

IMPACT OF POTASSIUM FERTILIZATION IN ASSOCIATION WITH SELENIUM ON ENHANCING YIELD, QUALITY AND STORABILITY OF ONION

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ABSTRACT: This work was conducted during the two winter seasons of 2022/2023 - 2023/2024 on the Research Farm of the Agricultural Research Station, El-Gemmeiza Gharbeya Governorate, Egypt to study the effect of potassium fertilization at rates of 24, 48 and, 72 kg/fed in association with foliar application of selenium at 0, 25, 50 and 100 ppm and their interactions on plant growth, productivity and bulb quality as well as the storability characteristics of onion plants (cv. Giza 20) grown under clay loam soil conditions.

The individual application of each of the potassium levels or selenium foliar application significantly increases the vegetative characteristics, yield, and quality parameters, such as N, P, and K contents, particularly at the highest concentration. However, higher results were obtained in response to the interaction between the two nutrients at the different concentrations. The best results were recorded with applying potassium at 48 kg /fed. in association with selenium at 50 ppm, irrespective of the studied traits.

The interaction effect between K₂O and selenium (at 72 kg K₂O/fed and 50 ppm Se, respectively) or (48 kg K₂O/fed and 50 ppm Se, respectively) showed the best efficacy in bulb content of TSS at both harvesting and storage times. Not many significant results were observed between the two treatments in this regard, and a reduced weight loss percentage in bulbs at different storage periods.

In conclusion, using potassium fertilizer in conjunction with selenium is a promising and cost-effective approach for enhancing the growth and yield of onions, both quantitatively and qualitatively.

Keywords: Onion, potassium, selenium, yield, and storability.

INTRODUCTION

After potatoes and tomatoes, onions (*Allium cepa* L.) are regarded as Egypt's third-most important vegetable crop. It has significant export potential. For onion growers, increasing the yield of high-quality onions is a key objective. The total area devoted to production in 2024 in Egypt was 333.000 fed, with an average of 15.450 tons/fed*.

Numerous physiological activities, including transpiration, ionic balance regulation, the opening and closing of photosynthetic stomata, the translocation of photosynthates, and the activation of plant enzymes, among others,

depend on potassium (Thompson, 2010). Potassium is essential for the development of disease and pest resistance, the activation of plant catalysts, photosynthetic translocation, and pore modulation (Rani *et al.*, 2020). Moreover, potassium enhances various characteristics of crops, including onions, such as their color, luster, and dry matter accumulation (Subhani *et al.*, 1990).

Fertilizing onion plants with a moderate rate of potassium produced the best productivity and good quality (Feteh 2020, Bairwa *et al.*, 2022, Mohamed *et al.*, 2022, Ahmed *et al.*, 2023, and El-Sherpiny *et al.*, 2024).

* Agriculture Economic Bulletin, 2024, Ministry of Agriculture and reclaimed soil, Cairo, Egypt.

Selenium (Se) is a sulfur-like element and a crucial mineral that offers substantial nutritional benefits for plants (Feng *et al.*, 2013). It has positive impacts on plant vitality by increasing water uptake and reducing water loss from plant cells, which eventually helps plants maintain their water content [Kuznetsov *et al.*, 2003]. Se plays an important role in hormonal balance, antioxidant responses, and other physiological activities in plant cells. It is needed in low concentrations in different crops. It can boost glutathione peroxidase (GPX) activity, which increases crop tolerance to unconventional biological influences (Filek *et al.*, 2008).

According to several authors, applying a selenium spray to onion plants greatly increased their growth, yield, and quality (Pöldma *et al.*, 2013; Rebecca, 2017; Bybordi *et al.*, 2018; Mobini *et al.*, 2019; El-Bassiony *et al.*, 2020; Machado *et al.*, 2024; and Laiza *et al.*, 2024).

Therefore, the aim of this research work was to study the effect of different levels of potassium fertilizer under different concentrations of foliar application of selenium on the productivity, quality, and storability of

onion plants growing under clay soil conditions in the middle Delta.

MATERIALS AND METHODS

This experiment was conducted in El-Gemmeiza Agricultural Research Station, Gharbeya Governorate Egypt (Lat. 30° 48' 752" and Long. 31° 81' 025") during the winter seasons of 2022/2023 - 2023/2024 to evaluate the effect of twelve treatments which were the interactions between three levels of potassium fertilization (24, 48, 72 kg/fed.) in the form of potassium sulfate (48 % K₂O) and four spraying dose of selenium at a concentration of (0, 25, 50, 100 ppm) in the form of sodium selenite (Na₂SeO₃) on plant growth, yield and quality as well as the storability of onion cv. Giza 20 was grown under clay soil conditions. Some physical and chemical properties of the experimental soil are listed in Table 1.

These treatments were arranged in a split-plot design with three replications. Potassium levels were arranged in the main plots, while selenium concentrations were applied as a foliar spray in the subplots.

Table 1. The physical and chemical properties of the experimental soil (according to Black *et al.*, 1981).

Parameter	2022/2023	2023/2024
1. Physical properties		
Coarse sand (%)	3.84	4.22
Fine sand (%)	13.40	14.70
Silt (%)	40.46	39.98
Clay (%)	42.30	41.10
Textural class	Clay loam	Clay loam
2. Chemical properties		
EC dS m ⁻¹ (soil paste extract)	2.32	2.33
pH (1: 2.5 soil: water suspension)	8.02	7.99
CaCO ₃ (%)	2.51	2.47
Organic matter (%)	1.83	1.85
Available nitrogen (ppm)	39.0	41.0
Available phosphorus (ppm)	7.60	8.10
Available potassium (ppm)	257.0	238.0
Available selenium (ppm)	0.008	0.007

Seeds of onion were sown in the nursery on October 15th in the two successive seasons and transplanted on December 15th in both seasons at 10 cm apart on both sides of the ridge. All experimental units' area was 10.5 m² (i.e., 1/400 fed), containing six ridges (3.5 m length x 50 cm width/each). One ridge was used to take the vegetative samples to measure the vegetative growth, and the other two ridges were used for yield determination.

All different rates of potassium (24, 48, and 72 kg K₂O/fed) in the form of potassium sulphate were applied in the second irrigation. While different concentrations of selenium were added four times after 30, 45, 60, and 75 days from transplanting in the form of sodium selenate by hand sprayer until saturation of leaves. Sodium selenate was obtained from Al-Gomhouria Company in Zagazig, Sharkia Governorate, Egypt.

All plots received equal amounts of phosphorus at 45 P₂O₅ kg /fed in the form of calcium superphosphate (15.5% P₂O₅), which is added before ridging, and nitrogen fertilizer at 90 kg N/fed was added in two equal portions at 30 and 60 days after transplanting in the form of ammonium nitrate (33.5% N).

The normal agricultural practices in both experiments were carried out as commonly followed in the district.

Data Recorded

A. Plant growth measurements

At 90 and 120 days following transplanting in both study seasons, a random sample of ten plants was selected from each experimental unit, and the following measurements were noted: plant height (cm), leaves number per plant and bulbing ratio, this is done by dividing the maximum diameter of the bulb by the minimum diameter of the neck according to (Mann, 1952) as well as total fresh weight (g) were measured. Also, the dry weight of the plant (leaves + bulb) was estimated by drying it in an electric oven at a temperature of 70 degrees Celsius till constant of the weight (g).

B. Bulb yield and its components

When 50% of the onion plants were down, they were harvested, allowed to be cured for two weeks, and then the tops and roots were removed. The bulbs were then weighed, and the following data was noted: Marketable yield (ton /fed.) Which are single bulbs with diameter more than 3 cm, callus yield (t/fed) which bulbs was diameter less than 3 cm, doubles, bolters, off-color and scallions and total yield (t/fed) = marketable + culls yield as well as the average bulb weight was then estimated by dividing the weight of the single bulbs per plot by the plot number of bulbs.

C. Bulb Quality at Harvesting Date

To estimate the chemical content of the bulbs at harvest in both growing seasons, 5 bulbs were taken from each experimental plot and dried in an electric oven at 70°C till constant weight. After that, Cottenie et al. (1982) estimated the nitrogen, phosphorus, and potassium content. While the selenium concentration (ppm) in bulbs was determined and analyzed using Atomic Absorption Spectroscopy, according to Levesque and Vendette (1971).

The percentage of total soluble solids (TSS%) was estimated at the harvesting date and monthly during the storage period (150 days after harvesting) in both seasons using a Carl Zeiss refractometer. The dry matter content (DM%) was also estimated by drying one hundred grams of fresh bulbs in the electric oven at a temperature of 105°C till constant weight and calculating DM% at the time of harvest and monthly during storage periods till November 1st in both seasons.

D. Storability

Three kg of marketable yield of each plot were selected, placed in common burlap bags, and then kept under normal storage conditions. The total weight loss% was recorded monthly beginning June 1st, and the finish date was November 1st (fifth month after harvesting). To calculate the percentage of weight loss in both seasons, the storage zero date was June 1st, and the finish date was November 1st. The weight

loss (%) in bulbs was calculated by the differences between the previous weight - subsequent weight / the previous weight for each month according to Abubaker *et al.* (2019).

Statistical analysis

Statistical analysis of variance for data was performed on the acquired data Snedecor and Cochran (1980). The differences among treatments were compared using Least significant difference (LSD) test at probability of 5%. The means with the same letter/s in each column were statistically insignificant, while means with a different letter were statistically significant.

RESULTS AND DISCUSSION

1. Plant growth

1.1 Effect of K₂O levels

Data in Tables 2 and 3 indicate that plant height, number of leaves/plant, bulbing ratio, fresh weight/plant, and dry weight/plant significantly increased with increasing plant growth period (90 and 120 days after transplanting in both seasons). Fertilizing onion plants with K₂O at 48 kg/fed increased plant height, number of leaves, bulbing ratio, fresh weight, and dry weight/plant at 90 and 120 days after transplanting (DAT), with no significant differences when applied at 72kg /fed, particularly with plant height, fresh weight at 90 and 120 DAT in both seasons. At 120 DAT, K₂O at 48 kg /fed. increased plant height (73.69 and 72.24 cm), number of leaves (8.43 and 8.28), bulbing ratio (2.43 and 2.40), fresh weight/ plant (209.16 and 208.53 g), and dry weight/plant (14.42 and 14.36 g) in the 1st and 2nd seasons, respectively. Bulbing ratio is more than 1, whereas the bulbing ratio value, as neck diameter/bulb diameter, is less than 1.

Characteristics of onion plants with plant height were (72.96 cm), number of leaves (8.35), bulbing ratio (2.41), fresh weight (208.84 g), and dry weight (14.39 g) as an average of the two seasons. The increases in total dry weight/plant at 120 DAT due to fertilizing with K₂O at 48 kg/fed were about 4.80 and 4.59% over

fertilizing with K₂O at 72 kg /fed in both seasons.

The positive influence of potassium on growth parameters could be attributed to its role in enhancing the plant's utilization of nitrogen, which is essential for growth and various nitrogen metabolism processes (Forshey and Makee, 1970). In this context, potassium's beneficial effect on vegetative growth may stem not only from its facilitation of the movement of newly synthesized photosynthetic products but also from its advantageous impact on metabolic processes that contribute to plant development (Gardener *et al.*, 1985).

These results are in harmony with those obtained with Shafeek *et al.* (2013), Behairy *et al.* (2015), Aftab *et al.* (2017), and Mohamed *et al.* (2022), all on onion. They showed that plant height, number of leaves/plant, bulbing ratio, and both fresh and dry weight/plant significantly improved by increasing potassium fertilization in soil.

1.2 Effect of selenium concentrations

Foliar spray of onion plants with selenium in the form of sodium selenite at 25, 50, and 100 ppm increased plant height, number of leaves, bulbing ratio, fresh weight, and dry weight/plant compared to control (spraying with water) in both samples at 90 and 120 DAT and in both seasons (Tables 2 and 3).

Spraying with Se at a concentration of 50ppm caused the best results in increasing plant height, number of leaves, bulbing ratio, fresh weight, and dry weight/plant in both seasons compared to the other treatments. At 120 DAT spraying with Se at 50 ppm gave the tallest plants (78.06 and 76.75 cm) and recorded the maximum values of number of leaves/plant (8.74 and 8.50), bulbing ratio (2.63 and 2.59) fresh weight/plant (215.26 and 214.01 g) and dry weight/plant (14.54 and 14.50 g) in the 1st and 2nd seasons, respectively. The increases in total dry weight/plant at 120 DAT due to spraying with Se at 50 ppm were about 35.89 and 35.64 % over the control in each of the two seasons.

Table 2. Effect of potassium levels and foliar spray with selenium on vegetative growth of onion plants during 2022/2023 and 2023/2024 seasons.

Treatments	Plant height (cm)				Number of leaves/plant				Bulbing ratio			
	Days after transplanting											
	90		120		90		120		90		120	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
K ₂ O (kg/fed)	Effect of potassium levels											
24	56.51 b	54.68 b	63.62b	62.04 b	5.54 c	5.42 c	7.17 b	7.10 c	1.62 c	1.61 b	1.83 c	1.81 c
48	60.37 a	59.32 a	73.69 a	72.24 a	7.22 a	7.03 a	8.43 a	8.28 a	1.84 a	1.81 a	2.43 a	2.40 a
72	59.64 a	58.54 a	72.65 a	70.79 a	6.80 b	6.66 b	8.28 a	7.93 b	1.80 b	1.78 a	2.27 b	2.24 b
LSD at 0.05 significance level	1.46	1.00	1.30	1.48	0.06	0.14	0.33	0.24	0.024	0.065	0.068	0.052
Se (ppm)	Effect of foliar spray with selenium											
Without (control)	57.13 c	56.20 c	61.22 d	59.85 d	6.02 c	5.87 c	7.08 d	6.91 d	1.58 c	1.61 c	1.76 d	1.75 d
25	57.14 c	55.40 c	66.61 c	65.00 c	6.53 b	6.34 b	7.70 c	7.58 c	1.71 b	1.68 b	1.86 c	1.85 c
50	61.66 a	60.18 a	78.06 a	76.75 a	7.05 a	6.89 a	8.74 a	8.50 a	1.87 a	1.85 a	2.63 a	2.59 a
100	59.43 b	58.27 b	74.05 b	71.84 b	6.48 b	6.38 b	8.31 b	8.08 b	1.85 a	1.81 a	2.45 b	2.42 b
LSD at 0.05 significance level	0.88	0.88	1.83	2.00	0.33	0.29	0.31	0.29	0.050	0.065	0.096	0.084

S1=2022/2023 season and S2=2023/2024 season.

The effect of selenium on plant growth primarily depends on its concentration. At moderate levels, it can promote plant growth by enhancing antioxidant activity, particularly through increasing superoxide dismutase (SOD) activity and preventing the depletion of tocopherols (Xue *et al.*, 2001).

These results are in agreement with those obtained by Pöldma *et al.* (2013), Rebecca 2017 and Bybordi *et al.* (2018), and El-Bassiony *et al.* (2020). They indicated that foliar application with Se has significantly increased the vegetative growth parameters, including fresh and dry weight.

Table 3. Effect of potassium levels and foliar spray with selenium on fresh and dry weight/plant of onion during 2022/2023 and 2023/2024 seasons.

Treatments	Fresh weight/plant (g)				Dry weight/plant (g)			
	Days after transplanting							
	90		120		90		120	
	S1	S2	S1	S2	S1	S2	S1	S2
K ₂ O (kg/fed)	Effect of potassium levels							
24	131.49 b	128.46 b	174.13 c	172.22 c	6.87 b	6.24 b	10.92 c	10.90 b
48	163.56 a	161.17 a	209.16 a	208.53 a	8.27 a	7.82 a	14.42 a	14.36 a
72	165.09 a	165.23 a	202.69 b	201.33 b	8.03 a	7.57 a	13.76 b	13.73 a
LSD at 0.05 significance level	2.92	7.62	3.77	4.81	0.66	0.42	0.47	0.64
Se (ppm)	Effect of foliar spray with selenium							
Without (control)	129.26 d	127.35 c	174.83 d	174.04 d	6.74 c	6.05 c	10.70 c	10.69 c
25	149.00 c	150.08 b	183.54 c	181.55 c	7.70 b	7.21 b	12.71 b	12.76 b
50	169.81 a	166.02 a	215.26 a	214.01 a	8.48 a	8.02 a	14.54 a	14.50 a
100	165.46 b	163.03 a	207.68 b	206.51 b	7.98 ab	7.55 b	14.19 a	14.05 a
LSD at 0.05 significance level	2.56	5.21	2.92	2.95	0.60	0.42	0.56	0.63

S1=2022/2023 season and S2=2023/2024 season

1.3 Interaction effect

The interaction between the application of K₂ O at 48 kg/fed and foliar spraying with selenium (Se) at 50 ppm significantly increased plant height, number of leaves, bulbing ratio,

fresh weight, and dry weight per plant at 90 and 120 days after transplanting (DAT) in both seasons. This was followed by the interaction between K₂ O at 48 kg/fed and Se foliar spray at 100 ppm (Tables 4 and 5).

Table 4. Effect of the interaction between potassium levels and foliar spray with selenium on vegetative growth of onion during 2022/2023 and 2023/2024 seasons.

Treatments		Plant height (cm)		Number of leaves/plant		Bulbing ratio	
		Days after transplanting					
K ₂ O level kg/fed	Se (ppm)	90	120	90	120	90	120
		2022/2023 season					
24	Without (control)	54.03 h	57.96 f	5.31 e	6.37 g	1.41 g	1.64 e
	25	56.06 g	62.76 de	5.33 e	6.99 f	1.61 f	1.78 de
	50	59.06 cde	68.10 c	6.21 d	7.80 de	1.75 cd	1.97 c
	100	56.90 fg	65.66 cd	5.33 e	7.52 def	1.71 cde	1.91 cd
48	Without (control)	58.42 ef	63.16 de	6.54 cd	7.41 ef	1.68 def	1.85 cd
	25	58.40 ef	68.58 c	7.33 ab	8.07 cd	1.78 c	1.92 cd
	50	63.66 a	83.63a	7.88 a	9.44a	1.98 a	3.17a
	100	61.00 bc	79.37 b	7.13 b	8.80 b	1.93 ab	2.79 b
72	Without (control)	58.93 de	62.53 e	6.23 d	7.45 ef	1.65 ef	1.80 d
	25	56.96 fg	68.50 c	6.93 bc	8.05 d	1.74 cd	1.88 cd
	50	62.26 ab	82.46 a	7.05 b	9.00ab	1.89 b	2.74 b
	100	60.40 cd	77.13 b	6.98 bc	8.62 bc	1.91 ab	2.64 b
LSD at 0.05 significance level		1.53	3.17	0.57	0.55	0.08	0.167
		2023/2024 season					
24	Without (control)	53.08 g	56.70 f	5.22 d	6.31 h	1.53 f	1.62 f
	25	53.51 fg	61.41 e	5.16 d	6.95 g	1.55 ef	1.77 e
	50	57.41 c	66.76 cd	5.94 c	7.74 def	1.70 cd	1.96 d
	100	54.73 ef	63.32 de	5.36 d	7.40 efg	1.68 cd	1.89 de
48	Without (control)	57.66 c	62.10 e	6.22 c	7.18 g	1.66 cde	1.84 de
	25	57.12 cd	67.10 c	7.11 b	7.99 d	1.76 bc	1.91 de
	50	62.07 a	82.23 a	7.81 a	9.26 a	1.97 a	3.11 a
	100	60.43 b	77.53 b	7.00 b	8.68 b	1.87 ab	2.77 b
72	Without (control)	57.86 c	60.77 e	6.19 c	7.24 fg	1.63 def	1.78 e
	25	55.56 de	66.49 cd	6.75 b	7.82 de	1.73 cd	1.87 de
	50	61.06 ab	81.25 a	6.91 b	8.52 bc	1.88 a	2.72 bc
	100	59.67 b	74.67 b	6.79 b	8.15 cd	1.89 a	2.60 c
LSD at 0.05 significance level		1.52	3.47	0.50	0.51	0.11	0.146

Table 5. Effect of the interaction between potassium levels and foliar spray with selenium on fresh and dry weight/plant of onion during 2022/2023 and 2023/2024 seasons

Treatments		Fresh weight/plant (g)		Dry weight/plant (g)	
		Days after transplanting			
K ₂ O level (kg/fed)	Se (ppm)	90	120	90	120
		2022/2023 season			
24	Without (control)	111.36 h	160.93 h	6.06 f	8.84 i
	25	123.42 g	170.83 g	6.23 ef	9.92 h
	50	148.63 d	184.37 ef	7.91 bcd	11.69 g
	100	142.57 e	180.40 f	7.29 cde	13.26 ef
48	Without (control)	131.70 f	181.57 f	6.84 def	10.70 h
	25	163.02 c	190.40 d	8.65 ab	14.35 cd
	50	181.40 a	236.50 a	9.16 a	16.66 a
	100	178.14 ab	228.15 b	8.46 ab	15.97ab
72	Without (control)	144.73 de	181.99 f	7.33 cde	12.58 fg
	25	160.57 c	189.39 de	8.23 abc	13.86 de
	50	179.40 ab	224.90 b	8.38 abc	15.27 bc
	100	175.67 b	214.50 c	8.20 abc	13.35 ef
LSD at 0.05 significance level		4.43	5.06	1.04	0.97
		2023/2024 season			
24	Without (control)	110.22 g	160.17 g	4.96 g	8.82 j
	25	121.68 f	165.57 f	5.77 f	10.17 i
	50	142.78 d	183.78 de	7.45 cd	11.65 gh
	100	139.15 de	179.35 e	6.80 de	12.97 ef
48	Without (control)	128.80 ef	181.04 e	6.39 ef	10.67 hi
	25	161.23 c	190.03 d	8.23 ab	14.28 cd
	50	179.03 a	235.63 a	8.61 a	16.61 a
	100	175.63 ab	227.40 b	8.05 abc	15.88 ab
72	Without (control)	143.04 d	180.90 e	6.82 de	12.56 fg
	25	167.33 bc	189.04 d	7.64 bc	13.84 de
	50	176.23 ab	222.63 b	8.00abc	15.23 bc
	100	174.30 ab	212.77 c	7.80 bc	13.30 def
LSD at 0.05 significance level		9.03	5.11	0.72	1.09

Under different rates of K₂O (24, 48, and 72 kg/fed and spraying with Se at 25, 50, and 100 ppm, increased onion plant growth was observed compared to spraying with no selenium. The

increases in total dry weight/plant at 120 DAT due to the interaction between fertilizing with K₂O at 48 kg/fed and spraying with Se at 50 ppm were about 32.43 and 32.25 % respectively, over

fertilizing with K₂O at 72 kg /fed. only in each of the two seasons. The stimulative effect of the interaction between K₂O at 48 kg /fed. and foliar spray with Se at 50 ppm on dry weight/plant may be due to this treatment increasing plant height, number of leaves/ plant (Table 4), and fresh weight/plant (Table 5).

2. Yield and its components

2.1 Effect of K₂O levels

Fertilizing onion plants with 48 or 72 kg K₂O/fed increased marketable yield, total yield /fed, and average bulb weight more than K₂O at 24 kg/fed in both seasons, K₂O at 48 kg/fed gave the highest values of marketable yield (16.744 and 16.841 ton/fed) and total yield (18.139 and 18.289 ton/fed) and average bulb weight (108.31 and 109.61 g) in the 1st and 2nd seasons, respectively (Table 6).

Culls yield decreased with increasing K₂O rate. In this regard, using K₂O at 72 kg/fed gave the lowest estimation (1.113 and 1.167 ton/fed) in the 1st and 2nd seasons, respectively. On the other side, fertilizing with K₂O at 24 kg/fed produced the percentage of marketable yield from total yield, which were about (89.13 and 88.86%) for 24 kg K₂O, (92.31 and 92.08%) for 48 kg K₂O, and (93.62 and 93.34%) for 72 kg/fed in the 1st and 2nd seasons, respectively.

The increases in total yield were about 2.064 and 2.102 tons, which equal 12.84 and 12.99%, respectively, for K₂O at 48 kg/fed and 1.365 and 1.356 tons, which equal 8.49 and 8.38%, respectively, for K₂O at 72 kg/fed over the K₂O at 24 kg/fed in the 1st and 2nd seasons, respectively. These increases may be due to the beneficial position of potassium, which plays a pivotal role of K₂O in pigment production, photosynthesis activation, and the assimilation of carbohydrates (Hilman and Asandhi, 1987). Increases in vegetative growth (Table 2), high dry weight (Table 3), and high mean bulb weight (Table 6) were directly responsible for the increase in total yield.

These results were in agreement with those reported by Ali *et al.* (2016), Naher *et al.* (2017), Kumara *et al.* (2018), and Bairwa *et al.* (2022), who showed that fertilizing plants with potassium produced the best productivity of onion.

2.2. Effect of selenium concentrations

Data in Table 6 show that spraying onion plants with Se four times at 25, 50, and 100 ppm significantly increased marketable yield, total yield, and average bulb weight as compared to the control treatment in both seasons. However, the highest values of marketable yield (16.767 and 16.876 tons) and total yield (18.427 and 18.594 tons/fed) and average bulb weight (110.22 and 111.85 g) were produced from the plants which sprayed with Se at 50 ppm in the 1st and 2nd seasons, respectively. Spraying plants with Se at 100 ppm produced the lowest cull yield (1.017 and 1.074 ton/fed) in both seasons.

The increases in total yield were about 5.98 and 6.17 % for spraying with Se at 25 ppm, 13.58 and 14.07% for Se at 50 ppm and 4.95 and 5.25% for Se at 100 ppm and in marketable yield were about (8.81 and 8.92), (15.09 and 15.57) and (9.88 and 10.13%) for Se at 25, 50 and 100 ppm compared to the control in the 1st and 2nd seasons, respectively.

Se may improve the transfer of photo assimilates for bulb growth, serving as a potent sink for both Se and carbohydrates, according to the increased yield of plants sprayed with Se. Se may have a beneficial influence on onion plant output because of its antioxidative properties, which postpone senescence (Yassen *et al.*, 2018).

These results are in agreement with those obtained by El-Bassiony *et al.* (2020) and El-Ghamry *et al.* (2024) on onion. They found that spraying plants with selenium produced the highest yield and its components as compared to unsprayed plants.

Table 6. Effect of potassium levels and foliar spray with selenium on yield and its components of onion during 2022/2023 and 2023/2024 seasons

Treatments	Culls yield (ton/fed)		Marketable yield (ton/fed)		Total yield (ton/fed)		Average bulb weight (g)	
	S1	S2	S1	S2	S1	S2	S1	S2
K₂O (kg/fed)	Effect of potassium levels							
24	1.747 a	1.803 a	14.328 c	14.384 c	16.075 c	16.187 c	86.66 c	87.20 c
48	1.394 b	1.448 b	16.744 a	16.841 a	18.139 a	18.289 a	108.31 a	109.61 a
72	1.113 c	1.167 c	16.327 b	16.375 b	17.440 b	17.543 b	104.39 b	105.50 b
LSD at 0.05	0.247	0.237	0.405	0.395	0.279	0.259	1.61	2.21
Se (ppm)	Effect of foliar spray with selenium							
Without (control)	1.655 a	1.698 a	14.569 c	14.603 c	16.224 c	16.301 c	91.71 d	92.00 d
25	1.340 b	1.401 b	15.853 b	15.905 b	17.194 b	17.306 b	95.46 c	95.94 c
50	1.659 a	1.717 a	16.767 a	16.876 a	18.427 a	18.594 a	110.22 a	111.85 a
100	1.017 c	1.074 c	16.009 b	16.083 b	17.027 b	17.157 b	101.76 b	103.28 b
LSD at 0.05	0.138	0.146	0.313	0.305	0.330	0.336	2.11	1.76

S1=2022/2023 season and S2=2023/2024 season

2.3. Interaction effect

The interaction between K₂O at 48 kg and foliar spray with Se at 50 ppm increased average bulb weight (127.78 and 130.30g), marketable yield (18.007 and 18.252 ton/fed), and total yield (19.900 and 20.168 ton/fed) in the 1st and 2nd seasons, respectively, followed by the interaction between K₂O at 48 kg/fed and spraying with Se at 100 ppm, and the interaction between K₂O at 72 kg/fed and spraying with Se at 50 ppm (Table 7). Spraying Se at 25, 50, and 100 ppm increased average bulb weight, marketable yield, and total yield under different rates of K₂O compared to without Se under the same K₂O rates in both seasons. As for cull yield, the interaction between K₂O at 72 kg/fed and spraying with Se at 100 ppm gave the lowest values of cull yield in both seasons. Spraying with Se at 100 ppm decreased cull yield under different rates of K₂O compared to 25 and 50 ppm and control under the same rates of K₂O.

The increase in total yield due to the interaction between fertilizing with K₂O at 48 kg /fed. and spraying with Se at 50 ppm were about

(22.29 and 23.23%), and marketable yield was about (19.12 and 20.28 %) over fertilizing with K₂O at 72 kg/fed only in each of the two seasons.

The stimulative effect of K₂O at 48 kg/fed and foliar spray with Se at 50 ppm on total yield may be due to this treatment increasing dry weight/plant (Table 5), average bulb weight, and marketable yield (Table 7). The outcomes of potassium and selenium foliar application may be explained by the positive effects of both selenium and potassium on boosting plant growth through antioxidant levels. Selenium is an essential component of many proteins, such as the antioxidant enzyme glutathione peroxidase, which can efficiently eliminate oxygen-free radicals (Ríos *et al.*, 2009). According to Habibi (2013), selenium can change the antioxidant levels in plants and detoxify superoxide radicals, thereby avoiding oxidative damage and safeguarding the membranes and enzymes. The onion plant's ability to absorb nutrients, grow, and yield was all enhanced by the additional selenium.

Table 7. Effect of the interaction between potassium level and foliar spray with selenium on yield and its components of onion during 2022/2023 and 2023/2024 seasons

Treatments		Culls yield (ton/fed)		Marketable yield (ton/fed)		Total yield (ton/fed)		Average bulb weight (g)	
K ₂ O (kg/fed)	Se (ppm)	S1	S2	S1	S2	S1	S2	S1	S2
24	Without (control)	2.099 a	2.166 a	13.240 g	13.256 g	15.340 h	15.423 g	79.57 h	80.13 h
	25	1.993 ab	2.016 ab	14.171 f	14.239 f	16.165 fg	16.255 ef	87.00 g	87.52 g
	50	1.583 cd	1.663 cd	15.143 e	15.170 e	16.726 ef	16.833de	91.50 f	91.91 f
	100	1.313 ef	1.365 ef	14.757 e	14.872 e	16.070 g	16.237 f	88.57 fg	89.24 fg
48	Without (control)	1.710 bcd	1.738 bcd	15.350 e	15.377 e	17.060de	17.115 d	95.45 e	95.77 e
	25	1.049 gh	1.153 fgh	16.495 cd	16.547cd	17.544 cd	17.700 c	98.37 de	99.28 d
	50	1.893 abc	1.916 abc	18.007 a	18.252 a	19.900 a	20.168 a	127.78 a	130.30 a
	100	0.927 gh	0.985 gh	17.125 b	17.188 b	18.052 c	18.174 c	111.65 b	113.10 b
72	Without (control)	1.156 fg	1.190 fg	15.117 e	15.175 e	16.273 fg	16.366 ef	100.13 d	100.11 d
	25	0.980 gh	1.033 gh	16.893bc	16.930 bc	17.873 c	17.964 c	101.00 d	101.03 d
	50	1.503 de	1.573 de	17.150 b	17.207 b	18.653 b	18.780 b	111.37 b	113.35 b
	100	0.813 h	0.873 h	16.147 d	16.188 d	16.960 e	17.061 d	105.07 c	107.50 c
LSD at 0.05		0.239	0.252	0.542	0.529	0.572	0.582	3.66	3.05

S1=2022/2023 season and S2=2023/2024 season

3. Bulb quality

N, P, and K, as well as Se, at harvesting

3.1. Effect of K₂O levels

Data in Table 8 indicate that N (1.65 and 1.68%), P (0.389 and 0.392 %), and K (2.92 and 2.95%) contents in bulbs significantly increased with increasing K₂O applied at 72 kg/fed; however, significant differences with observed between using 48 or 72 kg K₂O/fed application rate in both seasons. As for selenium concentration in the bulb, data show that selenium concentration increased with increasing K₂O up to 72 kg/fed. This means that using K₂O at 72 kg /fed. increased selenium concentration (10.79 and 10.90 ppm) in bulbs in both seasons.

These results could be attributed to potassium's role in plant metabolism. Furthermore, a number of processes in the synthesis of proteins require potassium (Edmond *et al.*, 1977). The mineral content of the bulbs is further increased by potassium's essential functions in plants, which include osmotic management (Lindhauer, 1985), enzyme

activation, cell turgor maintenance, ion homeostasis, photosynthesis, and transport of outputs to storage organs (Marschner, 1995). Similar results were obtained by Barman *et al.* (2013), El-Morsy *et al.* (2016), Marrocos *et al.* (2018), Yassen *et al.* (2018), Feteh (2020), and Ahmed *et al.* (2023). They indicated that bulb quality was the best when fertilizing onion with different rates of potassium than untreated plants.

3.2. Effect of selenium concentration

Foliar spray with different Se concentrations significantly increased N, P, and K as well as selenium content in bulbs compared to control (0 Se) in both seasons (Table 8). However, spraying with 50 ppm Se produced the maximum values of N (1.61 and 1.66 %), P (0.398 and 0.402%), and K (2.98 and 3.03 %), in both seasons, while Se content in bulbs gradually increased with increasing Se application to the high level, which produced 13.44 and 13.72 ppm in both seasons. However, control treatment produced the minimum contents of N, P, K, and Se in bulbs at harvesting time in both seasons.

Table 8. Effect of potassium levels and foliar spray with selenium on N, P, K, and selenium content in onion bulbs during harvesting time during 2022/2023 and 2023/2024 seasons.

Treatments	Nitrogen (%)		Phosphors (%)		Potassium (%)		Selenium (ppm)	
	S1	S2	S1	S2	S1	S2	S1	S2
K₂O (kg/fed)	Effect of potassium levels							
24	1.24 b	1.25 b	0.349 b	0.351 b	2.40 b	2.39 b	9.64 b	9.80 c
48	1.58 a	1.62 a	0.386 a	0.392 a	2.93 a	2.99 a	9.94 b	10.13 b
72	1.65 a	1.68 a	0.389 a	0.392 a	2.92 a	2.95 a	10.79 a	10.90 a
LSD at 0.05	0.078	0.104	0.014	0.016	0.144	0.055	0.29	0.26
Se (ppm)	Effect of foliar spray with selenium							
Without (control)	1.33 c	1.35 c	0.349 c	0.354 c	2.53 d	2.50 d	5.40 d	5.43 d
25	1.51 b	1.51 b	0.378 b	0.380 b	2.67 c	2.68 c	9.28 c	9.37 c
50	1.61 a	1.66 a	0.398 a	0.402 a	2.98 a	3.03 a	12.38 b	12.59 b
100	1.51 b	1.53 b	0.374 b	0.377 b	2.81 b	2.89 b	13.44 a	13.72 a
LSD at 0.05	0.068	0.091	0.012	0.014	0.125	0.048	0.19	0.23

S1=2022/2023 season and S2=2023/2024 season

Foliar applications of Se enhanced the concentration of Se in certain plants without adversely affecting the amounts of N, P, and K. However, Se delays senescence and increases the efficiency of nitrogen use and nitrogen metabolism (Zhang *et al.*, 2023). These findings are consistent with those of Yassen *et al.* (2018) discovered that applying Se topically to potato plants raised the percentage of N, P, K, and protein in the tuber yield. Also, Pöldma *et al.* (2013) obtained similar results on onion.

3.3. Interaction effect

Data in Table 9 indicate that there were significant differences regarding the interaction between potassium level and foliar spray with selenium on N, P, K, and selenium concentration in onion bulbs at harvesting time during 2022/2023 and 2023/2024 seasons. The interaction between K₂O at 48 kg/fed and Se at 50 ppm increased the contents of N (1.86 and 1.99%), P (0.418 and 0.424%) and K (3.28 and 3.35 %) in bulbs in both seasons, whereas the interaction between K₂O at 72 kg/fed and Se at 100 ppm increased the concentration of Se in bulbs (14.05 and 14.32 ppm, Fig. 1) in both seasons, respectively.

4. TSS at harvesting time and during storage periods

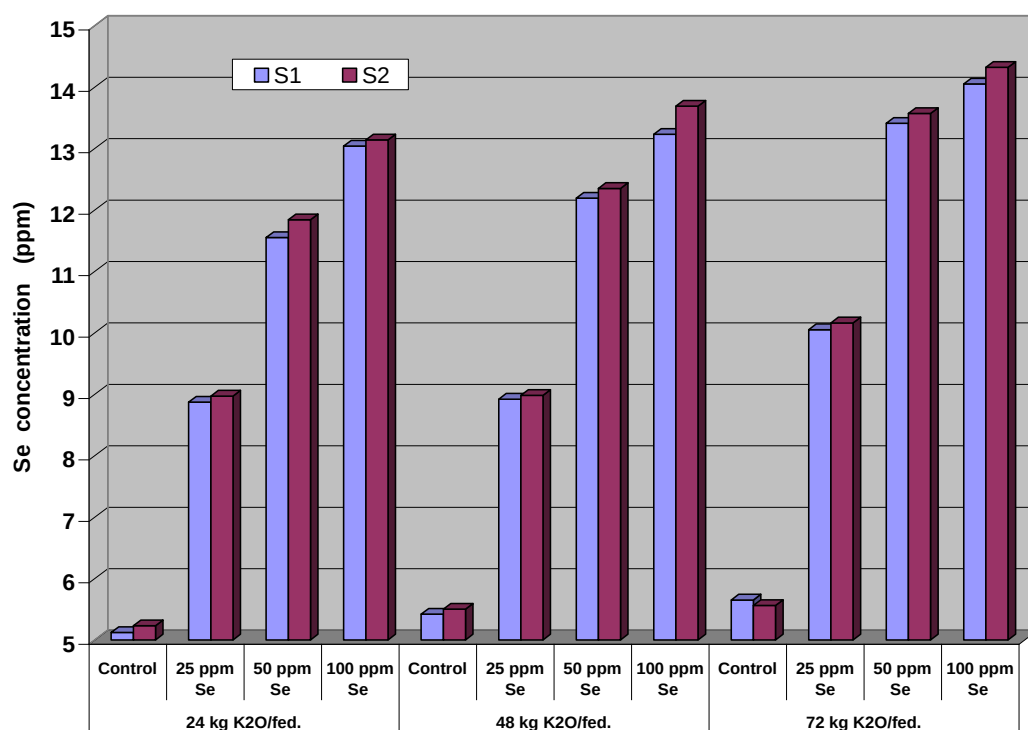
4.1 Effect of K₂O levels

Data in Table 10 indicate that K₂O at 72 kg/fed increased (total soluble solids) TSS in the bulb at harvesting time (17.01 and 17.15%) in both seasons and during storage periods, especially after 150 days from storage (15.15 and 15.36%) in both seasons, followed by K₂O at 48 kg/fed in both seasons. After five months of storage, TSS values ranged between 14.35% and 15.15% in the 1st season and 14.61% and 15.36% in the 2nd season. TSS in bulbs under storage period decreased compared to TSS at harvesting time under different rates of K₂O. TSS, a measure of onion quality, is one of the factors that K fertilization greatly affects. These outcomes are consistent with Gerjes *et al.* (2011) and Bekele 2018 and Deepa *et al.* (2018). They demonstrated that the maximum potassium rate (72 kg/fed) markedly raised TSS in bulbs during both the harvest and storage periods. Sandhu *et al.* (2023) showed that maximum TSS was recorded with the application of potassium at 60 kg/ ha.

Table 9. Effect of the interaction between potassium levels and foliar spray with selenium on N, P, K, and selenium in onion bulbs at harvesting time during 2022/2023 and 2023/2024 seasons.

Treatments		Nitrogen (%)		Phosphors (%)		Potassium (%)		Selenium (ppm)	
K ₂ O (kg/fed)	Se (ppm)								
		S1	S2	S1	S2	S1	S2	S1	S2
24	Without (control)	1.15 f	1.16 g	0.321 g	0.319 f	2.13 h	2.04 h	5.12 h	5.23 h
	25	1.24 ef	1.24 fg	0.356 ef	0.358 e	2.44 g	2.45 g	8.87 f	8.97 g
	50	1.31 e	1.32 ef	0.368 def	0.370 de	2.56 fg	2.57 f	11.55 d	11.84 e
	100	1.26 ef	1.28 fg	0.354 ef	0.357 e	2.48 g	2.50 fg	13.04 b	13.14 c
48	Without (control)	1.24 ef	1.29 fg	0.345 fg	0.357 e	2.67 efg	2.68 e	5.42 gh	5.50 h
	25	1.54 d	1.49 de	0.386 bcd	0.389 bcd	2.75 def	2.78 d	8.92 f	8.98 g
	50	1.86 a	1.99 a	0.418 a	0.424 a	3.28 a	3.35 a	12.19 c	12.35 d
	100	1.69 bc	1.72 bc	0.397 abc	0.400 abc	3.03 bc	3.17 b	13.23 b	13.69 b
72	Without (control)	1.61 cd	1.62 cd	0.382 cd	0.388 cd	2.80 cde	2.80 d	5.65 g	5.56 h
	25	1.77 ab	1.82 ab	0.393 bc	0.395 bcd	2.83 cde	2.83 d	10.05 e	10.16 f
	50	1.66 bcd	1.69 bc	0.410 ab	0.413 ab	3.12 ab	3.17 b	13.41 b	13.57 bc
	100	1.59 cd	1.61 cd	0.373 cde	0.375 cde	2.94 bcd	3.01 c	14.05 a	14.32 a
LSD at 0.05		0.118	0.158	0.022	0.024	0.217	0.084	0.34	0.40

S1=2022/2023 season and S2=2023/2024 season

**Fig. (1). Effect of the interaction between potassium level and foliar spray with selenium on selenium content (ppm) in onion bulbs at harvesting time during 2022/2023 and 2023/2024 seasons**

4.2 Effect of selenium concentrations

Spraying Se at 50 ppm increased TSS in bulbs at the harvesting date and during storage periods compared to the other concentrations and control (Table 10).

After five months of storage, TSS in bulbs decreased compared to TSS at harvesting time under different concentrations of selenium. At harvesting date, TSS values ranged between 15.50 and 17.17% in the 1st season and from

15.62 to 17.24% in the 2nd one, whereas during storage periods of 5 months, they ranged between 14.46 and 15.44% in the 1st season and from 14.66 to 15.66% in the 2nd season.

These results are in harmony with those reported by Belal (2020), who demonstrated that spraying tomato plants with Se at 20 ppm significantly alleviated TSS in fruits as compared to 0 or 40 ppm.

Table 10. Effect of potassium levels and foliar spray with selenium on TSS in bulbs at harvesting time and different storage periods of onion during 2022/2023 and 2023/2024 seasons.

Treatments	At harvesting time		Storage periods									
			1 st month		2 nd month		3 rd month		4 th month		5 th month	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
K ₂ O kg/fed	Effect of potassium levels											
24	15.36 b	15.50 b	14.51 c	14.63 c	13.46 c	13.72c	12.91 b	13.08 b	13.93 b	14.08b	14.35 b	14.61 b
48	16.65 a	16.76 a	15.23 b	15.38 b	14.41 b	14.53b	13.90 a	14.06 a	14.71 a	14.93a	15.01 a	15.25 a
72	17.01 a	17.15 a	16.00 a	16.13 a	14.88 a	15.13a	14.20 a	14.25 a	14.78 a	14.95a	15.15 a	15.36 a
LSD at 0.05 significance level	0.49	0.60	0.35	0.29	0.37	0.39	0.31	0.38	0.39	0.44	0.15	0.30
Se (ppm)	Effect of foliar spray with selenium											
Without (control)	15.50 d	15.62 c	14.42 d	14.60 c	13.88 b	14.27 b	13.40 b	13.62 b	14.40 b	14.57 b	14.86 b	15.20 b
25 ppm	16.15 c	16.35 b	15.02 c	15.15 b	13.86 b	14.02 b	13.26 b	13.37 b	14.24 b	14.40 b	14.57 c	14.77 c
50 ppm	17.17 a	17.24 a	16.13 a	16.28 a	15.11 a	15.24 a	14.51 a	14.60a	15.13a	15.26 a	15.44a	15.66 a
100 ppm	16.53 b	16.66 b	15.42 b	15.48 b	14.15 b	14.31 b	13.51 b	13.60 b	14.13 b	14.37 b	14.46 c	14.66 c
LSD at 0.05 significance level	0.30	0.34	0.37	0.38	0.29	0.34	0.33	0.30	0.34	0.32	0.13	0.19

S1=2022/2023 season and S2=2023/2024 season

4.3 Interaction effect

The interaction between K₂O at 72 kg /fed and Se at 50 ppm, and the interaction between K₂O at 48 kg/fed and spraying with Se at 50 ppm increased TSS in bulbs at harvesting time and during storage periods, with no significant differences between them (Table 11). At harvesting date, TSS values were from 14.66 to 18.00% in the 1st season and from 14.66 to 17.93% in the 2nd season, whereas during storage periods at 5 months, they were from 14.00 to 15.93% in the 1st season and from 14.20 to 16.20% in the 2nd season.

5. Dry matter at harvesting date and during storage periods

5.1 Effect of K₂O levels

In general, dry matter (%) in bulbs significantly increased with increasing K₂O rates up to 72 K₂O kg/fed, with no significant differences with K₂O at 48 kg/fed (Table 12). At harvesting date and after a five-month storage period, K₂O at 48 kg/fed increased dry matter (%) in bulbs in both seasons. Dry matter percentage ranged from 15.74 to 17.33% in the first season and from 15.76 to 17.36% in the second season at harvesting time and ranged from 14.84 to 15.76% in the 1st season and 14.93 to 15.75% in the 2nd season after five months of storage. After five months of storage, dry matter (%) in bulbs decreased compared to dry matter at harvesting time under all K₂O rates in both seasons. These results align with the findings of

Geries *et al.* (2011) and Bekele (2018). They showed that the maximum potassium rates of 120 kg/ha significantly increased the dry matter (%) in onion bulbs at harvesting time and during the different storage periods.

5.2 Effect of selenium concentrations

Spraying onion plants with Se at 50 ppm increased dry matter % (17.56 and 17.50%) in both seasons at harvesting time and during the

storage periods, especially after five months from storage (15.98 and 15.96%) as compared to the other concentrations in both seasons (Table 12). Dry matter (%) ranged between 15.91 to 17.56% in the 1st season and from 15.96 to 17.50 % at harvesting time and the end of storage after five months. Dry matter (%) ranged between 15.09 and 15.98% in the 1st season and between 15.03 and 15.96% in the 2nd season.

Table 11. Effect of the interaction between potassium levels and foliar spray with selenium on TSS in bulbs at harvesting time and different storage periods of onion during 2022/2023 and 2023/2024 seasons.

Treatments		At harvesting time	Storage periods				
K ₂ O level	Se (ppm)		1 st month	2 nd month	3 rd month	4 th month	5 th month
2022/2023 season							
24	Without (control)	14.66 h	14.00 h	13.66 ef	13.33 cd	14.53 bc	14.93 bc
	25 ppm	15.26 g	14.13 h	12.46 g	12.26 f	13.73 de	14.00 f
	50 ppm	16.13 cde	15.53 cde	14.40 cd	13.33 cd	14.00 cde	14.46 e
	100 ppm	15.40 fg	14.40 fgh	13.33 f	12.73 ef	13.46 e	14.00 f
48	Without (control)	15.86 efg	14.26 gh	13.80 ef	13.06 de	14.00 cde	14.53 e
	25 ppm	16.40 cd	14.88 efg	14.13 de	13.73 bc	14.80 b	15.06 bc
	50 ppm	17.40 ab	16.20 ab	15.06 b	14.86 a	15.80 a	15.93 a
	100 ppm	16.93 b	15.60 bcd	14.66 bc	13.93 b	14.26 bcd	14.53e
72	Without (control)	16.00 def	15.00 def	14.20 cde	13.80 bc	14.66 b	15.13 b
	25 ppm	16.80 bc	16.06 abc	15.00 b	13.80 bc	14.20 bcd	14.66 de
	50 ppm	18.00 a	16.66 a	15.86 a	15.33 a	15.60 a	15.93 a
	100 ppm	17.26 b	16.26 a	14.46 cd	13.86 bc	14.66 b	14.86 cd
LSD at 0.05 significance level		0.52	0.65	0.51	0.58	0.59	0.22
		2023/2024 season					
24	Without (control)	14.66 f	14.13 g	14.16 cd	13.53 bc	14.66 bcd	15.33 b
	25 ppm	15.53 e	14.26 g	12.66 f	12.33 e	13.86 ef	14.26 ef
	50 ppm	16.26 cd	15.66 cd	14.53 cd	13.53 bc	14.13 def	14.66 d
	100 ppm	15.53 e	14.46 fg	13.53 e	12.93 d	13.66 f	14.20 f
48	Without (control)	16.00 de	14.46 fg	14.00 de	13.40 cd	14.20 def	14.93 bcd
	25 ppm	16.53 cd	15.00 ef	14.20 cd	13.86 bc	15.00 b	15.26 b
	50 ppm	17.53 ab	16.33 ab	15.20 b	14.93 a	15.93 a	16.13 a
	100 ppm	17.00 bc	15.73 bcd	14.73 bc	14.06 b	14.60 bcd	14.66 de
72	Without (control)	16.20 de	15.20 de	14.66 bc	13.93 bc	14.86 bc	15.33 b
	25 ppm	17.00 bc	16.20 abc	15.20 b	13.93 bc	14.33 cde	14.80 cd
	50 ppm	17.93 a	16.86 a	16.00a	15.33 a	15.73 a	16.20 a
	100 ppm	17.467 ab	16.26 abc	14.66 bc	13.80 bc	14.86 bc	15.13 bc
LSD at 0.05 significance level		0.59	0.67	0.59	0.53	0.56	0.34

S1=2022/2023 season and S2=2023/2024 season

Table 12. Effect of potassium levels and foliar spray with selenium on dry matter (%) in bulbs at harvesting time and different storage periods of onion during 2022/2023 and 2023/2024 seasons.

Treatments	At harvesting time		At harvesting time									
			1 st month		2 nd month		3 rd month		4 th month		5 th month	
K ₂ O kg/fed	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Effect of potassium levels												
24	15.74 b	15.76 b	15.10 c	14.94 c	13.90 b	14.05 c	13.27 b	13.35 b	14.58 b	13.14 c	14.84 b	14.93 b
48	17.06 a	17.06 a	15.71 b	15.69 b	14.76 a	14.99 b	14.22 a	14.36 a	15.26 a	15.32 b	15.74 a	15.84 a
72	17.33 a	17.36 a	16.38 a	16.52 a	15.11 a	15.48 a	14.54 a	14.54 a	15.47 a	15.45 a	15.76 a	15.85 a
LSD at 0.05 significance level	0.56	0.51	0.36	0.28	0.50	0.32	0.43	0.43	0.39	0.10	0.60	0.24
Effect of foliar spray with selenium												
Without (control)	15.91 d	15.96 d	14.97 d	14.91 d	14.20 b	14.63 b	13.71 b	13.96 b	15.09 b	13.61 c	15.49 b	15.79 a
25	16.41 c	16.56 c	15.46 c	15.46 c	14.23 b	14.46 b	13.58 b	13.66 b	14.80 b	14.70 b	15.23bc	15.37 b
50	17.56 a	17.50 a	16.58 a	16.62 a	15.48 a	15.62 a	14.91 a	14.84 a	15.68 a	15.58 a	15.98 a	15.96a
100	16.95 b	16.90 b	15.91 b	15.88 b	14.46 b	14.65 b	13.84 b	13.87 b	14.83 b	14.67 b	15.09 c	15.03 c
LSD at 0.05 significance level	0.37	0.31	0.38	0.28	0.32	0.32	0.38	0.31	0.34	0.09	0.37	0.21

S1=2022/2023 season and S2=2023/2024 season

5.3 Interaction effect

The interaction between K₂O at 48 kg/fed and spraying with Se at 50 ppm, and the interaction between K₂O at 72 kg/fed and Se at 50 ppm increased dry matter (%) in bulbs at harvesting time and during the storage periods in both seasons (Table 13).

At harvesting time, dry matter values were from 15.00 to 18.25 % in the 1st season and from 15.01 to 18.16% in the 2nd season, whereas after five months of storage were from 14.40 to 16.65% in the 1st season and from 14.34 to 16.55% in the 2nd season. There was a positive correlation between TSS% and DM% in bulbs. This means that the interaction between K₂O at 48 kg/fed and spraying with Se at 50 ppm increased TSS and dry matter contents.

The stimulative effect of the interaction between K₂O at 48 kg/fed and foliar spray with Se at 50 ppm on dry matter contents may be due

to this treatment increasing average bulb weight (Table 7) and TSS in bulbs (Table 11).

6. Weight loss percentage

6.1 Effect of K₂O levels

At 1, 2, 3, 4, and 5 months of storage, weight loss percentage in bulbs gradually decreased with increasing K₂O rates (Table 14). This means that K₂O at 48 kg/fed decreased weight loss (%) during storage periods (2.18 and 2.08%), while fertilizing with 24 kg K₂O/fed produced the maximum weight loss (2.78 and 2.67%) in the 1st and 2nd seasons, respectively. After five months, weight loss (%) ranged between 2.18 to 2.78 in the 1st season and ranged from 2.08 to 2.67% in the 2nd season. There were no significant differences between all rates of K₂O on weight loss (%) after four months in both seasons.

Potassium fertilization is the primary component that affects bulb formation and storage. When there is sufficient K fertilization, bulb formation is positively impacted. Bulb

storage quality is improved with optimal K fertilization. Onion K shortage manifests as poor bulb formation and brown tips on older leaves (Maisura *et al.*, 2019). These outcomes are consistent with Obiadalla *et al.* (2016), Bekele

(2018), and Fawaz *et al.* (2020). They demonstrated that weight loss (%) in onion bulbs over the various storage periods was greatly reduced by the maximum potassium rate as compared to the minimum rate.

Table 13. Effect of the interaction between potassium level and foliar spray with selenium on dry matter (%) in bulbs at harvesting time and different storage periods of onion during 2022/2023 and 2023/2024 seasons.

Treatments		At harvesting time	Storage periods				
K ₂ O level	Se (ppm)		1 st month	2 nd month	3 rd month	4 th month	5 th month
2022/2023 season							
24	Without (control)	15.00 g	14.80 de	14.02 ef	13.66 bc	15.31 bc	15.50 cd
	25	15.55 fg	14.66 e	12.88 g	12.66 e	14.18 e	14.40 e
	50	16.52 de	16.00 bc	14.89 bcd	13.77 bc	14.80 cd	14.87 de
	100	15.88 ef	14.93 de	13.82 f	12.98 de	14.02e	14.60 e
48	Without (control)	16.20 ef	14.66 e	14.06 ef	13.46 cd	14.51 de	15.45 cd
	25	16.60 de	15.40 cd	14.56 cde	13.92 bc	15.30 bc	15.70 bc
	50	17.93 ab	16.60 ab	15.53 ab	15.20a	16.12 a	16.65 a
	100	17.50 abc	16.20 b	14.88 cd	14.30 b	15.10 bcd	15.16 cde
72	Without (control)	16.53 de	15.45 cd	14.50 def	14.01 bc	15.44 b	15.52 cd
	25	17.08 cd	16.31 b	15.24 bc	14.14 bc	14.93 bcd	15.60 cd
	50	18.25 a	17.15 a	16.04 a	15.78a	16.11 a	16.42 ab
	100	17.48 bc	16.60 ab	14.67 cde	14.25 b	15.39 bc	15.51 cd
LSD at 0.05 significance level		0.64	0.66	0.57	0.67	0.59	0.64
		2023/2024 season					
24	Without (control)	15.01 h	14.52 f	14.45 d	13.81 b	10.58 i	15.73 bc
	25	15.71 g	14.47 f	13.02 f	12.68 c	13.97 g	14.75 f
	50	16.49 e	15.95 cd	14.89 cd	13.75 b	14.24 f	14.90 ef
	100	15.84 fg	14.84 f	13.83 e	13.14 c	13.79 h	14.34 g
48	Without (control)	16.48 ef	14.68 f	14.48 d	13.80 b	14.71 e	15.73 bc
	25	16.72 de	15.40 e	14.67 cd	14.13 b	15.32 d	15.92 b
	50	17.85 ab	16.55 b	15.73 a	15.18 a	16.40 a	16.55 a
	100	17.20 cd	16.15 bc	15.10 bc	14.35 b	14.87 e	15.16 de
72	Without (control)	16.40 ef	15.54 de	14.96 cd	14.26 b	15.55 c	15.92 b
	25	17.25 bcd	16.53 b	15.70 ab	14.17 b	14.80 e	15.44 cd
	50	18.16 a	17.35 a	16.25 a	15.59 a	16.09 b	16.45 a
	100	17.65 abc	16.65 b	15.01 cd	14.14 b	15.36 d	15.60 bc
LSD at 0.05 significance level		0.48	0.45	0.50	0.49	0.15	0.36

6.2 Effect of selenium concentrations

Data in Table 14 indicate that spraying with 50 ppm Se produced the minimum weight loss (%) in bulbs (2.41 and 2.34%), (3.02 and 2.96%), (3.40 and 3.33%), (2.63 and 2.55%) and (1.80 and 1.73%) for 1, 2, 3, 4 and five month after storage in the 1st and 2nd seasons, respectively, followed by spraying with Se at 100 ppm in both

seasons. On the other hand, control treatment (spraying with water) scored the maximum weight loss (%) in bulbs at different storage periods until five months in both seasons. At the end of storage (fifth month), weight loss (%) in bulbs ranged between 1.80 to 2.99 in the 1st season and ranged between 1.73 to 2.83% in the 2nd season.

Table 14. Effect of potassium levels and foliar spray with selenium on weight loss (%) in bulbs at different storage periods of onion during 2022/2023 and 2023/2024 seasons

Treatments	Storage periods									
	1 st month		2 nd month		3 rd month		4 th month		5 th month	
K ₂ O levels (kg/fed)	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Effect of potassium levels										
24	3.34 a	3.23 a	4.20 a	4.13a	4.89 a	4.69 a	3.25 a	3.12 a	2.78 a	2.67 a
48	2.90 b	2.86 b	3.52 b	3.44 b	4.08 b	3.96 b	3.27 a	3.14 a	2.18 c	2.08 c
72	2.87 b	2.83 b	3.71 b	3.62 b	4.10 b	3.92 b	3.44 a	3.38 a	2.51 b	2.40 b
LSD at 0.05 significance level	0.13	0.17	0.33	0.30	0.12	0.49	NS	NS	0.11	0.07
Se (ppm)	Effect of foliar spray with selenium									
Without (control)	3.36 a	3.27 a	4.22 a	4.13 a	4.85 a	4.53 a	3.86 a	3.69 a	2.99 a	2.83 a
25	3.40 a	3.32 a	4.08 a	3.98 a	4.64 b	4.53 a	3.56 ab	3.43 ab	2.72 b	2.60 b
50	2.41 c	2.34 c	3.02b	2.96 b	3.40 c	3.33 b	2.63 c	2.55 c	1.80 d	1.73 d
100	2.99 b	2.95 b	3.92 a	3.86 a	4.54 b	4.37 a	3.25 b	3.19 b	2.45 c	2.37 c
LSD at 0.05 significance level	0.22	0.24	0.37	0.37	0.11	0.37	0.38	0.37	0.10	0.09

S1=2022/2023 season and S2=2023/2024 season

6.3 Interaction effect

The interaction between K₂O at 48 kg/fed and spraying with Se at 50 ppm, followed by the interaction between K₂O at 72 kg/fed and spraying with Se at 50 ppm, gave the lowest weight loss percentage in bulbs at different storage periods (Table 15).

This means that fertilizing onion plants during growing seasons with 48 kg/fed K₂O and spraying with Se at 50 ppm produced the minimum weight loss in bulbs, which was 1.17 and 1.12% in the fifth month in the 1st and 2nd seasons, respectively.

There was a negative correlation between TSS (%) and weight loss (%) in bulbs during storage. The interaction between K₂O at 48 kg/fed and spraying with Se at 50 ppm gave the highest values of TSS in bulbs and the lowest values of weight loss (%) during storage periods. There was a negative correlation between dry matter (%) and weight loss (%) in bulbs. The interaction between K₂O at 48 kg/fed and spraying with Se at 50 ppm gave the highest values of dry matter (%) and the lowest values of weight loss (%) during storage periods in both seasons.

The aforementioned results indicate that fertilizing onion plants cultivated in clay soil during the winter season with K₂O at 48 kg/fed and applying selenium at 50 ppm enhanced dry weight per plant, average bulb weight, marketable yield, total yield, and the nitrogen,

phosphorus, and potassium contents in bulbs at harvest. Additionally, it improved total soluble solids and dry matter in bulbs at harvest or during storage, while decreasing weight loss percentage in bulbs across various storage durations.

Table 15. Effect of the interaction between potassium level and foliar spray with selenium on weight loss (%) in bulbs at different storage periods of onion during 2022/2023 and 2023/2024 seasons

Treatments		Storage periods									
K ₂ O (kg/fed)	Se (ppm)	1 st month		2 nd month		3 rd month		4 th month		5 th month	
		S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
24	Without (control)	3.66 ab	3.53 ab	4.98a	4.93 a	5.58a	5.11 ab	4.28 a	4.06 a	3.03 a	2.82abc
	25	4.01 a	3.89 a	4.67ab	4.51 ab	5.39 b	5.30 a	3.58 bc	3.35 bc	3.02 a	2.92 ab
	50	2.69 fg	2.56 ef	3.13 ef	3.06 ef	3.63 gh	3.59 de	2.41 e	2.33 d	2.35 c	2.26 ef
	100	3.02def	2.94 cde	4.04 bc	4.02 bc	4.97 c	4.76 ab	2.75 de	2.75 cd	2.74 b	2.68 d
48	Without (control)	3.29 cd	3.22 bc	4.03 bcd	3.94 bcd	4.93 c	4.74 ab	3.88 ab	3.73 ab	3.06 a	2.92 a
	25	3.40 bc	3.30 bc	4.19 bc	4.13 bc	4.59 d	4.48 bc	3.41bcd	3.27 bc	2.24 c	2.12 f
	50	2.04 h	2.02 g	2.56 f	2.50 f	3.04 i	2.96 e	2.51 e	2.41 d	1.17 e	1.12 h
	100	2.88 ef	2.89 cde	3.32 e	3.21 e	3.77 fg	3.66 d	3.29 bcd	3.17 bc	2.26 c	2.18 ef
72	Without (control)	3.14 cde	3.06 cd	3.65 cde	3.51 cde	4.03 e	3.75 cd	3.42 bcd	3.28 bc	2.90 ab	2.76 cd
	25	2.79 efg	2.77 def	3.39 de	3.31 de	3.96 ef	3.81 cd	3.68 ab	3.67 ab	2.91 ab	2.77 bcd
	50	2.49 g	2.45 f	3.39 de	3.32 de	3.53 h	3.43 de	2.96 cde	2.91 cd	1.88 d	1.82 g
	100	3.08 cde	3.02 cd	4.42ab	4.36 ab	4.90c	4.67 ab	3.72 ab	3.67 ab	2.36 c	2.27 e
LSD at 0.05 significance level		0.38	0.42	0.64	0.64	0.19	0.65	0.66	0.65	0.17	0.13

S1=2022/2023 season and S2=2023/2024 season

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تأثير التسميد بالبوتاسيوم مع السيلينيوم على تحسين إنتاجية وجودة وقابلية تخزين البصل

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الملخص العربى

تم تنفيذ هذا العمل خلال الموسمين الشتويين لعامى ٢٠٢٢/٢٠٢٣ - ٢٠٢٣/٢٠٢٤ فى المزرعة البحثية لمحطة البحوث الزراعية بالجميزة بمحافظة الغربية بمصر بهدف دراسة تأثير التسميد البوتاسى ٢٤ ، ٤٨ ، ٧٢ كجم K_2O للفدان والرش بالسيلينيوم بتركيزات ٠ ، ٢٥ ، ٥٠ ، ١٠٠ جزء فى المليون والتفاعل بينهما على نمو النبات والإنتاجية وجودة الأبصال وكذلك القابلية للتخزين لنباتات البصل (صنف جيزة ٢٠) النامي تحت ظروف الارض الطينية.

أدى الاستخدام المنفرد للبوتاسيوم أو السيلينيوم إلى زيادة ملحوظة فى الصفات الخضرية والإنتاجية وصفات الجودة مثل محتوى الأبصال من النيتروجين والفوسفور والبوتاسيوم، وخاصةً عند أعلى تركيز. ومع ذلك، تم الحصول على أفضل النتائج للتفاعل بين هذين العنصرين عند التركيزات المختلفة. وسُجلت أفضل النتائج عند استخدام البوتاسيوم بمعدل ٤٨ كجم/فدان مع السيلينيوم بتركيز ٥٠ جزء فى المليون للصفات التى تم دراستها.

أظهر تأثير التفاعل بين البوتاسيوم والسيلينيوم بمعدل ٧٢ و ٥٠ جزءاً فى المليون، على التوالي أو (٤٨ كجم و ٥٠ جزءاً فى المليون، على التوالي) أفضل فعالية فى محتوى الأبصال من المواد الصلبة الذائبة الكلية عند كل من فترتي الحصاد والتخزين ، كما انخفضت نسبة فقدان الوزن فى الأبصال عند فترات التخزين المختلفة. ولم تُلاحظ فروق ذات دلالة إحصائية بين كلا المعاملتين فى هذا الصدد.

ختاماً فإن استخدام سماد البوتاسيوم بالاشتراك مع السيلينيوم هو نهج واعد وفعال من حيث التكلفة فى تعزيز نمو وإنتاجية البصل من حيث الكمية والجودة.