparse roots, nitrogen fertilizer usage efficiency in onion production is typically low, and there is a considerable danger of leaching the nitrate (**Geisseler et al. 2022**).

Chemical fertilizers are becoming more expensive, and excessive use of them is contaminating the environment **(Farid et al. 2023).** Therefore, it has become imperative to mitigate excessive fertilizer application through methods and strategies. Emphasis is placed on implementing eco-friendly farming practices for sustainable agriculture in the current global context (**Fawzy et al. 2012a**). Natural stimulators such as yeast extract, fulvic acid, amino acids, and seaweed extract have emerged as vital components in agricultural production. As **Fathy and Farid (1996) and Hegazi et al., (2023)** point out, yeast provides cytokinins, which promote cell growth, division, and chlorophyll production. It has been estimated that spraying with fulvic acid increases the performance index (PI) and maximum quantum efficiency of photosystem II under well-watered and low water conditions (**Lotfi et al., 2015; Elshaboury and Sakara, 2021;**). Several amino acids have been identified as biostimulants that enhance plant growth, yield, and reduce damage from abiotic stressors (**Kowalczyk and Zielony, 2008**). Seaweed extract can assist crop plants facing nutrient stress, reducing the reliance on costly chemical fertilizers (**Papenfus et al., 2013**).

Given the aforementioned considerations, the goal of this study is to establish the ideal rate of nitrogen fertilizer and the most effective foliar spraying treatments with natural stimulators to improve growth, yield, and bulb quality.

2. Materials and methods

This investigation was carried out at the Shandaweel Agricultural Research Station, Agricultural Research Centre, Sohag Governorate, Egypt (latitude 24.54° N and longitude 32.94° E) to investigate the effect of nitrogen fertilization levels and foliar spray of various stimulators affect onion vegetative development, production, and quality during the 2019–2020 and 2020–2021 winter growing seasons. At a depth of 30 cm, the experimental soil was subjected to physical and chemical investigation using methods established **Piper (1950)** and **Jackson (1958)**. Soil studies were performed at the Agricultural Research CenterBold's - Soil and Water Lab (Table 1).

Table 1. Physical and chemical parameters of the trial site soil throughout the seasons 2019-2020 and 2020-2021.

Characteristics	Season	
	2019-2020	2020-2021
Particle size distribution		
Sand (%)	29.07	26.94
Silt (%)	40.53	41.00
Clay (%)	30.40	32.06
Textural class	Clay loam	Clay loam
Physical analysis		
pH (1:2.5)	7.24	7.21
EC (1:5 extract, dS m^{-1})	1.09	0.98
Organic matter (%)	1.09	1.15
Available N (mg kg^{-1})	16.00	16.05
Available P (mg kg^{-1})	8.22	8.35
Available K (mg kg^{-1})	246	232
Cations and anions (cmol kg^{-1})		
Ca^{+2}	14.45	13.88
Mg^{+2}	6.55	6.48
Na^{+}	3.83	3.63
K^{+}	0.43	0.45
HCO_3^{-}	5.40	5.58
SO_4^{-2}	10.02	9.85
Cl^{-}	9.58	9.30

The surface size of the experimental plot was 3.5 m long χ 3 m wide (10.5 m^2). Each plot had five ridges spaced 60 cm apart and orientated North-South. Transplants were planted at a distance of 7 cm on either side of the ridge. The specified cultural practices were followed, including nursery raising, preparation of the main field, transplanting, fertilizing, watering, weed control, and protecting the plants.

The seeds of onion were planted in the nursery on 15th and 20th Aug., during the 1st and 2nd seasons, respectively. The nursery bed was constructed and seeded with Giza 6 Mohassan onion seeds. The transplanting into permanent soil was place on October 20th in both seasons.

At 30 and 60 days after transplanting, ammonium nitrate (nitrogen fertilizer; 33.5%) was side-dressed in two equal dosages. Foliar spraying treatments began one month after planting and continued three more times at 15-day intervals during the growing seasons. The experiment was set up in an RCBD design with three Spilt-Plot replications. Nitrogen at rates of are 144, 216, and 288 kg Nitrogen per hectare were assigned to the main plots, while natural stimulants (yeast extract, fulvic acid, amino acids, seaweed extract, and water) were assigned to the sub-plots.

Natural stimulators preparation and application

To activate and reproduce yeast, active dried yeast was mixed in sugar and water at 1:1 -w/w ratio, then letting it overnight at the room temperature before being sprayed at a rate of 2g/L. Yeast extract included 47.2% protein, 2.6% arginine, 2.6% glycin, 1.4% histidin, 2.9% islysine, 3.8% laucine, 0.6% methionine systine, 3% phenyl-alanine, 2.1% tyrosine, 2.6% threonine, 0.5% tryptophan, and 2.9% vitamin B, according to N.R.P (1977). As mentioned by Khedr and Farid (2002), yeast contains a proper balance of hormones, macro and micro components, proteins, fatty acids, and amino acids. Fulvic acid 90% was applied at rate of 0.4 g/L, it was obtained from the Al-Masa company in Egypt. At a rate of 2g/L, an amino green chemical was sprayed (Dishner company - Egypt), it includes total organic acids (w/v), 15% amino acids, some micro-elements such as; 2.9% iron, 1.4% zinc, and 0.7% manganese, as well as proline, free amino acids, alanine, hydroxy proline, glycine, valine, methionine, escaliosin, serine, cycteine, glutamic acid, arginine, lysine, histidine and phenylalanine.

The used seaweed extract namely Stimu grow (Queisna comp. Egypt) was sprayed at a rate of 0.5 g/L. It contains 18% K_2O, 0.5-2% CaO, 0.5-2% MgO, 0.15-0.3% Fe, 0.30-0.45% Cu, alganic acids (8-9%), 5% amino acids, and 45-55% plant growth regulators.

Data recorded

1- Vegetative characteristics

Ten onion plants were randomly chosen from each experimental plot removed 120 days after transplantation to determine plant height, leaves No., fresh weight, neck and bulbs diameter as well as bulbing ratio. **Mann (1952)** determined the bulbing ratio as the next equation;

Bulbing ratio = Neck diameter / Bulb diameter

2- Yield and its components characteristics

All test plots were uprooted during harvest, and the following variables were recorded:

Average bulb weight/gram was based on the weight of individual bulbs divided by the No. of bulbs. Single bulbs devoid of distortions were classified as marketable yield (t ha^{-1}). Culls yield (t ha^{-1}) were defined as bulbs that doubled, bolted, were the diameter less than three cm, were off color, and contained scallions. All onion bulbs in each plot were weighted and translated to total yield in t ha^{-1}.

3- Bulb quality characteristics

The aforementioned traits were detected subsequent to the process of harvesting. The percentage of single bulbs has been determined for each experimental plot by calculating the proportion of single bulbs in relation to the total number of bulbs. The proportion of double bulbs was calculated by dividing the number of double bulbs by the total number of bulbs for each tested plot. The bolter percentage was calculated by dividing the number of bolter bulbs in each testing plot by the total number of bulbs. The average diameter of bulbs was obtained by selecting 10 bulbs at random from each experimental plot. As per the **A.O.A.C. (1975)**, the total soluble solids content was measured immediately after harvest by utilizing a hand refractometer on a representative sample consisting of ten bulbs. The dry matter percentage of the bulbs (DM%) was determined by measuring the reduction in fresh weight of a bulb sample after subjecting it to a drying process at temperatures of 105°C and subsequently 70°C until a consistent weight was achieved. This drying process was conducted in a ventilated oven. The calculation of DM% was performed using the following equation:

D.M. (%) = (Dry weight of sample / Fresh weight of sample) × 100

4- Chemical analyses

The contents of nitrogen, phosphorous, potassium, carbohydrates, and protein in dry onion bulbs were analyzed by employing a combination of concentrated sulphuric acid and perchloric acid, as described in the study conducted by **Wicks and Firminger (1942).**

The concentration of nitrogen was assessed utilizing the micro Kjeldahl method as described by the Association of Official Analytical Chemists (**A.O.A.C., 1975**). The concentration of phosphorus was determined using calorimetric analysis using **Jackson's (1958)** method, which involved the utilization of the chlorostannous reduced molybdophosphoric blue color approach. The estimation of potassium concentration (%) was conducted using photometric means utilizing a flame photometer, as stated by **Jackson (1958**). The percentage of carbohydrates was determined using **Fales' (1951)** anthrone sulphuric acid technique. The protein content was determined by employing the method described by **Lowry et al. (1951)**.

Statistical analyses

According to **Snedecor and Cochran (1967)**, the statistical analysis was performed on all collected data. The comparison of the means of the different parameters was conducted using Duncan's Multiple Range Test **(Duncan, 1955)**.

3-Results

1-Vegetative characteristics

Based on the result in Table 2, plant height, leaf number, as well as fresh plant weight were affected significantly by nitrogen rates in 1st and 2nd seasons, except in case of plant height in the first one. Onion plants fertilized with 288 kg N ha^{-1} exhibited the tallest plant, the leaves No. / plant^{-1}, and fresh weight of the plant, while those treated with 144 kg N ha^{-1} (**Control N**) showed lowest means in 1st and 2nd seasons.

The result also indicated that foliar spraying with natural stimulators significantly influenced plant height, No. of leaves per plant, and fresh weight of plant during both seasons. Among the treatments, spraying with fulvic acid resulted in the greatest plant height values during the 1st and the 2nd seasons. In the first season, seaweed extract spraying provided the highest values of the leaves No. per plant and fresh wt. of plant, whereas, yeast extract spraying produced the greatest values in the 2nd season. Conversely, the spraying with water produced the short plants, the leaves No. per plant, and fresh plant weight in the 1st and the 2nd seasons.

Only during the first season did the combination between nitrogen rate and natural stimulant spraying significantly affect plant height (Table 2). In this season the tallest plants were observed by fertilizing by 288 kg N ha^{-1} when sprayed with fulvic acid, whereas the shortest plants were observed by fertilizing by 144 kg N ha^{-1} (**Control N**) along with spraying water. The means value of the interaction among nitrogen rates and natural stimulators, on leaves No. per plant and fresh plant weight was insignificant.

Table 2. Plant height, leaves No. plant^{-1} and bulb weight of onion as influenced by nitrogen fertilizer and foliar spraying with natural stimulators, at 120 days from transplanting, during 2019-2020 and 2020-2021 seasons.

Treatments		2019-2020 Plant height (cm)	2019-2020 Leaves No/ plant	2019-2020 Fresh weight of plant (g)	2020-2021 Plant height (cm)	2020-2021 Leaves No/ plant	2020-2021 Fresh weight of plant (g)
Nitrogen rates (A):							
Control		77.11	7.51 c	188.56 b	91.53 b	8.26 c	188.11 b
216 kg N ha^{-1}		79.25	8.01 b	200.56 a	93.51 ab	8.57 b	201.67 ab
288 kg N ha^{-1}		80.89	8.77 a	204.00 a	96.51 a	8.88 a	212.89 a
F. test		NS	**	*	*	*	*
Spraying treatments (B):							
Control (water)		74.52 b	7.67 b	180.00 b	87.74 b	8.06 c	185.74 b
Yeast extract		80.59 a	8.20 a	193.33 ab	94.33 a	9.00 a	217.96 a
Fulvic acid		80.64 a	8.17 a	203.70 a	96.37 a	8.37b c	187.96 b
Amino acids		79.41a	8.20 a	203.15 a	95.78 a	8.67 ab	202.04 ab
Seaweed extract		80.26 a	8.24 a	208.33 a	95.04 a	8.74 ab	210.74 a
F. test		*	*	**	*	*	**
Interaction (A x B):							
Control N	**Control (water)**	64.56 c	7.33	166.67	86.33	7.66	193.89 cde
	Yeast extract	79.44 ab	7.61	194.44	89.11	8.52	216.11 abc
	Fulvic acid	80.33 ab	7.50	188.89	95.11	8.22	181.67 cdef
	Amino acids	79.89 ab	7.72	191.67	95.33	8.67	170.56 ef
	Seaweed extract	81.33 ab	7.39	201.11	91.78	8.22	178.33 def
216 kg N ha^{-1}	**Control (water)**	78.67 ab	7.17	178.89	87.33	7.88	151.11 f
	Yeast extract	84.00 a	8.22	194.44	94.78	9.30	237.78 ab
	Fulvic acid	75.81 b	8.22	213.33	97.00	8.22	198.89 cde
	Amino acids	78.78 ab	8.22	210.00	93.89	8.78	217.22 abc
	Seaweed extract	79.00 ab	8.22	206.11	94.56	8.67	203.33 bcde
288 kg N ha^{-1}	**Control (water)**	80.33 ab	8.50	194.44	89.56	8.66	212.22 bcd
	Yeast extract	78.33 ab	8.78	191.11	99.11	9.19	200.00 cde
	Fulvic acid	85.78 a	8.78	208.89	97.00	8.67	183.33 cdef
	Amino acids	79.56 ab	8.67	207.78	98.11	8.56	218.33 abc
	Seaweed extract	80.44 ab	9.11	217.78	98.78	9.33	250.56 a
F. test		**	NS	NS	NS	NS	**

- *, **, and NS stand for significant, highly significant, and not significant, respectively, at 5% levels of probability.
- Duncan's Multiple Range Test indicates; There are no significant differences among the means for any factor specified by the same letter inside the same column at the 5% level.
- Control N = 144 kg N ha^{-1}.

As for the data illustrated in Table 3, nitrogen rates influenced significantly neck diameter in the 1st season, bulb diameter, and bulbing ratio in the 1st and the2nd seasons. Fertilizing by 288 kg N ha^{-1} obtained the largest mean values for neck and bulb diameter, whereas, 144 kg N per ha attained the smallest values during both seasons. Additionally, the fertilized by 288 kg N ha^{-1} produced the highest mean values for bulbing ratio during the 1st season.

Foliar spraying with natural stimulators significantly affected neck and bulb diameter, and bulbing ratio during the 1st and the 2nd seasons. With spraying by amino acids resulted in the maximum values for neck and bulbs diameter during the 1st and the 2nd growing seasons, while the spraying with water yielded the lowest values. Spraying with yeast extract led to the highest means for bulbing ratio, while spraying with water resulted in the lowest means in 1st and the 2nd seasons.

Only in the 2nd season, the combination between nitrogen rate and foliar spray with natural stimulators had a significant impact on neck diameter and bulb diameter. During 2nd season, the highest combination of neck diameter was found by application of 288 kg N ha^{-1} and seaweed spray, while the lowest combination was obtained by fertilized by 288 kg N ha^{-1} under control treatment. The highest interaction for bulbs diameter, in the 2nd season, was obtained when fertilized by 288 kg N ha^{-1} and fulvic acid spray, while the lowest interaction was gained through added of 144 kg N ha^{-1} (**Control N**) under the water spray. The combination effect among the two factors on bulbing ratio didn't reach to the significance level, during the two seasons.

Table 3. Neck diameter, bulb diameter, and bulbing ratio of onion as influenced by nitrogen fertilization and foliar spraying with natural stimulators, at 120 days from transplanting, during 2019-2020 and 2020-2021 seasons.

Treatments		2019-2020 Neck diameter (cm)	2019-2020 Bulb diameter (cm)	2019-2020 Bulbing ratio	2020-2021 Neck diameter (cm)	2020-2021 Bulb diameter (cm)	2020-2021 Bulbing ratio
Nitrogen rates (A):							
Control		1.26 c	6.58 b	0.19 c	1.80	6.18 b	0.29 b
216 kg N ha^{-1}		1.75 b	6.92 ab	0.25 b	2.06	6.22 b	0.33 a
288 kg N ha^{-1}		2.05 a	7.29 a	0.28 a	2.08	7.01 a	0.30 ab
F. test		**	*	**	NS	*	*
Spraying with natural stimulators (B):							
Control (water)		1.32 d	6.37 b	0.20 c	1.49 c	6.18 b	0.24 b
Yeast extract		1.83 ab	7.01 a	0.26 a	2.16 a	6.43 b	0.34 a
Fulvic acid		1.72 c	6.89 a	0.25 ab	1.96 b	6.27 b	0.32 a
Amino acids		1.84 a	7.21 a	0.25 ab	2.17 a	7.04 a	0.31 a
Seaweed extract		1.73 bc	7.16 a	0.24 b	2.13 ab	6.45 b	0.33 a
F. test		**	**	**	**	**	**
Interaction (A x B):							
Control N	**Control (water)**	0.87	5.86	0.15	1.50 fg	5.82 cd	0.26
	Yeast extract	1.44	6.74	0.21	1.93 cde	6.06 bcd	0.32
	Fulvic acid	1.29	6.58	0.20	1.73 ef	5.94 cd	0.29
	Amino acids	1.37	6.82	0.20	1.98 cde	6.74 ab	0.29
	Seaweed extract	1.31	6.90	0.19	1.83 def	6.36 bc	0.29
216 kg N ha^{-1}	**Control (water)**	1.40	6.16	0.23	1.68 ef	6.40 bc	0.26
	Yeast extract	1.86	7.09	0.26	2.18 abcd	6.10 bcd	0.36
	Fulvic acid	1.82	7.09	0.26	2.03 bcde	5.60 d	0.36
	Amino acids	1.93	7.30	0.26	2.29 abc	7.12 a	0.32
	Seaweed extract	1.76	6.97	0.25	2.14 abcd	5.86 cd	0.37
288 kg N ha^{-1}	**Control (water)**	1.69	7.09	0.24	1.28 g	6.31 bcd	0.20
	Yeast extract	2.18	7.21	0.30	2.37 ab	7.13 a	0.33
	Fulvic acid	2.04	7.01	0.29	2.12 abcd	7.26 a	0.29
	Amino acids	2.21	7.52	0.29	2.23 abc	7.24 a	0.31
	Seaweed extract	2.12	7.61	0.28	2.42 a	7.12 a	0.34
F. test		NS	NS	NS	*	*	NS

- *, **, and NS stand for significant, highly significant, and not significant, respectively, at 5% levels of probability.
- Duncan's Multiple Range Test indicates; There are no significant differences among the means for any factor specified by the same letter inside the same column at the 5% level.
- Control N = 144 kg N ha^{-1}

2- Yield and its components characteristics:

Data in Table 4 clearly demonstrates the significant impact of nitrogen rates on a range of yield characteristics during both 1st and the 2nd growing seasons, except for culls yield ha^{-1} in the 1st and 2nd seasons. Increasing the nitrogen rate from 144 kg up to 288 kg ha^{-1} resulted in a consistent increase in average bulb weight. In the 1st season, the rise in average bulb weight was by 11.64% and 2.60%, respectively, compared to the alternative nitrogen fertilizer at the rates of 144 kg and 216 kg ha^{-1}. Similarly, during the 2nd season, the average bulb weight increased by 7.62% and 4.01%, respectively, compared to the same alternative nitrogen levels.

Regarding marketable yield.ha^{-1}, the highest nitrogen level of 288 kg.ha^{-1} outperformed other nitrogen rates. In the 1st season, it resulted in a marketable yield ha^{-1} that was greater by 20.49% and 7.32% compared to nitrogen rates of 60 kg and 216 kg ha^{-1}, respectively. Similarly, in the 2nd season, the marketable yield ha^{-1} was higher by 13.71% and 8.17% compared to nitrogen at 60 kg and 216 kg ha^{-1}, respectively.

Considering the total yield ha^{-1}, onion plants cultivated under the high nitrogen of 288 kg ha^{-1} showed superior results during the 1st and 2nd seasons. During the 1st season, the total yield ha^{-1} was higher by 14.45% and 13.89% compared to nitrogen at 144 kg and 216 kg ha^{-1}, respectively. Similarly, during the 2nd season, the total yield ha^{-1} was greater by 12.88% and 5.49% compared to the other nitrogen rates (144 kg and 216 kg ha^{-1}, respectively).

Table 4. Yield and its components of onion as influenced by nitrogen fertilization and foliar spraying with natural stimulators during 2019-2020 and 2020-2021 seasons.

Treatments		2019-2020				2020-2021			
		Average bulb weight (g)	Marketable bulb yield (t ha^{-1})	Culls bulb yield (t ha^{-1})	Total bulb yield (t ha^{-1})	Average bulb weight (g)	Marketable bulb yield (t ha^{-1})	Culls bulb yield (t ha^{-1})	Total bulb yield (t ha^{-1})
Nitrogen rates (A):									
Control		95.43 b	28.10 c	6.00	34.10 b	95.57 b	30.21 b	3.81	34.02 c
216 kg N ha^{-1}		103.83 a	31.55 b	2.71	34.27 b	98.89 b	31.75 b	4.63	36.38 b
288 kg N ha^{-1}		106.54 a	33.87 a	5.16	39.03 a	102.85 a	34.33 a	4.06	38.39 a
F. test		**	**	NS	**	*	**	NS	**
Spraying with natural stimulators (B):									
Control (water)		92.87 d	30.12 c	3.29 b	33.41 c	88.82 c	29.44 d	2.74	32.18 d
Yeast extract		100.18 c	32.30 a	6.12 a	38.42 a	104.69 a	30.95 c	4.68	35.63 c
Fulvic acid		108.34 a	31.93 ab	6.00 a	37.93 a	107.10 a	33.18 ab	4.35	37.53 ab
Amino acids		104.69 ab	30.74 bc	4.32 b	35.05 b	98.62 b	34.34 a	4.46	38.79 a
Seaweed extract		103.60 bc	30.79 bc	3.38 b	34.17 bc	96.29 b	32.60 b	4.59	37.19 b
F. test		**	*	**	**	**	**	NS	**
Interaction (A x B):									
Control N	**Control (water)**	89.13 g	27.31 gh	5.99 b	33.30 fghi	91.70 bc	29.69 fg	1.31	31.00
	Yeast extract	94.27 e	27.85 fgh	5.99 b	33.84 efgh	97.53 b	28.37 g	4.78	33.15
	Fulvic acid	100.80 efg	30.35 def	5.91 b	36.25 cde	105.47 a	31.71 ef	4.28	35.98
	Amino acids	95.20 cde	26.29 h	5.99 b	32.28 ghi	90.30 cd	31.79 ef	3.50	35.29
	Seaweed extract	97.77 def	28.73 efgh	6.11 b	34.84 efg	92.87 bc	29.51 fg	5.16	34.68
216 kg N ha^{-1}	**Control (water)**	97.53 def	29.28 efg	1.80 c	31.08 i	84.23 d	28.82 g	2.76	31.57
	Yeast extract	102.67 bcd	36.49 a	1.84 c	38.33 cd	105.93 a	31.11 ef	5.35	36.47
	Fulvic acid	109.20 ab	31.11 cde	5.28 b	36.39 cde	108.50 a	31.67 ef	4.96	36.63
	Amino acids	103.60 bcd	31.44 cde	2.62 c	34.06 efgh	97.30 b	34.17 bcd	4.88	39.05
	Seaweed extract	106.17 bc	29.43 efg	2.03 c	31.46 hi	98.47 b	33.00 de	5.18	38.19
288 kg N ha^{-1}	**Control (water)**	91.93 fg	33.76 bc	2.08 c	35.84 def	90.53 cd	29.81 fg	4.15	33.95
	Yeast extract	103.60 bcd	32.55 bcd	10.54 a	43.09 a	110.60 a	33.36 cde	3.92	37.27
	Fulvic acid	115.03 a	34.33 ab	6.82 b	41.15 ab	107.33 a	36.16 ab	3.80	39.96
	Amino acids	115.27 a	24.48 ab	4.34 bc	38.82 bc	108.27 a	37.05 a	5.00	42.05
	Seaweed extract	106.87 bc	34.22 ab	2.01 c	36.22 cde	97.53 b	35.30 abc	3.42	38.71
F. test		*	**	*	**	**	**	NS	NS

- *, **, and NS stand for significant, highly significant, and not significant, respectively, at 5% levels of probability.
- Duncan's Multiple Range Test indicates; There are no significant differences among the means for any factor specified by the same letter inside the same column at the 5% level.
- Control N = 144 kg N ha^{-1}

The application of sprayed natural stimulants had a significant impact on various yield criteria, including average bulbs weight, marketable yield ha^{-1}, and total yield ha^{-1}, during both the 1st and 2nd seasons, while culls yield ha^{-1} was significantly affected by this treatment during the 1st season only, as indicated in Table 4. Spraying with yeast extract, fulvic acid, amino acids, and seaweed extract led to notable increases in average bulb weight by 7.87%, 16.66%, 12.73%, and 11.55%, respectively, compared to the spraying with water, during the 1st season. Similarly, in the 2nd season, spraying with yeast extract, fulvic acid, amino acids, and seaweed extract resulted in increased average bulb weight by 17.87%, 20.58%, 11.03%, and 8.41%, respectively, in comparison with water spraying.

Moreover, the spraying of these sprayed natural stimulants also positively influenced marketable yield ha^{-1} during the two seasons. In the 1st season, the marketable yield ha^{-1} was increased by 7.19%, 6.00%, 1.97%, and 2.21% with yeast extract, fulvic acid, amino acids, and seaweed extract, respectively, in comparison with the control. Similarly, in the 2nd season, the marketable yield ha^{-1} showed increments of 5.09%, 12.69%, 16.65%, and 10.75% with yeast extract, fulvic acid, amino acids, and seaweed extract, respectively, in comparison to the control.

Furthermore, the sprayed natural stimulants influenced culls yield during the 1st season, and total yield during the 1st and the 2nd seasons. In the 1st season, the culls yield ha^{-1} was reduced by 86.23%, 82.61%, 31.16%, and 2.90%, respectively, with yeast extract, fulvic acid, amino acids, and seaweed extract, compared to the control. from other hand, the total yield ha^{-1} increased by 14.96%, 13.53%, 4.91%, and 2.28% in the 1st season, and by 10.72%, 16.64%, 20.56%, and 15.61% in the 2nd season, with yeast extract, fulvic acid, amino acids, and seaweed extract, respectively, in comparison to the control.

The interaction between the nitrogen rates and the sprayed natural stimulants significantly affected average weight of bulbs and marketable yield ha^{-1} during the two seasons. For instance, applying a nitrogen of 288 kg N.ha^{-1} along with spraying amino acids resulted in the highest average bulb weight, during the 1st season, whereas, in the 2nd season, the highest average weight of bulbs was created when yeast was combined with 288 kg of N ha^{-1}. In contrast, the nitrogen of 144 or 216 kg ha^{-1} with water spray, resulted in lowest values for average weight of bulbs, during the 1st and 2nd seasons, respectively. The greatest marketable yield ha^{-1} were achieved by combining nitrogen of 288 kg ha^{-1} with spraying amino acids during the 1st and the 2nd seasons, whereas the lowest values were obtained with nitrogen rates of 144 kg or 216 kg ha^{-1} along with spraying amino acids or yeast, in the 1st and 2nd seasons, respectively.

Culls yield (kg ha^{-1}) and total yield (t ha^{-1}) were significantly affected by the interaction between the two factors under study in the 1st season only (Table, 4). The greatest mean values of culls yield, and total yield fed^{-1} were observed by fertilizing onion with 288 kg ha^{-1} and spraying with yeast, while the smallest values were obtained by fertilizing with 216 kg ha^{-1} under control treatments, in the 1st season.

3- Onion quality characteristics

The data provided in Table 5 demonstrated that the nitrogen rate for onions significantly affected the percentage of single bulbs, double bulbs, and bolters in each of the two seasons. Fertilizing by 144 kg N ha^{-1} (control N) from nitrogen fertilizer recorded the highest mean values of single bulbs, and bolters%, while fertilizing with 288 kg ha^{-1} recorded the lowest mean values, during both seasons. Data in Table 5 also showed that increasing nitrogen rates from 144 kg to 288 kg, increased the percentage of double bulbs. These increases ranged from 3.16 to 6.78% in the 1st season and from 2.35 to 5.35% in the second one.

Concerning to the effect of natural stimulators, data revealed to a significant variation within the features of single bulbs (%), double bulbs (%) and bolters (%) caused by spraying with natural stimulators, during both seasons. The greatest means of individual bulbs were seen when spraying with water, in 1st and 2nd seasons, whereas spraying with amino acids or yeast extract appeared the minimum values, during both seasons, respectively. The maximum mean values of double bulbs were gained by spraying with yeast extract, while the lowest values had been attained under water spray, in 1st and 2nd seasons. Spraying with water exhibited the highest mean values of bolter percentage in the 1st and 2nd seasons, while spraying with seaweed extract or amino acids exhibited the lowest mean values during the 1st and the 2nd seasons, respectively.

Interaction between nitrogen rate and spraying with natural stimulators had significant impact on the single, double bulbs, and bolters percentage during the two seasons. The highest combination for single bulbs% was recorded by application of 144 kg N ha^{-1} (control N) when sprayed with water, while the lowest combination was observed by adding of 288 kg ha^{-1} when sprayed by amino acids, in the 1st and 2nd seasons. The greatest combination for double bulbs were observed by adding of 288 kg ha^{-1} and spraying with yeast extract, while the lowest mean values were obtained by fertilizing with 216 kg ha^{-1} and spraying with water treatment, during the 1st and 2nd seasons. The combination between low nitrogen level (144 N kg ha^{-1}) and water spray gave the maximum mean values of bolters percentage, whereas the combination among moderate nitrogen level (216 kg ha^{-1}) and spraying with fulvic acid gave the minimum values, in 1st and 2nd seasons. According to data in Table 6, nitrogen rate significantly affected bulb diameter, TSS%, and dry matter% in the 1st and 2nd seasons.

From the data in Table 6, nitrogen rate significantly affected bulb diameter, TSS, and dry matter percentage in the 1st and 2nd seasons. It was observed that onion plants cultivated under 288 kg ha^{-1} recorded the highest values of bulb diameter, TSS and dry matter percentage, while those grown under 144 kg N ha^{-1} (control N) recorded the lowest mean values, during the 1st and 2nd seasons.

As a result of spraying with natural stimulators, data showed that foliar spraying with yeast extract, fulvic acid, amino acids and extract of seaweed significantly increased the values of bulb diameter, TSS and dry matter percentage, in comparison with the control, in 1st and 2nd seasons. The superiority of natural stimulators in respect to these characteristics might be due to that most of these substances include amino acids, growth regulators as well as vitamins which promote and improve the metabolic activities in vegetative tissues.

Data in Table 6, it can be illustrated that only during the 1st season did the interaction between the two parameters considerably affect bulb diameter, and only in the second season did it significantly affect TSS%. The interaction of the two aspects during both seasons had a significant impact on dry matter%. Onions planted at a moderate nitrogen (144 kg N ha^{-1}) and sprayed with fulvic acid showed the highest combination for bulb diameter, whereas onions planted at a moderate nitrogen rate under the water spray treatment showed the lowest combination., in the 1st season. The greatest combination for TSS% were observed by growing of onion at high nitrogen rate when sprayed with fulvic acid, while, the lowest combination was observed by using low nitrogen rate under control treatment, in the second season. For dry matter% characteristic, the highest combination was achieved under moderate nitrogen rate when sprayed with fulvic acids, in 1st and 2nd seasons, while the lowest combination was achieved under low nitrogen rate when sprayed by water (control) or amino acids, during the 1st and 2nd seasons, respectively.

Table 5. Single bulbs, double bulbs and bolters of onion as influenced by nitrogen fertilization and foliar spraying with natural stimulators during 2019-2020 and 2020-2021 seasons.

Treatments		2019-2020 Single bulbs (%)	2019-2020 Double bulbs (%)	2019-2020 Bolters (%)	2020-2021 Single bulbs (%)	2020-2021 Double bulbs (%)	2020-2021 Bolters (%)
Nitrogen rates (A):							
Control N		95.05 a	3.16 b	1.79 a	94.82 a	2.57 b	2.60 a
216 kg N ha^{-1}		94.97 a	3.49 b	1.54 b	93.28 b	4.76 a	1.96 b
288 kg N ha^{-1}		91.87 b	6.78 a	1.35 c	92.31 c	5.35 a	2.33 ab
F. test		**	**	**	**	**	*
Spraying with natural stimulators (B):							
Control (water)		95.46 a	2.30 c	2.25 a	94.52 a	1.93 d	3.55 a
Yeast extract		91.67 c	6.76 a	1.57 b	91.07 c	6.12 a	2.81 b
Fulvic acid		93.36 b	5.33 b	1.31 b	93.38 b	4.96 b	1.66 c
Amino acids		93.35 b	5.25 b	1.40 b	94.19 ab	4.21 c	1.60 c
Seaweed extract		95.99 a	2.74 c	1.27 b	94.20 ab	3.92 c	1.88 c
F. test		**	**	**	**	**	**
Interaction (A x B):							
Control N	**Control (water)**	94.51 bc	2.76 defg	2.73 a	93.38 cd	1.61 e	5.02 a
	Yeast extract	92.81 c	5.72 c	1.47 bcde	92.26 de	4.96 cd	2.77 bc
	Fulvic acid	94.52 bc	3.51 def	1.96 abcd	96.24 a	2.42 e	1.34 def
	Amino acids	96.22 ab	2.36 efg	1.41 cde	96.59 a	1.58 e	1.83 cdef
	Seaweed extract	97.20 a	1.43 g	1.37 cde	95.66 ab	2.30 e	2.04 bcdef
216 kg N ha^{-1}	**Control (water)**	96.49 ab	1.36 g	2.15 abc	95.96 a	1.57 e	2.48 bcde
	Yeast extract	94.80 bc	2.89 defg	2.31 ab	92.83 cde	4.62 d	2.55 bcd
	Fulvic acid	90.92 d	8.21 b	0.87 e	91.19 e	7.56 b	1.25 f
	Amino acids	96.41 ab	2.69 defg	0.90 e	93.54 cd	5.18 cd	1.27 ef
	Seaweed extract	96.23 ab	2.31 fg	1.46 bcde	92.85 cde	4.88 cd	2.27 bcdef
288 kg N ha^{-1}	**Control (water)**	95.37 ab	2.76d efg	1.87 abcd	94.23 bc	2.63 e	3.14 b
	Yeast extract	87.39 e	11.69 a	0.93 e	88.12 f	8.78 a	3.10 b
	Fulvic acid	94.63 bc	4.28 cde	1.09 de	92.71 cde	4.89 cd	2.40 bcdef
	Amino acids	87.43 e	10.70 a	1.88 abcd	92.43 cde	5.88 c	1.69 cdef
	Seaweed extract	94.54 bc	4.48 cd	0.98 e	94.08 bcd	4.59 d	1.33 def
F. test		**	**	**	**	**	**

- *, **, and NS stand for significant, highly significant, and not significant, respectively, at 5% levels of probability.
- Duncan's Multiple Range Test indicates; There are no significant differences among the means for any factor specified by the same letter inside the same column at the 5% level.
- Control N = 144 kg N ha^{-1}.

Table 6. Bulb diameter, TSS and dry matter of onion as influenced by nitrogen fertilization and foliar spraying with natural stimulators after harvesting, during 2019-2020 and 2020-2021 seasons.

Treatments		2019-2020			2020-2021		
		Bulb diameter (cm)	TSS (%)	Dry matter (%)	Bulb diameter (cm)	TSS (%)	Dry matter (%)
Nitrogen rates (A):							
Control N		7.00 b	13.51 b	13.29 b	6.77 b	13.05 b	13.49 b
216 kg N ha^{-1}		7.19 a	14.29 a	14.06 a	6.81 b	14.33 a	14.18 ab
288 kg N ha^{-1}		7.27 a	14.65 a	14.58 a	7.46 a	14.69 a	14.57 a
F. test		**	*	*	**	**	*
Spraying with natural stimulators (B):							
Control (water)		6.65 b	13.30 c	13.02 b	6.59 b	13.33 c	13.02 c
Yeast extract		7.19 a	14.01 b	13.54 b	7.12 a	13.85 b	13.60 c
Fulvic acid		7.35 a	14.86 a	15.30 a	7.17 a	14.69 a	14.99 a
Amino acids		7.27 a	14.34 ab	13.19 b	7.14 a	14.18 b	14.34 b
Seaweed extract		7.32 a	14.26 ab	14.83 a	7.04 a	14.09 b	14.44 ab
F. test		**	**	**	**	**	**
Interaction (A x B):							
Control N	**Control (water)**	6.38 c	12.63	11.23 i	6.60	12.33 h	12.70 e
	Yeast extract	6.97 b	13.37	12.30 hi	6.74	12.87 gh	13.57 cde
	Fulvic acid	7.21 ab	13.57	14.27 cdef	6.90	13.07 fg	13.73 cde
	Amino acids	7.25 ab	14.43	12.77 gh	6.75	13.93 de	12.60 e
	Seaweed extract	7.22 ab	13.57	15.90 ab	6.87	13.07 fg	14.87 ab
216 kg N ha^{-1}	**Control (water)**	6.30 c	13.40	14.83 abcde	6.13	13.60 ef	12.97 de
	Yeast extract	7.47 ab	14.07	13.77 defg	7.10	14.07 cde	13.30 de
	Fulvic acid	7.51 a	15.13	16.13 a	7.01	15.13 b	15.70 a
	Amino acids	7.30 ab	14.33	12.13 hi	6.93	14.33 cd	15.07 a
	Seaweed extract	7.36 ab	14.53	13.43 efgh	6.88	14.53 bcd	13.87 bcd
288 kg N ha^{-1}	**Control (water)**	7.26 ab	13.87	13.00 fgh	7.05	14.07 cde	13.40 de
	Yeast extract	7.13 ab	14.60	14.57 bcde	7.53	14.60 bcd	13.93 bcd
	Fulvic acid	7.33 ab	15.87	15.50 abc	7.61	15.87 a	15.53 a
	Amino acids	7.25 ab	14.27	14.67 bcde	7.73	14.27 cde	15.37 a
	Seaweed extract	7.39 ab	14.67	15.17 abcd	7.38	14.67 bc	14.60 abc
F. test		*	NS	**	NS	**	**

- *, **, and NS stand for significant, highly significant, and not significant, respectively, at 5% levels of probability.
- Duncan's Multiple Range Test indicates; There are no significant differences among the means for any factor specified by the same letter inside the same column at the 5% level.
- Control N = 144 kg N ha^{-1}.

4- Chemical analyses

Results in Table 7 demonstrated that nitrogen, phosphorus, and potassium percentage of onion bulbs were significantly affected by adding of different nitrogen rates from 144 to 288 kg ha^{-1}. Highest percentages of nitrogen, phosphorus and potassium in onion were found in case of high dose of nitrogen (288 kg ha^{-1}), whereas the lowest value of content was recorded in case of low dose (144 kg N ha^{-1}) during 1st and 2nd seasons.

Belong to the spraying effect with natural stimulators, significant influence of spraying treatments on nutrient content parameters was observed in the two seasons. Spraying with seaweed extract made the greatest increase in the nitrogen content during the 1st and the 2nd seasons, and phosphorus in the 2nd season, while, the highest levels of phosphorus were detected in the first season while spraying with amino acids. Spraying with fulvic acid appeared the highest potassium% values in both seasons. Conversely, control plants recorded the lowest nitrogen, phosphorus and potassium values.

The interaction between nitrogen rates and spraying with natural stimulators had a substantial impact on nitrogen phosphorus, and potassium contents, during both seasons, as indicated in Figure 1. The best chemical content of nitrogen, phosphorus and potassium for onion bulbs was associated with the plants which received 288 kg ha^{-1} when sprayed with different natural stimulators. The maximum value of N% (1.853 and 1.986%) were occurred under 288 kg ha^{-1}, when sprayed with seaweed or yeast, during the 1st and 2nd seasons, respectively. The highest values of phosphorus content varied from (0.230 and 0.241%) were achieved under 288 kg ha^{-1} when sprayed with seaweed during the 1st and 2nd seasons, respectively. Fertilizing by 288 kg ha^{-1} with fulvic acid gave the highest potassium content (2.407 and 2.377%), during the 1st and 2nd seasons, respectively. The lowest values of nitrogen, phosphorus and potassium content were found by application of 144 kg N ha^{-1} under water spray (control), during the 1st and 2nd seasons.

The information in Table 8 showed that carbohydrate and protein contents in onion bulbs were significantly affected by nitrogen rates, spraying with natural stimulators and their interaction during the two seasons. High nitrogen rates (288 kg ha^{-1}) showed the highest carbohydrates. and protein contents, while low nitrogen rates of 144 kg N ha^{-1} (control N) showed the lowest mean values during the 1st and 2nd seasons. Spraying onion plants with seaweed extract achieved the highest contents of carbohydrate and protein, whereas, control treatments achieved the lowest contents during the 1st and 2nd seasons. The highest combinations between nitrogen rates and spraying treatments (Figure 2), in respect to carbohydrate and protein contents, was obtained under high nitrogen rate (288 kg N ha^{-1}), when sprayed with seaweed extract, while the lowest combinations were obtained under low nitrogen rate (144 kg N ha^{-1}), when sprayed with water in both seasons.

Table 7. Nitrogen, phosphorus, and potassium content (%) of onion bulbs as influenced by nitrogen fertilization and foliar spraying with natural stimulators during 2019-2020 and 2020-2021 seasons.

Treatments	2019-2020			2020-2021		
	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Nitrogen (%)	Phosphorus (%)	Potassium (%)
Nitrogen rates (A):						
Control N	0.817 c	0.144 c	1.407 c	1.019 c	0.150 c	1.360 c
216 kg N ha^{-1}	1.270 b	0.173 b	1.816 b	1.233 b	0.172 b	1.750 b
288 kg N ha^{-1}	1.593 a	0.205 a	2.132 a	1.701 a	0.210 a	2.033 a
F. test	**	**	**	**	**	**
Spraying with natural stimulators (B):						
Control (water)	0.769 c	0.133 d	1.438 e	0.808 d	0.131 c	1.423 e
Yeast extract	1.351 ab	0.174 c	1.913 b	1.514 a	0.177 b	1.883 b
Fulvic acid	1.171 b	0.175 c	2.059 a	1.299 c	0.174 b	1.964 a
Amino acids	1.382 ab	0.197 a	1.819 c	1.436 b	0.201 a	1.662 c
Seaweed extract	1.460 a	0.191 b	1.696 d	1.532 a	0.204 a	1.639 d
F. test	**	**	**	**	**	**
Interaction (A x B):						
F. test	**	**	**	**	**	**

- *, **, and NS stand for significant, highly significant, and not significant, respectively, at 5% levels of probability.
- Duncan's Multiple Range Test indicates; There are no significant differences among the means for any factor specified by the same letter inside the same column at the 5% level.
- Control N = 144 kg N ha^{-1}.

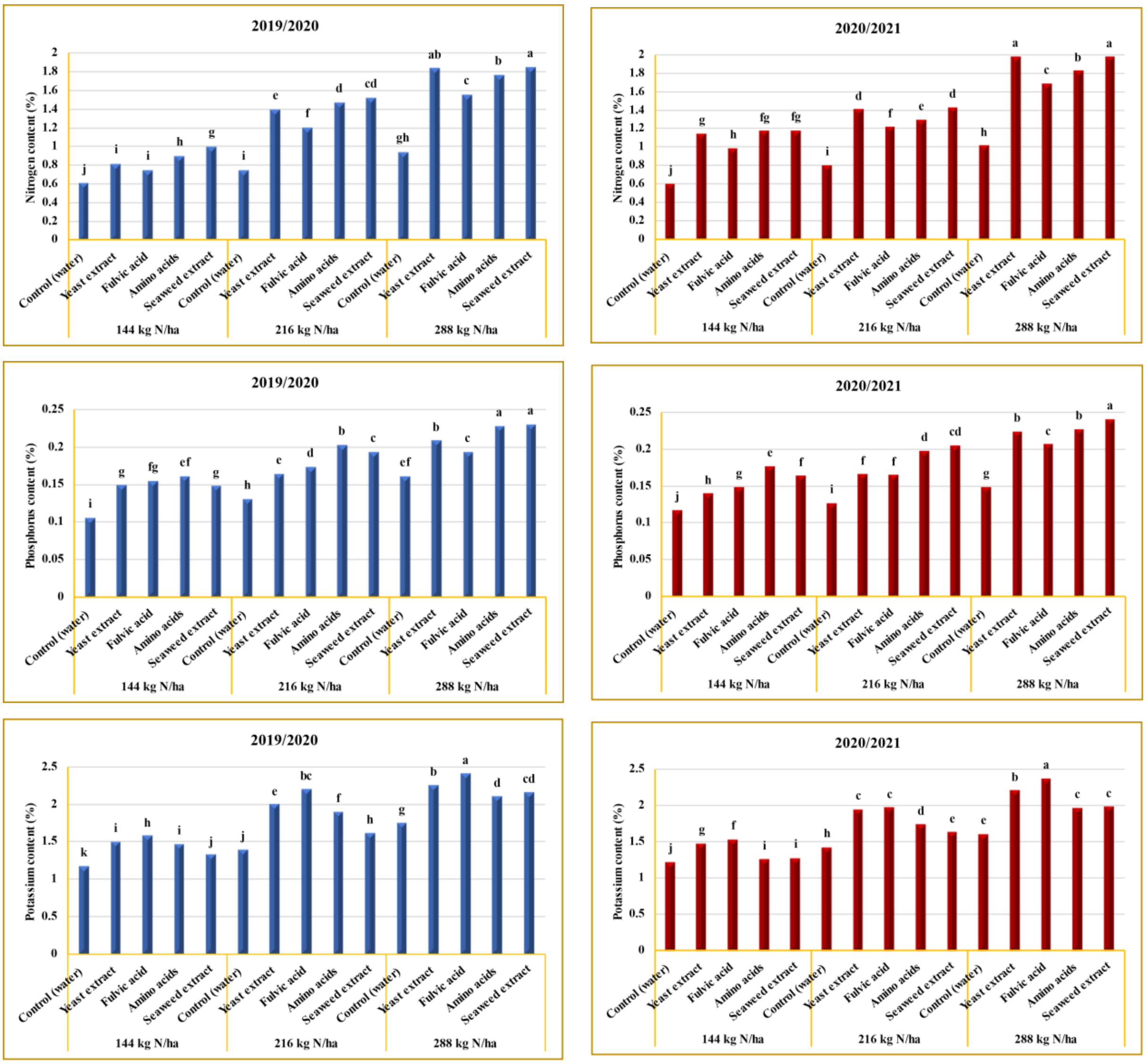

Fig. 1. Nitrogen, phosphorus, and potassium content (%) of onion bulbs as influenced by the interaction between nitrogen fertilization and foliar spraying with natural stimulators during 2019-2020 and 2020-2021 seasons.

Table 8. Carbohydrate and protein content (%) of onion as influenced by nitrogen fertilization and foliar spraying with natural stimulators during 2019-2020 and 2020-2021 seasons.

Treatments	2019-2020		2020-2021	
	Carbohydrate (%)	Protein (%)	Carbohydrate (%)	Protein (%)
Nitrogen rates (A):				
Control N	11.80 c	6.89 c	12.33 c	7.58 c
216 kg N ha^{-1}	14.50 b	11.43 b	15.13 b	11.32 b
288 kg N ha^{-1}	16.85 a	13.38 a	16.91 a	14.20 a
F. test	**	**	**	**
Spraying with natural stimulators (B):				
Control (water)	11.99 d	8.85 e	12.40 d	9.09 e
Yeast extract	13.92 c	10.13 d	14.42 c	10.40 d
Fulvic acid	14.82 b	10.53 c	15.27 b	11.07 c
Amino acids	15.04 b	11.13 b	15.48 b	11.91 b
Seaweed extract	16.16 a	12.18 a	16.37 a	12.69 a
F. test	**	**	**	**
Interaction (A x B):				
F. test	**	**	*	**

- *, **, and NS stand for significant, highly significant, and not significant, respectively, at 5% levels of probability.
- Duncan's Multiple Range Test indicates; There are no statistically significant differences among the means for any factor specified by the same letter inside the same column at the 5% level.
- Control N = 144 kg N ha^{-1}

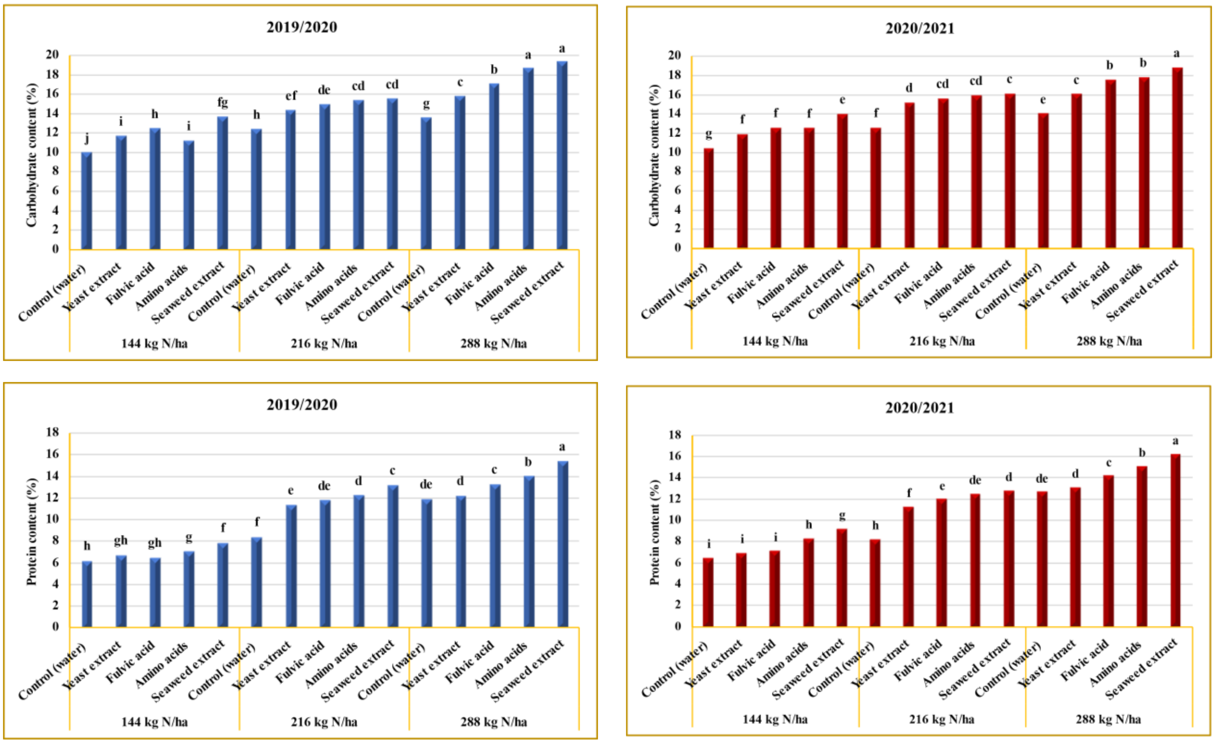

Fig. 2. Carbohydrate and protein content (%) of onion bulbs as influenced by the interaction between nitrogen fertilization and foliar spraying with natural stimulators during 2019-2020 and 2020-2021 seasons.

3. Discussion

The research revealed that nitrogen fertilization had an encouraging effect on the onion crop's vegetative growth characteristics. Increased nitrogen levels presumably contributed significantly to the formation of critical amino acids, which are required for stimulating protein synthesis, chlorophyll synthesis, cell division, and cell elongation, which accounts for the observed improvements. These physiological processes consequently improved the onion plants' general growth traits as a whole. Many researchers (**El-Shaikh, 2005; Abdissa et al., 2011; Bekele, 2018; Kadam et al., 2020**) came to the same conclusion.

The results demonstrate that the improvements in vegetative growth characteristics observed after yeast spraying could be attributed to the elevation of endogenous hormone levels in the treated plants, which are believed to stimulate cell growth and division **(Khedr and Faried, 2002).** These effects could also be explained by the yeast extract containing vitamins and amino acids was found to enhance the processes of metabolism and elevate the levels of natural hormones, such as indole acetic acid "IAA" and gibberellic acid "GA3", thereby augmenting their physiological functions **(Chailakhyn, 1957 and N.R.P., 1977).** The role of natural stimulators in promoting vegetative growth was confirmed by **Anjum et al., (2011)** who reported that the leaf chlorophyll and water content were increased by the fulvic acid application. Fulvic acid treatment also enhanced photosynthesis and decrease stomata opening status, which stimulated growth and reduced water loss. In this regard, the maximum mean values for plant height, leaves No., and fresh weight of onion plants were reportedly obtained when yeast at a concentration of 3 g/L was applied, according to estimation **of Fawzy et al. (2012-b).**

Application the highest nitrogen level appeared the greatest mean values of bulb and neck diameter, this result was coincide with that obtained by many researchers, such as **Jilani et al. (2004)** who observed that addition of N at 200 kg N ha^{-1} improved the number of thick-necked bulbs, **Nawaz et al., (2017)** who also cleared that the uppermost diameter of bulb was recorded in 150 % N of recommended dose, and **Hafez and Geries (2019)** who noticed that the lowest mean values of bulbing ratio was found with 80 kg N ha^{-1} at 110 DAT in both seasons and that the maximum ratio was reached at 100 or 288 kg N ha^{-1} without a significant distinction between them.

The results of foliar spraying with natural stimulators on vegetative growth traits of onion were consistent with those of **Fawzy et al. (2012-b)**, who found that the quality of all onion bulbs "bulb diameter, neck diameter, and bulbing ratio" was improved by foliar application of yeast and amino acid when compared to control.

By raising the nitrogen rate from 144 kg to 288 kg N ha^{-1}, the average bulb weight increased. Increasing of bulb weight under high nitrogen rate might be as a result of the fertilization-induced increase in growth characteristics as "plant height, number of leaves produced, leaf diameter, leaf length, and physiological maturity", these factors may have also enhanced assimilate production and allocation on the bulbs **(Etana et al., 2019),** the increase in plant height, the number of leaves per plant, and the length of the leaves may be responsible for these results since these factors directly affect the production of dry matter (**Bala et al., 2014; Messele, 2016)**.

Etana et al. (2019) confirmed that increasing marketable yield ha^{-1} and total yield ha^{-1} under high nitrogen rate, revealing that maximum application of N at 150 kg N ha^{-1} increased the marketable bulb yield (t/ha) and total bulb yield (t/ha), as compared to other nitrogen rate (0, 50, and 100 kg N ha^{-1}), also **Mahmoud et al., (2019)** concluded that the increase in fulvic acid levels was clearly associated with an increase in the vegetative growth and production of onion plants.

The increases in yield components "average bulb weight, marketable yield ha^{-1}, culls yield ha^{-1}, and total yield ha^{-1} " under various spraying treatments are primarily attributable to the efficiency of these stimulators in activating onion growth parameters, which is reflected in the increase in bulb weight and, consequently, onion yield. These increases in bulb weight and bulb yield as a result for spraying with different natural stimulators were in a coincide with that reported by **Fawzy et al., (2012-b)** who found that, applying amino green and yeast to the onion's leaves increased bulb weight and yield compared to the control.

Bolters mean values (%) were highest when 144 kg N per hectare were added. **Yamasaki and Tanaka (2005)** found that low nitrogen levels induced bolting in *Allium fistulosum* L. plants, similarly, **Gebretsadik (2016)** found that nitrogen levels increased from 0 to 150 kg ha^{-1} resulted in a 62% decrease in bolting percentage.

Data confirmed that increasing nitrogen amount from 144 kg to 288 kg N ha^{-1} enhanced the percentage of double bulbs. According to **Abdissa et al. (2011)**, splitted bulb development was increased by about 45% when nitrogen fertilization was applied at a rate of 69 kg N ha^{-1}.

The largest mean values for bulb diameter were found in onion plants grown under 288 kg N ha^{-1}. The increased dry matter percentage of onion bulbs was caused by a larger bulb diameter caused by high nitrogen application. More nitrogen is likely responsible for this increase because it enhances the number of leaves by simulating cell division and development. These results are consistent with those of **Nasreen et al. (2007)**, who investigated the significant increase in mean bulb diameter by applying N up to 288 kg N ha^{-1}, as well **as Moursy et al. (2007)**, who demonstrated that increasing the amount of N fertilizer to 80 kg N ha^{-1} caused a rise in the TSS percentage of approximately 8.5% when compared to the level of 40 kg nitrogen per hectare.

Foliar spraying with yeast extract, fulvic acid, amino acids and extract of seaweed significantly increased the values of bulb diameter, TSS and dry matter.

These results were in consistent with that published by **Fawzy et al. (2012-b)**, who concluded that employing yeast at rates of 3 gm/L produced the greatest TSS values when compared to other treatments.

Foliar spraying with natural stimulators appeared the highest mean values of nutrient content criteria in comparison with the control treatment in the two seasons. **Fawzy et al. (2012-b)** reported similar findings, noting that when compared to other treatments, foliar sprays of amino acids at various rates produced the highest values of nitrogen, phosphorus, and potassium content. High nitrogen rates showed the highest mean values of carbohydrate and protein content, whereas, low nitrogen rates showed the lowest mean values in both seasons. These findings partially in coincide with those of **Ali and El-Tokhy (2018)**, who found that hand weeding and mineral nitrogen at the greatest rate (535.71 kg N ha^{-1}) substantially improved the quality of the onion bulb, including its content of crude protein and total carbohydrates.

4. Conclusions

According to the findings, onion plants fertilized with 288 kg N ha^{-1} attained the highest mean values of plant height, leaves No., and plant fresh weight over the 1st and 2nd seasons. Marketable yield t ha^{-1} for onion plant cultivated under 288 kg N ha^{-1} was higher than those under other nitrogen rates of 144 kg N and 216 kg N ha^{-1} in the 1st and 2nd seasons. Spraying with yeast, fulvic acid, amino acids and seaweed extract increased marketable yield ha^{-1} in comparison to control treatment, in the 1st and 2nd seasons. The onions that received nitrogen fertilization at a rate of 288 kg N ha^{-1} and sprayed with amino acids over a period of two seasons produced the maximum marketable yield measured in t ha^{-1}. The highest dry matter percentages were achieved by applying fulvic acid as a spray and fertilizing onion plants with N at a rate of 216 kg N ha^{-1}. While, the highest protein and carbohydrate levels were achieved by spraying seaweed extract and 288 kg N ha^{-1}.

5. References

A.O.A.C. (1975). "Official Methods of Analysis of the Association of Official Agriculture Chemists". Twelfth Ed. published by the Association of Official Agriculture Chemists. Washington, D.C. 832.**29** (2): 184-185.

Abdissa, Y., Tekalign, T. and Pant, L. M. (2011). Growth, bulb yield and quality of onion (*Allium cepa* L.) as influenced by nitrogen and phosphorus fertilization on vertisol. I: growth attributes, biomass production and bulb yield. *Afr. J. of Agric. Res.,* **6** (14), 3252-3258.

Ali, Mohamed A.M. and El-Tokhy, Ahmed I. (2018). Effect of nitrogen and some weed control methods on yield and quality of onion in a newly reclaimed soil. *Egyptian J. Desert Res.,* **68** (1): 117-133.

Anjum, S. A., Wang, L., Farooq, M., Xue L. and Ali, S. (2011). Fulvic acid application improves the maize performance under well-watered and drought conditions. *Journal of Agro. Crop Sci.* **197** (6) 409-417.

Bala, N.; Dey, A., Das, S., Basu R. and Nandy P. (2014). Effect of hydroxyapatite nanorod on chickpea (*Cicer arietinum*) plant growth and its possible use as nano-fertilizer. *Iranian J. of Plant Phys.,* **4**: 1061-1069.

Bekele, M. (2018). Effects of different levels of potassium fertilization on yield, quality and storage life of onion (*Allium cep*a L.) at Jimma, *Southwestern Ethiopia. J Food Sci. Nutr.*;**1** (2):32-39.

Chaliakhyan, M. Kh. (1957). Effect of vitamins on growth and development of plants. DoklyAkad. Nauk. SSSK, **111**: 894-897.

Duncan, D.B. (1955). Multiple Range and Multiple F-test. Biometrics, **11**: 1-24.

El-Hamady, M.M. (2017). Growth and yield of onion (*Allium cepa* L.) as influenced by nitrogen and phosphorus fertilizers levels. *Canadian J. Agric. Crops.,* **2** (1): 34-41.

El-Morsy, Ayatullah E., El-Kassas, A.A.I. and El-Tantawy, E.M. (2016). Onion plant growth and yield as affected by nitrogen, potassium and sulphur combinations under El-arish region conditions. *SINAI Journal of Applied Sciences,* **5** (3): 345-362.

El-Shaikh, K. A. A. (2005). Growth and yield of onion as affected by bio fertilization, application of nitrogen and phosphorus fertilizers under south valley conditions. *Assiut J. Agric. Sci,* **36** (1), 37-50.

Elshaboury, H., and Sakara, H. (2021). The role of garlic and onion extracts in the growth and productivity of onion under soil application of potassium humate and fulvate. *Egyptian Journal of Soil Science,* **61**(2), 187-200.

Etana, M. B., Mohammed, A. and Nebiyu, A. (2019). Effects of Different Level of Nitrogen Fertilizer Application on Growth, Yield, Quality and Storage Life of Onion (*Allium cepa* L.) at Jimma, *Southwestern Ethiopia. J. of Nat. Sci. Res.,* **9** (10): 32-40.

Fales, F. (1951). The assimilation and degradation of carbohydrates by yeast cells. *J. of Biological Chemistry,* **193** (1), 113-124.

FAOSTAT (2023). Food and Agriculture Data. Food and Agriculture Organization of the United Nation.

Farid, I.M., Abbas, M.H., and El-Ghozoli, A. (2023). Wheat Productivity as Influenced by Integrated Mineral, Organic, and Biofertilization. *Egyptian Journal of Soil Science,* **63** (3), 287-299.

Fathy, E.S.L., Farid, S. (1996). The possibility of using vitamin Bs and yeast to delay senescence and improve growth and yield of common beans (*Phaseolus vulgaris* L.). *J. Agric Sci Mansoura Univ.,* **21**(4): 1415-1423.

Fawzy, Z. F., Abou El-magd, M. M., Yunsheng, Li, Ouyang, Zhu and Hoda, A.M. (2012-b). Influence of foliar application by EM “Effective microorganisms”, amino acids and yeast on growth, yield and quality of two cultivars of onion plants under newly reclaimed soil. *J. of Agric. Sci.,* **4** (11): 26-39.

Fawzy, Z.F., El-Shal, Z.S., Yunsheng, L., Zhu, O. and Sawan, O.M. (2012-a). Response of garlic (*Allium Sativum* L.) plants to foliar spraying of some bio-stimulants under sandy soil condition. *Appl Sci Res.,* **8** (2): 770-776.

Gebretsadik, K. (2016). Agronomic and economic evaluation of nitrogen fertilizer rates and intra row spacing on growth and bulb yield of onion (*Allium cepa* L.) under rainfall condition. *Journal of Biology, Agriculture and Healthcare,* **6** (21): 1-10.

Geisseler, D., Ortiz, R. S., Diaz J. (2022). Nitrogen nutrition and fertilization of onions (*Allium cepa* L.) – A literature review. *Scientia Horticulturae,* **291**: 110591.

Gîtina, L., Dinicaˇ, R., Neagu, C., Dumitrascu, L. (2014). Sulfur compounds identification and quantification from Allium spp. fresh leaves. *J. Food Drug Anal.,* **22**: 425-430.

Gutiérrez-Rodríguez, E., Lieth, H.J., Jernstedt, J.A., Labavitch, J.M., Suslow, T.V. and Cantwell, M.I. (2013). Texture, composition and anatomy of spinach leaves in relation to nitrogen fertilization. *J. Sci. Food Agric.,* **93**: 227-237.

Hafez, E. and Geries, L. (2019). Onion (*Allium Cepa* L.) growth, yield and economic return under different combinations of nitrogen fertilizers and agricultural biostimulants. *Acta Scientific Agriculture,* **3** (4): 259-269.

Hegazi, M., Eisa, A., Nofal, E., and El-Ramady, H. (2023). The Effectiveness of Safe NPK Alternatives on the Growth, Productivity, and Essential Oil Content of Fennel Plants under Semi-Arid Saline Soils. *Egyptian Journal of Soil Science,* **63** (4).

Jackson, M.L. (1958). Soil chemical analysis. Prentice Hall Private, Itd, New York.

Jilani, M.S., Ghaffoor, A. Waseem, K. and Farooqi, J.I. (2004). Effect of different levels of nitrogen on growth and yield of three onion varieties. *International J. of Agric. and Biology,* **6** (3):507-510.

Kadam, V. S., Mankar, A. N. and Deshmukh, M. M. (2020). Effect of plant density and fertilizer levels on growth parameter at successive crop growth stages in onion. *Green Farming,* **11** (1):43-46.

Khedr, Z. M. A., and Farid, S. (2002). Response of naturally virus infected tomato plants to yeast extract and phosphoric acid application. *Annals of Agric. Sci. Moshtohor. Egypt,* **38** (2): 927-939.

Kowalczyk K. and Zielony, T. (2008). Effect of aminoplant and asahi on yield and quality of lettuce grown on rockwool. Proc. Conf. of Biostimulators in Modern Agriculture, 7-8 Febuary, Warsaw, Poland.

Lotfi, R., Gharavi, P.M. and Khoshvaghti H. (2015). Physiological responses of Brassica napus to fulvic acid under water stress: Chlorophyll a fluorescence and antioxidant enzyme activity. *The Crop Journal,* (3): 434 - 439.

Lowry, O. H., Rosebrough, N. J., Farr, A. L., and Randall, R. J. (1951). Protein measurement with the Folin phenol reagent. *J. of biological chemistry,* **193**: 265-275.

Mahmoud, S.H., EL-Tanahy, A.M.M., Marzouk, Neama M. and Abou-Hussein, S.D. (2019). Effect of fulvic acid and effective microorganisms (EM) on the vegetative growth and productivity of onion plants. *Current Science International,* **8** (2): 368-377.

Mann, L.K. (1952). Anatomy of garlic bulb and factors affecting bulb development. *Hilgardia,* **21**: 195 - 228.

Messele, B. (2016). Effects of Nitrogen and Phosphorus Rates on Growth, Yield, and Quality of Onion (*Allium cepa* L.) At Menschen Für Menschen Demonstration Site, Harar, Ethiopia Agri Res & Tech: *Open Access J.,* **1** (3): ARTOAJ.MS.ID.55563.

Moursy, M. El., Khalifa, H. E., Attia, M. M., Sayed, M. A. and Osman, A. M. (2007). Effect of organic and nitrogen fertilizers and plant densities on onion production in sandy soils under Drip irrigation system. *Alex. J. Agric. Res.,* **52** (1): 103-108.

Moursy, M.A.M., Emara, E.I.R., Hamid, A.E., Gamal, S., and Hamed, L.M.M. (2019). Response of Allium crops to nitrogen fertilization rates and different irrigation water sources. *Egyptian Journal of Soil Science,* **59** (2): 193-205.

N. R. P. (1977). Nutrient Requirements of Domestic Animals, (Rabbits), No. 17th Rev. Ed., p.16-26. National Academy of Science, Washington, D. C.

Nasreen, S., Haque, M. M., Hossain, M. A. And Farid A. T. M. (2007). Nutrient uptake and yield of onion as influenced by nitrogen and sulphur fertilization. *Bangladesh J. Agric. Res.,* **32** (3): 413-420.

Nawaz, M. Q., Ahmed, K., Hussain, S. S., Rizwan, M., Sarfraz, M., Wainse, G. M. and Jamil, M. (2017). Response of onion to different nitrogen levels and method of transplanting in moderately salt affected soil. *Acta agriculturae Slovenica,* **109** (2): 303 - 313.

Papenfu, H.B., Kulkarni, M.G., Stirk, W.A., Finnie, J.F. and Van Staden, J. (2013). Effect of a commercial seaweed extract (kelpak®) and polyamides on nutrient-deprived (N, P and K) of okra seedlings. *Sci Hortic-Amsterdam,* **151**: 142-146.

Piper, C.S. (1950). Soil and plant analysis. Inter-science Publishers Inc, New York.

Sarhan, M. G., Bashandy, S. (2021). Enhancing Onion Yield, Quality, Storability and Profitability by Using FYM, Copper and Bio-fertilizer. *Egyptian Journal of Soil Science,* **61** (3), 323-335.

Sekara, A., R. Pokluda; L. Del Vacchio; S. Somma and G. Caruso (2017). Interactions among genotype, environment and agronomic practices on production and quality of storage onion (*Allium cepa* L.)-A review. *Hort. Sci.* (Prague), **44**: 201-212.

Snedecor, G. W. and Cochran, W. G. (1967). Statistical methods, 6th edn. Ames. Iowa, USA: Iowa State University Press, 129, 31.

Suleria, H. A. R., Butt, M. S., Anjum, F. M., Saeed, F., and Khalid, N. (2015). Onion: Nature Protection Against Physiological Threats. Critical reviews in food science and nutrition, **55** (1): 50-66.

Wicks, L. and Firminger, H. (1942). Perchloric acid in micro-Kjeldahl digestions. Industrial and Engineering Chemistry Analytical Edition, **14** (9): 760-762.

Yamasaki, A. and Tanaka, K. (2005). Effect of nitrogen on bolting of bunching onion (*Allium fistulosum* L). *Hort. Res. (Japan),* **4** (1): 51-54.