The Future of Horticulture

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Effect of Licorice Extract and Two Different Sources of Potassium on The Yield, Quality and Storability of Onion (*Allium cepa* L).

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DOI: https://doi.org/10.37229/fsa.fjh.2024.06.02

CrossMark

Future Science Association

Available online free at
www.futurejournals.org

Print ISSN: 2692-5826

Online ISSN: 2692-5834

Received: 17 April 2024
Accepted: 20 May 2024
Published: 2 June 2024

Abstract: Two-year studies were carried out at the Mallawi Agriculture Research Station Experimental Farm in Minia Governorate, Egypt, to study the effect of potassium sulphate, feldspar rock inoculated with releasing bacteria (RB) and without potassium fertilizer (control) as soil application and the spraying of four levels (0, 2.5, 5.0 and 10 g/L.) of licorice root extract on the growth, production, quality and storability (evaluated over three storage periods; 0, 3 and 6 months) of *Allium cepa L* (onion) plants, cultivar Giza 6. All the tested treatments improved the onion plant growth and yield comparing to control. Field treatment by licorice extract(LE) at 10 g/L alone or in combination with other treatments had a greater stimulatory effect, as well as the highest contents of nitrogen, phosphorus and protein were found in onion bulbs treated by 5 or 10 g/L. (LE) with no significant differences between the two concentrations. The potassium (K) content in onion plants was significantly greater with feldspar treatment than with potassium sulphate. Results revealed that the length of the storage period has a negative effect on bulbs composition and decreased their quality. However, field treatment by LE at 5 and 10 g/L. alone or combined with other treatments and feldspar inoculated with RB reduced the progressively decreasing trend together with maintaining some better chemical composition and desired properties (The maximum dry matter content (DM) %, nitrate content (No_3), total phenolic compounds (TPC), titratable acidity and the lowest moisture content) of the onion bulbs throughout long-term storage at room temperature.

Key words: Phenols, licorice, feldspar, onion, biochemical composition, potassium.

1. Introduction

Onion (*Allium cepa* L.), which belongs to the Alliaceae family (**Purseglove, 1972**) is a major crop produced and consumed worldwide (**Lee, 2010**). Egyptian onion is known worldwide for its high quality which is related to its high storability and pungency and is one of the income sources of the country (**Ahmed *et al*., 2018**). It is characterized by its nutritional, medicinal and commercial value and contains many vitamins; C, A and K, proteins, thiamine, riboflavin, niacin and ascorbic acid, its medicinal value is due to its content of flavonoids such as cysteine, antioxidant and anti-cancer agents (**Patil *et al*., 1995** and **Malik, 1994**).

Storage of onion bulbs under favorable conditions is very important to maintain their quality and also minimize losses and maintain the quality. The purpose of storage is available during the year and limit losses caused by biotic and environmental factors (FAO, 2003). According to **Sharma *et al*. (2014)**, the storage time extends to 10 weeks under normal conditions for bulbs, whereas growing and environmental conditions are important and can participate in the variations in the storage capacity of the cultivar and over time. However, storage is a multifaceted problem with many factors for the successful preservation of the desirable properties and bioactive compounds for a long-term storage. These factors can be addressed post-harvest and before harvest such as the selection of cultivars and planting practices as irrigation and fertilization which can be control to improve the storability of onion bulbs (**Petropoulos *et al*., 2016**).

Mineral fertilizer is the principal factor that increases the growth and production of onion. Potassium is the most useful element in the nutrition of plants because of its effects on the translocation of photosynthates, protein synthesis, ionic balance, tolerance of stress and water use, the enzymes activity and the management of other processes (**Christian *et al*., 2014**). **Nabi *et al*. (2010)** reported that potassium fertilization is necessary for the storage of onion bulbs and maintain their quality, because the potassium levels,75-100Kg/ha reduce the weight losses and the bulb sprouting compared with less or more potassium. Chemical potassium fertilizers are expensive, increase production costs and cause environmental pollution, so most farmers ignore their use. Public health and environmental safety also promote using the natural products to improve growth, nutrition and food production quality. However, the use of feldspar rock as natural potassium is a cheaper source of potassium and can replace chemical potassium for plant fertilization **(Labib *et al*., 2012)**. In addition, the inoculation of soil with K-solubilizing bacteria and feldspar alone or together enhances the rapid and continuous supply of potassium consequently plant growth, productivity and quality improve (**Abou-el-Seoud, 2012** and **Abdel-Salam and Shams, 2012**). In addition, these bacteria can chelate silicon ions release potassium into solution and dissolve K powder, such as feldspar through plant production and display organic acids in the soil (**Bennett *et al*., 1998; Sheng *et al*., 2003** and **Badr *et al*., 2006**).

On the other hand, the use of medicinal plants as alternative substances for synthetic growth regulators and chemical fertilizers is of interest. The licorice plant is a medicinal plant called *Glycyrrhiza glabra* L., which belongs to the Leguminaseae family. Various studies **(Moses, *et al*., 2002** and **Al-Ajeeli, 2005**) have shown that licorice plant extract contains vitamins, amino acids, a wide range of minerals and others which have similar effects on growth promoters. It also contains mevalonic acid, glycyrrhizin, glycyrrhejel, liquoric acid and flavonoids, e.g. glabridin and glabrin (**Tyler, 1993** and **AL-Marsoumi, 1999**). Licorice root extract has been reported to have antioxidant, antibacterial, antifungal and expectorant activities (**DerMarderosian, 2001)**. **Younes *et al*., (2021)** reported that the use of LE as a biostimulant may be successful strategy for improving productivity bulb quality of onion plants in field conditions. Many studies in the literature (**Al-Khafagy** and **Al-Gebory, 2010** and **Ghaloom and Faraj, 2012**) concluded that licorice root extract significantly increased growth and yield of onion plants. Foliar spraying of licorice extract (5%) significantly increased all growth parameters, crop yield and reduced the incidence of physiological disorders and damage to potatoes (**Ezzat *et al*., 2016**).

On that, the aim of this investigation was to study the possibility of the use feldspar in combination with biofertilizers such as potassium-releasing bacteria and the spraying of licorice root extracts on onion plants under field conditions and their effects on the production and quality of onion and also the changes in the chemical composition of onion during the storage.

2. Materials and methods

2.1. Experimental layout

This study was conducted in two consecutive seasons, 2019/2020 and 2020/2021, at the Agricultural Research Station of the Malawi Agricultural Research Station in Minia Governorate, Egypt, to appreciate the effects of spraying of licorice extract (LE) and soil treatment by two sources of potassium on the growth, yield, composition and storage capacity of onion bulbs.

Soil samples were collected and analyzed for physical and chemical properties (Table 1) according to **Jackson (1967)**.

Table (1). Physical and chemical characteristics of the soil used

Properties	**Physical analysis**				**Mechanical analysis**			**Soluble Cations (meq/L)**	
	Sand (%)	Silt (%)	Clay (%)	Soil texture	Organic matter (%)	pH soil-water suspension ratio (1:2.5)	EC (ds m^{-1})	Ca^{++}	Mg^{++}
2019/ 2020	8.47	54.71	36.82	Silt clay loam	1.60	8.14	1.52	7.25	2.10
2020/ 2021	10.11	49.32	40.57		1.72	8.00	1.59	7.40	2.15
Properties	**Soluble anions (meq/L)**				**Available nutrient**				
	CO_3^-	HCO_3^-	Cl^-	SO_4^{--}	N %	P (ppm)	K (ppm)	Na^+	K^+
2019/ 2020	-	3.18	4.15	5.40	0.19	16	250	3.20	0.18
2020/ 2021	-	3.20	4.10	5.72	0.18	19	270	3.22	0.20

2.2. Experimental design

The onion seedlings cultivar Giza 6 were planted between 5 October and 10 October in the 2019/2020 and 2020/2021 seasons respectively. The unit area was 10.5 m^2 (3.5 m in length and 3.0 m in width) including five ridges with a distance of 50 cm, the seedlings planted on the two sides of ridges at 10 cm distances. The experiment was planned in a split plot, randomized complete block design (RCBD) with three replications. The main plot contained three potassium fertilizers, and the subplots contained four licorice root extract(LE) treatments as follows:

The main plots were:

1: Recommended dose of NPK (200 -150 - 50 kg/fed.)

2: Feldspar + recommended NP dose (200 -150 kg /fed.)

3: No potassium fertilizer + recommended dose of NP (200- 150 kg/fed.)

The subplots:

1: Control (spray with tap water).

2: Spray 2.5 g/L. LE

3: Spray 5 g/L. LE

4: Spray 10 g/L. LE

The soil received the recommended dose of NPK (200 -150-50 kg/fed.). Nitrogen was added as ammonium nitrate (33.5% N), and phosphorus was added as calcium super phosphate (15.5% P_2O_5)

during soil preparation. Potassium fertilizer was added in the form of potassium sulphate (48% k_2o) or feldspar (١٠.٥ % k_2o) at a rate of 24 kg k_2o/fed. for each. Feldspar was delivered by Al Ahram Mining Co., Ltd., Egypt, as natural local potassium powder in a soluble form. Potassium-releasing microscopic organisms, Bacillus circulans (given by biofertilizer unit of Agriculture College, University of Ain Shams), was added at 5X10-1 cfu. to feldspar.The first dose of potassium was applied during soil preparation, and the second one was applied 60 days after onion transplantation. Spraying the plants by licorice extracts three times; once two months after planting (January 10^{th}) and then every three weeks.

2.3. Preparation of licorice root extract

The samples of licorice powder (2.5, 5.0 and 10 g) were soaked separately in a half of liter of water for 24 hours, then dissolved to prepare 2.5, 5.0 and 10 g/L of LE. After the solution was filtered through cheesecloth, it was filtered again through filter No. 2 Whatman filter paper, make up to one liter of distilled water. The phytochemical and mineral proximate compositions of the aqueous LE are shown in Table 2 by **Morsi *et al.* (2008)**.

2.4. Growth and yield attributes

At harvest time, ten plants were chosen randomly for each plot to evaluate the diameter of the onion nick (cm), plant height (cm), diameter of the onion bulb (cm), bulb length (cm), average weight of the onion bulb (g) and onion yield (kg/plot). Additionally, the percentages of total nitrogen (N) according to the method described by **Jackson (1967)**, phosphorus (P) according to **Watanabe** and **Olsen (1965)** and potassium (K) according to **Brown** and **Lilleland (1946)**, were determined in dry matter, and the protein was calculated by multiplying the nitrogen content by 6.25.

Table (2). Chemical composition of Egyptian licorice root extract

Components	Value (mg/ g)	Components	Value (mg/ g)
Lysine	5.8	Proline	15.2
Histidine 19.9	7.6	N	20.2
Phenylalanine	19.8	P	21.3
Methionine 4.20	4.20	K	47.2
Cysteine	21.6	Mg	2.16
Glutamic acid 20.5	20.5	Ca	6.54
Aspartic acid	19.9	Fe	0.04
Threonine	14.3	Zn	0.21
Arginine	1.20	Cu	0.02
Selenium(Se)	7.7(mg/kg)	Sucrose	17.5(g/kg)
Gibberellin	0.62(g/kg)	Glucose	38.4(g/ kg)

mg/ g means milligram per gram dry weight of LRE, and g /kg means gram per gram dry weight of LRE.

2.5. Quality and Storability

Portion of field-treated onion bulbs (27 kg of dry onion bulbs from each treatment) were collected during June of the two cultivation seasons. When the samples were ready for commercial use, they were divided into three replicates (each 3 kg), packed in a plastic mesh bags and stored for 6 months in the laboratory at room temperature (25±5^{0}C). The samples were designed in a factorial scheme (12x3) with twelve treatments and were evaluated three times during the storage period (0, 3,and 6 months).

The average monthly data of temperature (^{0}C) and relative humidity data used as storage conditions are presented in Table 3.

Samples were taken at harvest time and every three months to determine and evaluate the following quality features; total phenolics, nitrate, dry matter and moisture contents, total soluble solids (TSS), pH value and total titratable acidity.

Table (3). Average monthly meteorological data of the Minia weather station in the two growing seasons (2019/2020 and 2020/2021).

Years	2019/2020				2020/2021			
Parameters	Temperature (^{0}C)		Relative humidity	Wind speed (km/h)	Temperature (^{0}C)		Relative humidity	Wind speed (km/h)
Months	Max	Min			Max	Min		
April	29.2	11.8	51.5	4.1	30.2	12.3	52.5	4.0
May	37.3	17.5	36.4	4.1	38.1	17.9	39.2	4.2
June	38.0	22.0	40.8	4.6	40.2	22.9	45.2	5.2
July	37.1	22.3	50.6	4.2	39.5	23.2	51.8	4.6
August.	37.3	22.0	52.2	3.5	40.6	25.1	50.2	4.1
September	34.4	20.4	59.7	4.3	36.4	21.4	53.7	4.8
October	32.8	17.1	60.5	3.3	23.1	18.3	57.2	4.0
November	28.1	12.2	69.8	2.5	29.2	14.2	59.2	3.3
December	21.8	7.00	76.3	2.4	22.1	7.00	77.3	2.9

2.5.1. Extraction of phenolic compounds

The samples were extracted in triplicate, on the basis of the method previously reported by **Bonaccorsi *et al*. (2005)**, but with a few small adjustments. One gram or so of onion powder were used. The mixture was kept at 4^{0}C for entire night in 75% ethanol (20 mL). After the supernatant was removed, the residue was combined with 20 millilitrs of 75% ethanol once more and agitated for an hour via a magnetic stirrer. The slurry was subsequently centrifuged for 20 minutes at 4^{0}C at 10,000 rpm. After the supernatant was removed fresh 75% ethanol was combined with the residual powder. There were two centrifugation cycles. On a rotating evaporator set at 45 ^{0}C, the combined ethanol fractions were evaporated to about 8 milliliters, and then ten milliliters of 75% ethanol were added and stored at 20°C.

2.5.2. Analysis of total phenolic content (TPC)

The total phenolics analyzed by spectrophotometrically at 765 nm via the Folin-Ciocalteu colorimetric method described by **Dalamu *et al.* (2010)**.

2.5.3. Determination of nitrate content

The nitrate content in onion powder was determined via a rapid colorimetric method at 410 nm using a Spectronic 20D (**Cataldo *et al*., 1975**).

2.5.4. Determination of dry matter

The dry matter (%) was determined in triplicate for each treatment. Samples about 35 g pieces were kept in an oven initially at 80°C with air circulation for 24 h and then at 105°C for two hours (**AOAC, 2007)**.

2.5.5. Total soluble solids (TSS)

Bulb tissue (20 g) was homogenized in a blender and centrifuged for 20 min at 4000 rpm. The supernatant was analyzed for total soluble solids at 20^{0}C with a hand refractometer and expressed as ^{0}Brix. **(AOAC, 2007)**.

2.5.6. Moisture content

Weighed 10 gram of fleshy scales of onion bulb and placed in a glass container and placed it in an oven up to 60^{o}C for 24 hours. Then the dried samples were weighed when they reached to the room temperature).

2.5.7. pH value

The pH was measured by the pH meter.

2.5.8. Titratable acidity

Titratable acidity of the bulb juice was determined by titrating the sample with a 0.01 M standard sodium hydroxide (NaOH) solution to the visual endpoint. The characteristics of juice were subsequently determined **(AOAC, 2007).** Titratable acidity of the juice was measured by the next formula

$$\text{Titratable acidity (TA)} = \frac{\text{ml of NaOH consumed} \times \text{Acid factor}}{\text{ml of juice consumed}} \times 100$$

2.6. Statistical analysis

Data from the field experiments were collected and analyzed via the analysis of variance (ANOVA) in a split plot design via MSTATC, at LSD test at 5% according to Gomez and Gomez (1984). The data of storability were collected and subjected to analysis of variance (ANOVA) as a factorial analysis, with three replicates for each treatment using the computer software program STATISTIX version 8.1, followed by LSD test at 5% (**Steel *et al*., 1997**).

3. Results and Discussion

3.1. Growth and yield attributes

The results in Tables (4,5 and 6) showed that the addition of feldspar rock and /or the spraying with licorice extract treatments significantly increased all the studied traits (plant height, neck diameter, bulb diameter, bulb length and yield of onion kg/plot) in control treatment compared with the mineral potassium sulphate, which had a positive effect with the difference in order. The interactions between the tested treatments showed differences on the most of studied traits. The treated soil with potassium sulphate and spraying with 10 g/L. LE together, gave the most elevated development characters and yield (42.70 and 42.80 kg/plot in both seasons individually), taken after by the treated with feldspar+RB interacted with 10 g/L. LE (Table 6).

Treatment with feldspar has better effects on many physiological processes such as photosynthesis, respiratory and contributes to the processes of phosphorylation, electronic transport and ATP formation, as well as encourages cell division and tissue growth (**Taha, 2001**). Some microorganisms in soil environment have enzymes that work similarly to chitinase and cellulases; that is, they specialize in breaking down minerals and extracting the elements necessary for metabolic processes structures, (**Barker *et al.*,1997**). And also this increase may be due to the extract's role. Since the extract contains many terpene compounds, it acts similarly to gibberellins, stimulating vegetative growth of plants by promoting dormant buds, thus increasing cell elongation and division by acting like gibberellins, this result is consistent with reported by **Al-Khafaji, (2010)** which is in agreement with the findings of **Al-Jawary, (2002), Al-Abdali (2002)** and **Shafeek *et al*. (2015)** they reported that foliar application of licorice, yeast and seaweed extracts with each other had the greatest stimulatory effect on onion plant growth characteristic, total bulb yield and its components compared with those of the control and other treatments. **Younes *et al*. (2021)** reported that compared with the corresponding LRE-devoid control plants, both onion cultivars pre-treatments with LRE presented growth indices and yield-related features. The water extract of *G. glabra* that are absorbed by the leaves during spraying is similar to that of the gibberellin in stimulating flowering because it contains the mevalonic acid compound and sugary compounds which improves vegetative growth by stimulating the enzymes necessary to convert complex compounds into simpler compounds, and by using them to produce the energy necessary for the plant's growth. (**Almarsumi, 1999** and **Al-Sahhaf and Al-Marsoumi, 2001)**.

Table (4). Effects of soil application of two sources of potassium and spraying licorice extract at different concentrations on the plant height (cm) and diameter of necks (cm) of *Allium cepa* during the two seasons, 2019/2020 and 2020/2021

Characters	Plant height (cm)								Diameter of necks (cm)							
seasons	1st				2nd				1st				2nd			
Treat. (B) Treat. (A)	NPK	F+NP	NP	Mean	NPK	F+ NP	NP	Mean	NPK	F+NP	NP	Mean	NPK	F+ NP	NP	Mean
0.0 g/L. (LE)	٣٧,٢٠	٣٧,٨٠	٣٢,٧٤	٣٥,٩١	37.57	37.93	33.30	٣٦,٢٧	0.87	0.86	0.77	٠,٨١	0.89	0.90	0.77	٠,٨٥
2.5 g/L. (LE)	٥٢,٤٤	٥٠,٥٧	٤٣,٣٣	٤٨,٧٨	53.00	51.67	44.07	٤٩,٥٨	1.25	1.21	1.18	١,٢١	1.29	1.23	1.21	١,٢٤
5.0 g/L. (LE)	٥٣,٩٣	٥٣,٣٠	٤٤,٢٠	٥٠,٤٨	55.27	53.84	44.53	٥١,٢١	1.32	1.31	1.27	١,٣٠	1.32	1.33	1.31	١,٣٢
10 g/L. (LE)	٦٢,٢١	٥٧,٢٣	٤٦,٢٠	٥٥,٢١	64.43	57.57	46.67	٥٦,٢٢	1.41	1.38	1.30	١,٣٧	1.44	1.39	1.32	١,٣٨
Mean	51.45	49.73	41.62		52.57	50.25	42.14		1.21	1.19	1.13		1.23	1.21	1.15	
LSD 5%	A = 1.97 B = ٠,٩٦ A*B = ١,٦٦				1.50 ٠,٩٤ ١,٦٢				0.05 0.3 0.08				٠,٠٥ ٠,١٥ 0.08			

N: nitrogen, P: phosphorus, K: potassium, F: feldspar and LE : licorice extract, comparison of significance of differences among treatments at $p \leq 0.05$ level via L.S.D test

Table (5). Effect of soil application of two sources of potassium and spraying licorice extract at different concentrations on the diameter and length of bulb (cm) of *Allium cepa* during the two seasons, 2019/2020 and2020/2021

Characters	Diameter of bulb (cm)								Length of bulb (cm)							
seasons	1st				2nd				1st				2nd			
Treat. (B) Treat. (A)	NPK	F+NP	NP	Mean	NPK	F+ NP	NP	Mean	NPK	F+NP	NP	Mean	NPK	F+ NP	NP	Mean
0.0 g/L. (LE)	4.10	4.02	4.05	٤,٠٦	4.14	4.07	4.06	٤,٠٩	5.14	5.08	5.03	٥,١١	5.19	5.09	5.03	٥,١١
2.5 g/L. (LE)	5.74	5.73	5.13	٥,٥٣	5.85	5.76	5.17	٥,٦٠	6.99	6.91	6.06	٦,٦٥	6.91	6.92	6.09	٦,٦٤
5.0 g/L. (LE)	5.98	5.58	5.14	٥,٥٧	6.06	5.60	5.16	٥,٦١	7.21	7.09	6.91	٧,٠٧	7.24	7.14	6.96	٧,١١
10 g/L. (LE)	6.85	6.77	6.17	٦,٦٠	6.88	6.82	6.18	٦,٦٣	8.07	8.01	7.97	٨,٠٢	8.12	8.10	8.00	٨,٠٧
Means	5.67	5.52	5.12		5.73	5.57	5.14		6.85	6.77	6.50		6.86	6.81	6.52	
LSD 5%	A: 0.25 B: ٠,١٧ A*B: 0.30				0.20 ٠,١٤ 0.24				0.05 ٠,٠٦ 0.10				0.08 ٠,٠٦ 0.12			

N: nitrogen, P: phosphorus, K: potassium, F: feldspar and LE : licorice extract, comparison of significance of differences among treatments at $p \leq 0.05$ level via L.S.D test

Table 6. Effect of soil application of two sources of potassium and spraying licorice extract at different concentrations on the yield of *Allium cepa* during the two seasons, 2019/2020 and 2020/2021

Characters	**Weight of bulb (g)**								**Yield (Kg / plot)**							
seasons	**1st**				**2nd**				**1st**				**2nd**			
Treat. (B) **Treat. (A)**	**NPK**	**F+NP**	**NP**	**Mean**	**NPK**	**F+NP**	**NP**	**Mean**	**NPK**	**F+NP**	**NP**	**Mean**	**NPK**	**F+NP**	**NP**	**Mean**
0.0 g/L. (LE)	99.3	95.7	93.3	٩٦,١	101.0	96.0	94.0	٩٧,٠	34.75	33.5	32.65	33.63	35.35	33.60	32.90	33.95
2.5 g/L. (LE)	118.0	116.0	113.0	.١١٥7	119.0	116.7	113.3	١١٦,٣	41.30	40.6	39.55	40.48	41.65	40.85	39.65	40.73
5.0 g/L. (LE)	119.3	118.3	114.3	١١٧,٣	119.7	118.7	115.0	.١١٧8	41.75	41.4	40.00	41.05	41.70	41.55	40.25	41.18
10 g/L. (LE)	122.0	119.7	114.7	.١١٨8	122.3	120.0	115.3	١١٩,٢	42.70	41.9	40.15	41.58	42.80	42.00	40.35	41.73
Mean	114.67	112.4	108.8		115.5	112.8	109.4		40.13	39.35	38.1		40.13	39.5	38.3	
LSD 5%	A: 1.83 B: ٢,٥٣ A*B: 4.38				1.57 ٢,٠١ 3.48				0.13 ٠,١٨ 0.31				0.11 ٠,١٤ 0.34			

N: nitrogen, P: phosphorus, K: potassium, F: feldspar and LE : licorice extract, comparison of significance of differences among treatments at $p \leq 0.05$ level via L.S.D test

3.2. Nitrogen(N), phosphorus (P), potassium(K) and protein contents

The results in Table 7 and 8, revealed that, compared with the control treatment, all the tested treatments significantly increased the N, K and protein contents in onion bulbs during the two cultivation seasons. In terms of the nitrogen (N) and the protein content in onion bulbs, licorice extract at10 gm/L. and feldspar inoculated with k-releasing bacteria (RB) had the highest values in both seasons. However, the potassium (K) content in onion bulbs was significantly greater with the feldspar inoculated with RB than with the potassium sulphate and the other treatments. In addition, the potassium content increased significantly with increasing licorice extract concentrations. The greatest N, P and protein % (2.68, 0.500 and 16.23 sequentially) were recognized in onion bulbs treated with 10 g/L (LE) alone, after that the onion plants treated with 10 g/L (LE) combined with feldspar +RB. The raised potassium rate was found in onion bulbs treated by10 g/L (LE) after that, treated by 5 g/L (LE) when they combined with feldspar +RB (Table 7). These results are in line with the findings of **Awatef *et al.* (2015) and Ahmed *et al*. (2018)** who reported that potassium fertilizers increased the potassium content in onion plants. when feldspar plus SDB was applied, the total uptake of potassium was greater followed by potassium sulphate fertilizer, and this indicates that the major amount of the K in the feldspar minerals and in the organic materials is available for uptake and contributed to the crops nutrients (**Badr *et al*., 2006**). **EL-Shabrawy *et al.* (2019)** reported that inoculation of potato plants with silicate-lysing bacteria increased nutrient (N, P or K) uptake in the case of the application of K-bearing rock (feldspar). However, foliar application of LE treatment increased the percentage of nitrogen, and protein in bulb tissues in both seasons compared to the control and other foliar applications (**Shafeek *et al*., 2015 and Younes *et al*., 2021**).The beneficial effects (stimulation and antioxidant protective effects) of LE on the composition of onion bulbs may be due to its contents of minerals, (Mg, Fe, Ca and K) and natural antioxidants, e.g., total phenols, flavonoids, tannins, saponins and carotenoids (**Morsi *et al*., 2008**).

3.3. Quality and Storability

3.3.1. The total phenolic compounds (TPC)

Total phenol (TP) content is a physiological parameter that reflects the health condition of onion plants. The effects of potassium sources interacted with licorice extract field treatments on the TP contents of bulbs through six months of storage were studied (Table 9). All the treatments and storage times significantly affected ($p \leq 0.05$) on the TPC in both cultivated seasons. The greater content of TPCs was detected in the zero month, after which a significant decrease was recorded up to the 6th month under the control treatment (Without potassium + 0 g/L.(LE). While the mean values of TPC have a significantly and gradually decreased up to the six month, prolonged decreases in the TPC may be as a result of increasing respiration. In this respect, **Ezzat *et al.* (2016)** reported that the interaction of phenolic compounds and polyphenol oxidase is activated in the case of the control treatment because of the oxidative stress that occurred in the field. **Downes *et al*. (2009)** reported notable changes in the TPC of stored onions for 32 weeks, under controlled conditions indicating that dormancy break and/or sprouting could be the controlling factors of TPC due to their role in the oxidative stress, signaling, and also dormancy. Similarly, **Ren (2019)** demonstrated that the TPC of onions is highly influenced by many factors such as agronomy, temperature and storage time. In terms of the tested treatments, the statistical analysis of the obtained data revealed differences across the different treatments. The highest values of TP content were observed in the onion plants treated with potassium sulphate combined with 10g/L LE, followed by potassium sulphate combined with 5g/L LE throughout the long-term storage during the two studied seasons. The effect of LE may be due to its growth promoter content. The highest TPC was observed in GA (growth regulator) treatment at the later storage period (8th and 9th months), thus indicating the potential contribution of the growth regulators in reducing storage crop losses (**Wakchaure *et al*., 2023).** Significant variation was also observed which we attributed to altered regulation of phenolic synthesis at different storage times, this may be due to higher sprouting and decay of the bulb possibly due to the differences in meteorological conditions. (**Benkeblia *et al*., 2000**). **Younes *et al.* (2021)** suggested that onions pre-treated with LRE absorb antioxidants (phenols and flavonoids) contained in LRE which leads to increase their endogenous levels and improve the nutritional and antioxidant properties of onions.

Table (7). Effect of soil application of potassium fertilizers and spraying licorice extract at different concentrations and their interactions on the potassium (K) and phosphorus (P) contents of *Allium cepa L* at harvest time during the two cultivation seasons of 2019/2020 and 2020/2021

Characters	K %								P%							
Seasons	1st				2nd				1st				2nd			
Treat. (B) Treat. (A)	NPK (Re.)	F+ NP	NP	Mean	NPK	F+ NP	NP	Mean	NPK	F+NP	NP	Mean	NPK	F+ NP	NP	Mean
0.0 g/L. (LE)	1.81	2.73	0.55	1.69	1.83	2.74	0.56	1.71	0.310	0.433	0.353	0.366	0.320	0.450	0.363	0.378
2.5 g/L. (LE)	0.99	1.93	0.71	1.21	1.02	1.96	0.72	1.23	0.327	0.460	0.413	0.400	0.340	0.463	0.420	0.408
5.0 g/L. (LE)	1.85	2.86	0.75	1.82	1.86	2.87	0.77	1.83	0.403	0.457	0.393	0.418	0.420	0.460	0.400	0.427
10 g/L. (LE)	1.96	2.94	0.82	1.91	1.97	2.95	0.82	1.91	0.407	0.297	0.493	0.399	0.417	0.303	0.500	0.407
Mean	1.67	2.62	0.71		1.67	2.63	0.72		0.362	0.412	0.413	-	0.374	0.419	0.421	-
LSD 5%	A: 0.035 B: 0.025 A*B: 0.051				0.014 0.010 0.021				0.017 0.015 0.028				0.028 0.013 0.023			

N: nitrogen, P: phosphorus, K: potassium, Re: Recommended, F: feldspar and LE: licorice extract, comparison of significance of differences among treatments at $p \leq 0.05$ level via L.S.D test

Table (8). Effect of soil application of potassium fertilizers and spraying licorice extract at different concentrations and their interactions on the nitrogen (N) and protein contents of *Allium cepa* L at harvest time during the two cultivation seasons of 2019/2020 and 2020/2021

Characters	N %								Protein%							
Seasons	1st				2nd				1st				2nd			
Treat. (B) Treat. (A)	NPK	F+ NP	NP	Mean	NPK	F+ NP	NP	Mean	NPK	F+ NP	NP	Mean	NPK	F+ NP	NP	Mean
0.0 g/L. (LE)	2.33	1.79	1.59	1.90	2.35	1.81	1.58	1.91	14.54	11.19	10.13	11.95	14.69	11.31	9.86	11.95
2.5 g/L. (LE)	2.39	2.40	1.72	2.17	2.38	2.41	1.74	2.18	14.93	14.98	10.75	13.55	14.88	15.06	10.88	13.61
5.0 g/L. (LE)	2.43	2.27	2.09	2.26	2.44	2.28	2.13	2.28	15.12	14.12	13.12	14.12	15.27	14.25	13.33	14.28
10 g/L. (LE)	1.76	2.48	2.68	2.31	1.77	2.48	2.59	2.28	10.95	15.12	16.23	14.10	11.08	15.52	16.23	14.28
Mean	2.23	2.24	2.02	-	2.24	2.25	2.01	-	13.89	13.85	12.56		13.98	14.04	12.57	
LSD 5%	A: 0.034 B: 0.046 A*B: 0.076				0.031 0.024 0.047				0.26 0.23 0.43				0.17 0.14 0.27			

N: nitrogen, P: phosphorus, K: potassium, F: feldspar and LE: licorice extract comparison of significance of differences among treatments at $p \leq 0.05$ level via L.S.D test

Table (9). Effect of soil application with mineral potassium, feldspar and spraying licorice extract on the total phenolic content of onion during the storage period (0,3 and 6 months) at room temperature during the two seasons of 2019/2020 and 2020 /2021

Characters	TPC							
Seasons	1st				2nd			
Treatments (B) Storage time(months) (A)	0	3	6	Mean	0	3	6	Mean
Potassium sulphate + 0 g/L. (LE)	83.13	92.82	69.29	81.75	82.75	93.12	68.92	81.75
Potassium sulphate+ 2.5 g/L. (LE)	98.52	72.35	95.44S	88.77	98.46	72.29	95.36	88.77
Potassium sulphate + 5 g/L. (LE)	252.87	233.37	226.07	237.44	252.59	233.75	226.12	237.44
Potassium sulphate +10 g/L. (LE)	219.25	240.87	259.21	239.78	218.92	241.15	258.85	239.78
Feldspar + RB + 0 g/L. (LE)	100.90	116.73	69.11	95.58	101.52	117.23	69.39	95.58
Feldspar + RB + 2.5 g/L. (LE)	94.28	75.11	88.44	85.95	93.89	74.75	88.55	85.95
Feldspar + RB + 5 g/L. (LE)	115.41	102.50	104.08	107.33	115.79	102.89	104.12	107.33
Feldspar + RB +10 g/L. (LE)	122.77	114.35	105.78	114.30	122.69	114.29	106.02	114.30
Without potassium + 0 g/L.(LE)	131.97	102.99	91.36	108.77	131.74	103.11	91.64	108.77
Without potassium +2.5 g/L.(LE)	118.81	114.79	97.25	110.28	118.72	115.05	97.19	110.28
Without potassium +5 g/L. (LE)	149.11	166.13	115.23	143.49	148.72	165.75	114.85	143.49
Without potassium +10 g/L. (LE)	153.46	102.14	122.23	125.94	153.42	101.75	121.85	125.94
Mean	136.71	127.85	120.29	-	136.60	127.93	120.24	-
LSD 5%	A = 0.52 B = 1.45 A*B = 2.98				0.49 1.39 2.86			

LE: licorice extract and RB: releasing bacteria. comparison of significance of differences among treatments at $p \leq 0.05$ level via L.S.D test

3.3.2. Nitrate content(No_3)

The nitrate (No_3) content of the onion bulb decreased almost linearly through the storage period at room temperature. The nitrate content decreased from 30.96 and 31.09 (zero month) to 12.73 and 13.14 mg/100 g dry weight (6th month) during the two seasons throughout the storage period in the control treatment (without potassium+0 g/L licorice extract). The mean values of No_3 content have the same trend of control (tended to decrease) throughout the same storage period (Table 10). The decrease in nitrate content during storage may be due to the conversion of nitrate and nitrogenous compounds to nitrites (**Ezeagu, 1996**). Nitrate is a natural constituent of plant material. Although nitrate is apparently nontoxic below maximum residue levels (MRLs), it may be endogenously reduced to nitrite which is a toxic compound (**Santamaria, 2006** and **Yordanov *et al.*, 2001**). Nitrate concentration in vegetables depends on factors such as the temperature, humidity, harvest time, storage time and others (**Tamme *et al.*, 2006)**. The nitrate content (No_3) of onion plants during storage tested time was affected by the tested treatments. The highest No_3 content was recorded in the plants treated with 10 g/L.(LE) alone, followed by the plants treated with potassium sulphate +10 g/L.(LE) in the first and second periods of storage. After six months, all of the tested treatments significantly increased the nitrate content compared with that of the control. The highest No3 content was recorded in the onion plants treated with potassium sulphate combined with 10 g/L licorice extract. Fertilization and light intensity were determined as factors affecting nitrate content in vegetables (**Gruda, 2005**).

Table (10). Effects of soil application by mineral potassium, feldspar and licorice extract spraying on the content of nitrates (mg100 g−1 d.w.) in onion stored at room temperature during the two cultivation seasons 2019/2020 and 2020/2021

Characters	No3 (mg100 g−1 d.w.)							
Seasons	1st				2nd			
Treatments(B) Storagetime (months) (A)	0	3	6	Mean	0	3	6	Mean
Potassium sulphate + 0 g/L. (LE)	37.47	30.28	14.08	27.28	38.00	30.63	15.21	27.95
Potassium sulphate+ 2.5 g/L.(LE)	60.61	41.81	20.94	41.12	61.62	42.81	20.66	41.69
Potassium sulphate + 5 g/L. (LE)	71.28	40.93	31.71	47.97	71.75	40.91	31.95	48.20
Potassium sulphate +10 g/L. (LE)	100.18	63.92	43.33	69.14	101.03	63.75	43.96	69.58
Feldspar + RB + 0 g/L. (LE)	46.71	44.23	37.20	42.71	47.88	44.96	37.97	43.61
Feldspar + RB + 2.5 g/L. (LE)	40.63	41.09	34.16	38.63	41.00	41.97	34.96	39.31
Feldspar + RB + 5 g/L. (LE)	40.70	44.43	29.86	38.33	41.19	44.94	30.15	38.76
Feldspar + RB +10 g/L. (LE)	50.88	47.20	27.88	41.99	51.97	47.93	28.57	42.82
Without potassium + 0 g/L.(LE)	30.96	24.27	12.73	22.65	31.09	24.96	13.14	23.06
Without potassium +2.5 g/L.(LE)	77.72	37.12	26.33	47.06	78.32	37.98	27.15	47.82
Without potassium +5 g/L. (LE)	86.58	46.74	41.78	58.36	86.97	48.14	42.13	59.08
Without potassium +10 g/L. (LE)	129.75	84.20	25.40	79.79	129.02	87.50	25.94	80.82
Mean	64.46	45.52	28.78		64.99	46.37	29.32	
LSD5%	A = 0.020 B = 0.058 A*B = 0.118				0.187 0.528 1.08			

LE: licorice extract and RB: releasing bacteria. comparison of significance of differences among treatments at $p \leq 0.05$ level via L.S.D test

3.3.3. Dry matter content (DM%)

In our study, the dry matter (DM) content differed significantly with respect to the storage time and all the tested treatments (Table 11). The results revealed that the DM content in the control treatment significantly decreased at the 3rd month of storage, after which it increased during the last 6th month of storage period. The data of the mean values showed the same trend as the control during the six months which could be attributed to physiological changes resulting from the higher rate of moisture loss in onion bulbs produced under high and low stress conditions (temperature and humidity). An average humidity of 65% - 70% is known to preserve onion bulb weight better than lower or higher humidity (**Brewster, 2008**). **Sharma *et al.* (2014)** reported that the storage period caused one third of the organic matter in the onion to be degraded, because the organic matter became a volatile compound at 10 weeks which was coincided with the dormancy, and then the decrease in the DM content ended before sprouting process at week 18. **Tariq *et al.* (2005)** reported that the high percentage of components in dry matter are sugars and are consumed by respiration process. Additionally high storage temperatures significantly increase sprouting, decay and weight loss (**Krawiec, 2002; Ko Sweesuak *et al*., 2002** and **Ren, 2019**).The dry matter content of stored onion plants was affected by the growing condition, where the tested treatments; 10 gm/L licorice extract combined with feldspar or potassium sulphate led to increase the dry matter % of onion bulbs (13.31 and 13.28 mg/100 g d.w. in 6th month) followed by 5 gm/L licorice extract combined with potassium sulphate compared to the control (11.63 and 10.85 mg/100g) in both seasons, confirming the role of feldspar plus k-releasing bacteria and licorice extract in protecting the storage quality of onion. **Shafeek *et al.* (2015)** reported that foliar spraying of LEs improved onion bulb contents in terms of the dry matter %, compared with those of the other treatments. In contrast, **Chope *et al.* (2007) and Chope *et al*. (2012)** reported that the DM content was not affected by storage but was affected mostly by growing conditions, and that the loss in DM content has been reported as a combination of energy storage and water loss.

Table (11). Effects of soil application with mineral potassium, feldspar and spraying licorice extract on the dry matter content as a percentage of onion storage at room temperature during the two seasons of 2019/2020 and 2020/2021

Characters	**Dry matter content %**							
Seasons	**1st**				**2nd**			
Treatments(B) Storage time (months) (A)	**0**	**3**	**6**	**Mean**	**0**	**3**	**6**	**Mean**
Potassium sulphate + 0 g/L. (LE)	12.66	10.16	10.87	11.22	12.63	10.13	10.78	11.18
Potassium sulphate+ 2.5 g/L. (LE)	13.32	10.57	12.57	12.15	13.28	10.53	12.58	12.13
Potassium sulphate + 5 g/L. (LE)	12.71	10.61	13.77	12.36	12.67	10.60	13.73	12.34
Potassium sulphate +10 g/L. (LE)	14.64	14.03	10.29	12.98	14.59	14.04	10.29	12.97
Feldspar + RB + 0 g/L. (LE)	12.27	10.27	11.70	11.41	12.24	10.24	11.68	11.39
Feldspar + RB + 2.5 g/L. (LE)	11.98	10.49	11.67	11.38	11.94	10.46	11.64	11.35
Feldspar + RB + 5 g/L. (LE)	12.17	10.47	11.32	11.32	12.12	10.47	11.27	11.29
Feldspar + RB +10 g/L. (LE)	14.22	12.94	13.31	13.49	14.18	12.89	13.28	13.45
Without potassium + 0 g/L.(LE)	11.27	9.70	11.63	10.8	11.25	9.64	11.65	10.85
Without potassium +2.5 g/L.(LE)	12.77	10.76	11.46	11.66	12.57	10.73	11.47	11.65
Without potassium +5 g/L. (LE)	12.59	9.27	11.42	11.09	12.60	9.23	11.39	11.06
Without potassium +10 g/L. (LE)	13.38	10.93	11.87	12.06	13.34	10.90	11.84	12.03
Mean	12.83	10.85	11.82		12.78	10.82	11.80	
LSD 5%	A = 0.013 B = 0.025 A*B = 0.043				0.027 0.053 0.046			

LE: licorice extract and RB: releasing bacteria comparison of significance of differences among treatments at $p \leq 0.05$ level via L.S.D test

3.3.4. Total soluble solids (TSS) percentage

The results in Table 12, show the effects of the storage time and the tested treatments on the soluble solids content (TSS) of onion bulbs in the two seasons. In the control treatment the TSS increased from the 0 month to the 3rd month of storage followed by a decrease at the 6th month during the two seasons. While The mean values of total soluble solids increased gradually over the three storage periods. The increase in the percentage of TSS may be due to the decrease in fruit moisture with long storage time, the lower moisture content increases the cell juice concentration resulted in increases the percentage of soluble solids (**Buroton, 1982**). In addition, soluble solids are also used as a substrate source in respiration, and the respiratory rate is closely related to temperature, which explains why higher temperatures result in a greater reduction in soluble solids (**Moretti, 2007**). In terms of the effect of field treatments on the total soluble solid content, the results revealed that the greater TSS content and significant differences were recorded among all the tested treatments than that of untreated plants in the 6th month of storage period within the two seasons. The greater TSS content was detected in plants treated with 10 gm/L (LE) combined with feldspar (13.53% and 13.40% in both seasons) followed by the with the potassium sulfate compared to the control (9.38 and 9.25% in both seasons) in the later period of storage (6th month).When the onion plants treated by potash subestance the total soluble solids content within the bulbs was increased comparing to the control and other treatments (**Demiral and Koseoglu, 2005)** .The higher the solids substance means the higher in dry matter content, in this manner the onion plant are superior protected (**Mallor, 2008)**. These results are steady with the comes about of **Hemat *et al*., (2022)** who reported that Spraying licorice root extract on fruit resulted in greater total soluble solids than did not spraying fruits. GA is effective in increasing TSS content of onion bulb during storage. In contrast, significantly reduce in TSS in the last three storage months because of higher root elongation and bulb sprouting, even at a lower level than control (**Wakchaure *et al*., 2023). Dhia *et al*., (2017)** reported that compared with untreated fruits, fruits treated with *G. glabra* extract at of 4 g/L and 2 g/L concentrations showed the lowest percentages of decay and the highest total soluble solids.

Table (12). Effect of soil application with mineral potassium, feldspar and spraying licorice extract on the total soluble solids percentage of onion stored at room temperature during the two seasons of 2019-2020 and 2020-2021

Characters	**Total soluble solids (TSS)%**							
Seasons	**1st**				**2nd**			
Treatments(B) **Storage time (months) (A)**	**0**	**3**	**6**	**Mean**	**0**	**3**	**6**	**Mean**
Potassium sulphate + 0 g/L. (LE)	8.32	8.72	9.03	8.69	8.25	8.65	9.00	8.63
Potassium sulphate+ 2.5 g/L. (LE)	7.92	9.50	11.07	9.49	7.95	9.40	10.45	9.27
Potassium sulphate + 5 g/L. (LE)	7.93	9.40	11.78	9.70	7.93	9.35	11.70	9.66
Potassium sulphate +10 g/L. (LE)	8.50	11.35	12.25	10.72	8.55	11.35	12.25	10.72
Feldspar + RB + 0 g/L. (LE)	7.75	10.47	10.75	9.66	7.72	10.40	10.75	9.62
Feldspar + RB + 2.5 g/L. (LE)	7.45	10.20	10.40	9.35	7.40	10.15	10.40	9.32
Feldspar + RB + 5 g/L. (LE)	8.98	9.77	10.10	9.62	8.90	9.60	10.05	9.52
Feldspar + RB +10 g/L. (LE)	8.85	8.78	13.53	10.39	8.84	8.70	13.40	10.31
Without potassium + 0 g/L.(LE)	7.55	11.78	9.38	9.57	7.55	11.45	9.25	9.42
Without potassium +2.5 g/L.(LE)	7.40	9.95	8.59	8.65	7.40	9.95	8.60	8.65
Without potassium +5 g/L. (LE)	9.50	10.70	9.93	10.04	9.40	10.40	9.90	9.90
Without potassium +10 g/L. (LE)	8.32	10.21	10.80	9.77	8.30	10.20	10.75	9.75
Mean	8.21	10.07	10.64		8.18	9.97	10.54	-
LSD5%	A =0.097 B 0.274 A*B = 0.562				0.069 0.195 0.400			

LE: licorice extract and RB: releasing bacteria. comparison of significance of differences among treatments at $p \leq 0.05$ level via L.S.D test

3.3.5. Moisture %

The data (Table 13) revealed that the value of moisture content of onion bulbs tended to decrease from zero month to 3rd month then significantly increased during the last storage period (six month). The highest moisture percentage may be due to low temperature and high relative humidity which reduce the transpiration and respiration (**Hatem *et al.*, 2014).** In terms of the tested treatments, the results showed that the most of our treatments significantly decreased the moisture content of onion bulbs compared with that of untreated plants (control). During this study. The lowest moisture content in bulbs were found in bulb treated with feldspar and LE at 5 g/L (85.38, 86.04 and 85.95 and 86.61 % at 3rd and 6th months of storage in the two seasons, respectively) followed by LE at 2.5 g/L alone. **Nabi *et al.* (2010)** reported that a relatively high moisture content in bulbs was recorded in the control, whereas relatively low moisture content in bulbs was recorded at 100 kg K2O/ha, then at 50 and 75 kg K2O/ha, respectively, and the use of sulphate of potash can reduce the relatively moisture in onion plant.

Table (13). Effect of soil application with mineral potassium, feldspar and spraying licorice extract on the moisture percentage of onion stored at room temperature during the two seasons 2019-2020 and 2020-2021

Characters	Moisture %							
Seasons	1st				2nd			
Treatments(B) Storagetime (months) (A)	0	3	6	Mean	0	3	6	Mean
Potassium sulphate + 0 g/L. (LE)	88.46	87.29	89.26	88.33	89.12	87.95	89.92	88.99
Potassium sulphate+ 2.5 g/L. (LE)	88.60	87.40	90.74	88.91	89.27	88.07	91.40	89.58
Potassium sulphate + 5 g/L. (LE)	88.25	88.08	90.33	88.89	88.92	88.74	90.99	89.55
Potassium sulphate +10 g/L. (LE)	88.13	86.63	89.09	87.95	88.79	87.29	89.76	88.62
Feldspar + RB + 0 g/L. (LE)	87.39	86.69	89.44	87.84	88.05	87.36	90.10	88.50
Feldspar + RB + 2.5 g/L. (LE)	86.27	87.29	89.39	87.65	86.94	87.96	90.06	88.32
Feldspar + RB + 5 g/L. (LE)	89.68	85.38	85.95	87.00	90.35	86.04	86.61	87.67
Feldspar + RB +10 g/L. (LE)	89.14	87.34	89.86	88.78	89.80	88.00	90.53	89.45
Without potassium + 0 g/L.(LE)	88.72	87.86	89.51	88.69	89.38	88.53	90.17	89.36
Without potassium +2.5 g/L.(LE)	86.73	85.79	87.08	86.53	87.39	86.46	87.74	87.19
Without potassium +5 g/L. (LE)	88.31	87.74	89.74	88.59	88.97	88.40	90.41	89.26
Without potassium +10 g/L. (LE)	88.34	88.03	89.53	88.63	89.00	88.69	90.19	89.29
Mean	88.17	87.13C	89.16	-	88.83	87.79	89.83	-
LSD 5%	A = 0.02 B = 0.05 A*B = 0.10				0.08 0.23 0.46			

LE: licorice extract and RB: releasing bacteria. comparison of significance of differences among treatments at $p \leq 0.05$ level via L.S.D test

3.3.6. Titratable acidity

The results of titratable acidity in the Table 14 indicate a slight deficiency in the mean values of titratable acidity were observed throughout the entire time of storage period. A highly significant decrease was recorded from the initial time (zero month) to the last time of storage (6th month) in the control treatment. Compared with that of the untreated plants (control), the titratable acidity of the onion bulb was lower at the initial time of storage for all the studied treatments. In comparison, titratable acidity increased significantly in both seasons during long storage (6th month). The highest acidity was recorded in the onion bulbs treated with feldspar alone or with licorice extract within the entire storage period, with significant differences comparing to the control and other treatments. **Yadav *et al*. (2023)**

detailed that high significant differences was found among plant extract treatments for TA for a long-time storage, the most extreme titratable sharpness was watched with neem extract treatment, and the least found within the control.

Table (14). Effect of soil application of mineral potassium, feldspar and spraying licorice extract on the acidity of onion stored at room temperature during the two seasons 2019-2020 and 2020-2021

Characters	Titratable acidity							
Seasons	1st				2nd			
Treatments Storage time (months)	0	3	6	Mean	0	3	6	Mean
Potassium sulphate + 0 g/L. (LE)	0.167	0.140	0.127	0.144	0.167	0.143	0.133	0.148
Potassium sulphate+ 2.5 g/L. (LE)	0.153	0.157	0.177	0.162	0.147	0.160	0.177	0.161
Potassium sulphate + 5 g/L. (LE)	0.183	0.167	0.230	0.193	0.177	0.157	0.233	0.189
Potassium sulphate +10 g/L. (LE)	0.153	0.160	0.147	0.153	0.153	0.163	0.153	0.157
Feldspar + RB + 0 g/L. (LE)	0.177	0.247	0.203	0.209	0.177	0.247	0.207	0.210
Feldspar + RB + 2.5 g/L. (LE)	0.200	0.260	0.207	0.222	0.210	0.267	0.203	0.227
Feldspar + RB + 5 g/L. (LE)	0.217	0.217	0.160	0.198	0.217	0.217	0.167	0.200
Feldspar + RB +10 g/L. (LE)	0.177	0.223	0.227	0.209	0.173	0.220	0.213	0.202
Without potassium + 0 g/L.(LE)	0.230	0.160	0.160	0.183	0.230	0.170	0.167	0.189
Without potassium +2.5 g/L.(LE)	0.220	0.160	0.170	0.183	0.200	0.163	0.173	0.179
Without potassium +5 g/L. (LE)	0.153	0.173	0.190	0.172	0.167	0.177	0.193	0.179
Without potassium +10 g/L. (LE)	0.203	0.160	0.147	0.170	0.217	0.177	0.167	0.187
Mean	0.186	0.185	0.179	-	0.186	0.185	0.182	-
LSD5%	A =0.01 B= 0.02 A*B = 0.03				0.01 0.02 0.03			

LE: licorice extract and RB: releasing bacteria. comparison of significance of differences among treatments at $p \leq 0.05$ level via L.S.D test

3.3.7. pH

The results represented in the Figure 1 (a, b and c) illustrate effect of the treatments and long-term storage on the pH of onion bulbs tissues. According to long-term storage, Figure 1 a indicate that significantly increase in the mean value of pH from the zero month to 3rd month of storage time in the two seasons respectively, and then decreased at the end of storage (6th month). The same trend was found in the control treatment (Figure 1 b and c). The lower pH value was detected in the onion plants that treated by feldspar alone or combined with 10 g/L.(LE) compared to the control and other treatments in the most of the experimental storage times. In this respect, **Berno *et al*. (2019)** found that the higher the storage temperature resulted in the greater variations in the acidity. **Modolo *et al*. (2023)** reported that all onion cultivars evaluated over four storage periods at a controlled temperature, presented a reduction in pH values with increasing storage time (160 days). The pH of onion plants decreased as storage increased in all treatments (**Thivya, 2022**). With regard to the application of treatments the pH of onion bulbs was a reduced in the different storage periods with no significant difference between all studied treatments.

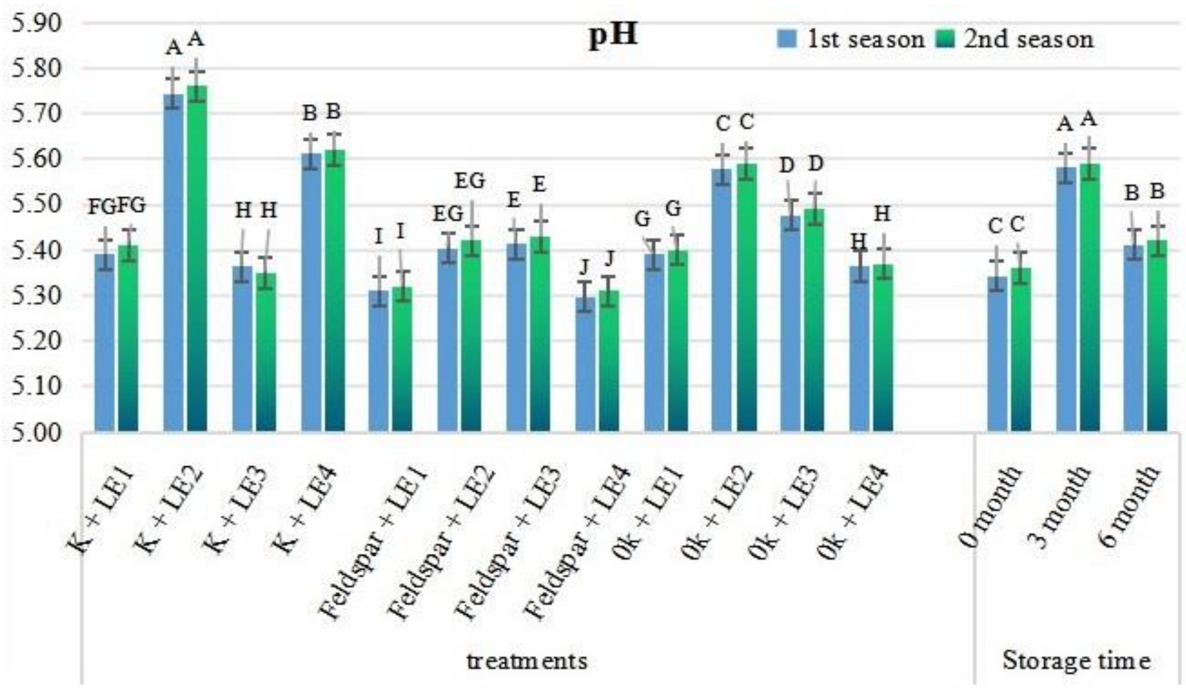

Figure (1 a). Changes in mean values of pH in onion bulb during storage time (0,3,6 months) at room temperature affected by soil treated by mineralpotassium (k), feldspar and spraying licorice extract (LE1=0 g/L, LE2=2.5 g/L, LE3=5 g/L and LE4= 10 g/L) during the two cultivation seasons

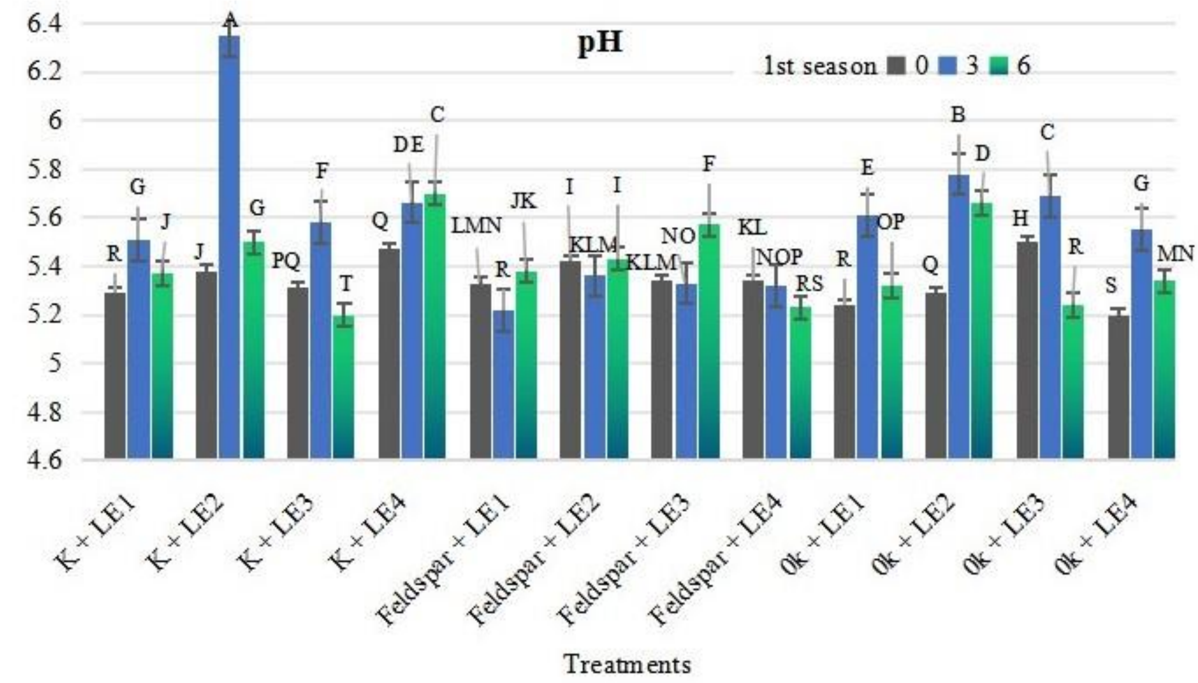

Figure (1 b). Changes in pH of in onion during storage time (0,3,6 months) at room temperature affected by soil treated by mineral potassium(k), feldspar and spraying licorice extract (LE1=0 g/L, LE2=2.5 g/L, LE3=5 g/L and LE4= 10 g/L) during the first season (1st)

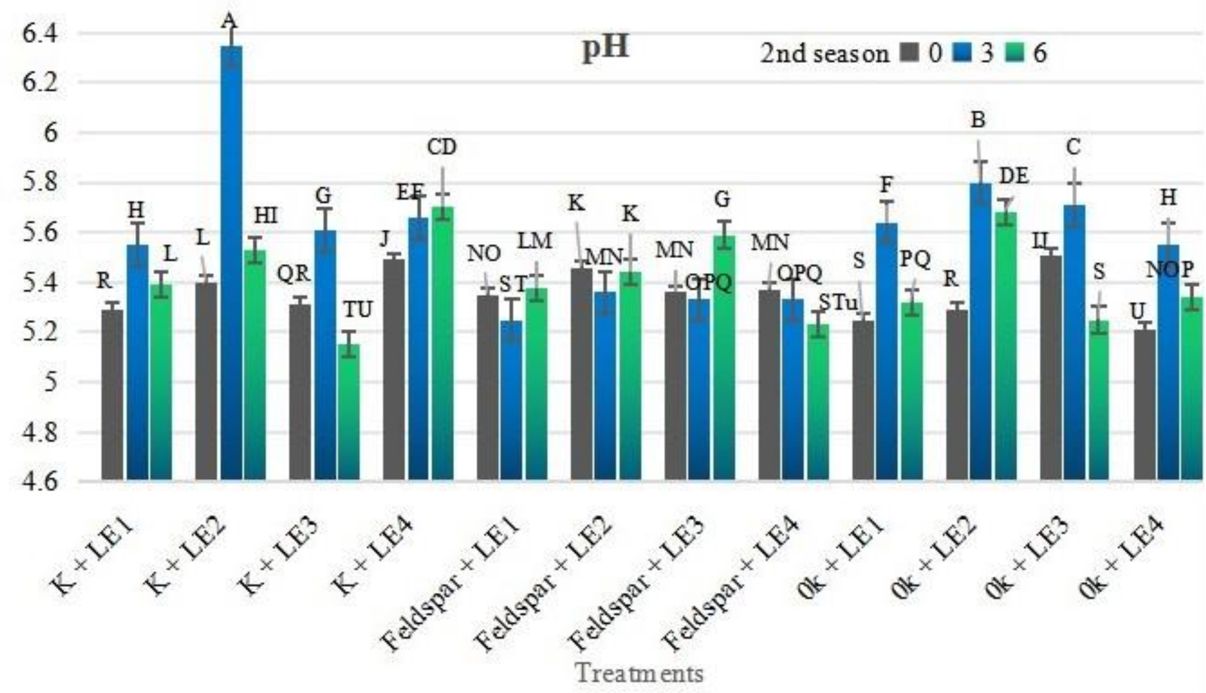

Figure (1 c). Changes in pH of onion during storage time (0,3 and 6 months) at room temperature affected by soil treated with mineral potassium(k), feldspar and spraying licorice extract (LE1=0 g/L, LE2=2.5 g/L, LE3=5 g/L and LE4= 10 g/L) during the second season (2nd)

4. Conclusion

Thus, it could be concluded that field treatments involving feldspar inoculated with RB combined and/or spraying with licorice extract were effective method and efficiently improve of onion growth, yield components and quality, and help to maintain some better chemical composition and desired properties of the onion bulbs and avoid the risks of chemical fertilizers during the long-time storage at room temperature.

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