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Onion Bulb Yield and Quality as Influenced by Seed or Seedling Planting Methods As well as Potassium Fertilizer Forms, K_2SO_4 and KCl, and Their Combination

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ABSTRACT

Agronomic approaches for increasing food crop yield and quality are crucial for boosting food security due to the depletion of terrestrial resources and the rising worldwide demand for food. As a consequence, the current study looks at ways to improve several essential components of existing onion production technique in Egypt by using two types of potassium fertilizer, KCl and K2SO4, either alone or in combination, as well as two different planting methods, seeding and seedling transplantation. The research focused on the performance of onion cv. Giza 9 through vegetative growth, bulbification (bulbing ratio), dry bulb yield and bulb quality during the successive winter seasons of 2019/2020 and 2020/2021. The obtained results demonstrated that direct seeding of onion produced higher plant growth, bulb yield, and quality than seedling transplantation. Compared to potassium combinations involving chloride, potassium fertilization of onion in the form of K2SO4 produced the best plant growth, bulb production, and their quality. As chloride levels in fertilizer compounds rise, onion plant growth and yield potential decline. On the other hand, chloride had a less negative impact when onion was grown from seeds rather than seedlings. Also, direct seed sowing and fertilization interactions with either pure K2SO4 or a mixture of 75% K2SO4 and 25% KCl resulted in the highest dry bulb yield measurements. Interestingly, supplying the onion plants with KCl fertilizer up to 25% of their potassium requirements without causing a significant decline in plant growth or bulb yield when planting onions by direct seeds but not to seedlings.

KEYWORDS: Onion, cultivation method, potassium fertilizer form, K2SO4 and KCl.

1. INTRODUCTION

The onion (*Allium cepa* L.) is an important and prominent crop of the Alliaceae family and genus Allium bulb crops (Griffiths *et al*., 2002; Kumar *et al.*, 2007). It is a crucial cool-season vegetable crop. Onion contains medicinal and health-promoting flavonoids, anthocyanins, fructo-oligosaccharides, and organosulphur compounds (Goldman, 2011). These compounds and others give onion its therapeutic characteristics. As a result, onion-based medicinal formulations have been created as therapies for a wide range of ailments (Block, 1985; Belay *et al.,* 2015). It has recently become a cash crop due to its high export potential. It is cultivated worldwide for food and culinary purposes (Choudhary, 2018). In terms of economic value, it is the world's second most crucial vegetable, behind tomatoes (Mallor *et al.,* 2011). According to the Egyptian ancient texts, the onion is one of Egypt's oldest continuously produced crops, dating back to at least 4,000 BC. Also, this claim is supported by both the Bible and the Holy Quran. According to FAO (2019), Egypt ranks fourth among the top ten nations in onion production. Egypt's onion production reached more than three million tons a year. The annual onion cultivated area in Egypt is approximately 64 thousand hectares accounting for about 8.64 % of the total vegetables cultivated area in the country (Adam and Fangary, 2020).

Nutrients are essential for enhancing the productivity and quality of vegetable crops. Plants require balanced nutrition and correct fertilization to reach their maximum genetic potential (Sekara *et al.,* 2017), which is achieved by giving nutrients for their growth and development at various stages of development. Because the root structure of the onion is shallow and unbranched, it takes a lot of fertilizer to produce a good yield (Brewster, 1994; Rizk *et al.,* 2012). Onion plant nutrition is one element that determines bulb production and quality (El-Morsy *et al.,* 2016 and Khokhar, 2019 A, B). Fertilization should be aimed at increasing onion production in terms of nutrient requirements for optimum yield, reducing fertilizer costs, and increasing fertilizer usage efficiency (Lee and Lee 2014). While the role of potassium (K) in plant nutrition is universally recognized, K fertilizer approaches remain inefficient in terms of agronomic efficiency. Plants use the K nutrient for many physiological and biochemical functions such as photosynthesis, nutrient translocation, protein synthesis, water balance, and enzyme activity (Marschner, 2012). Therefore, it is vital to provide a suitable amount and source of K to onions during critical growth phases to sustain growth and quality (Subba Rao and Brar, 2002). The most popular potassium fertilizers in Egypt are potassium sulphate (K_2SO_4), potassium nitrate (KNO_3), and potassium chloride (KCl). While potassium nitrate is becoming scarce due to its improper use, KCl is less expensive, has more potassium content, and is more widely available than K_2SO_4. In addition, it has been used to fertilize various crops (Mohr and Tomasiewicz, 2012; Cabral Filho *et al.,* 2022; Chen *et al.,* 2022). Since KCl fertilizer contains chloride anion, which competes with nitrate and sulphate and reduces their uptake by plants, as well as its role as one of the components that causes soil salinity and irrigation water contamination, it is not recommended for potassium fertility (Shannon and Grieve, 1999).

Dry onion bulbs are produced by planting onion seeds. Onion is grown from seeds in one of two ways: direct seeding or transplanting seedlings after they have been grown in a nursery (Khokhar, 2019A). Depending on growing conditions, the cultivation method of onion was determined. Hence it affects the maturity, quality and quantity of dry onions production. The transplanting method was implemented during the short growing season, while the seeding method took place during the long growing season (Massiha *et al.,* 2001). Onion cultivation in Egypt for dry bulbs is still limited to seedling transplantation. Hence, there have been several research and articles published on this issue. In contrast, there is a scarcity of publications on direct seed growing.

The proper fertilizer form, growing technique, and agronomic operations are required to achieve significant onion productivity and quality. As a result, this research has focused on planting methods; seedling transplantation or direct seeding, and potassium fertilizer types to improve onion bulb yield and their quality.

2. MATERIALS AND METHODS

The experiment was established from October to April on clay soil at the experimental farm of the Hort. Dept., Faculty of Agriculture, Ain Shams University, Cairo, Egypt, for two consecutive winter seasons of 2019-2020 and 2020-2021. The effects of two planting methods (direct seeding and seedlings) and two potassium fertilizer types (K_2SO_4 48-52% K_2O and KCl 50% K_2O), and their combination percentages in meeting the potassium requirements of onion plants cv. Giza9 were investigated. The potassium fertilizer treatments are 100% K_2SO_4, 75% K_2SO_4 + 25% KCl, 50% K_2SO_4 + 50% KCl, 25% K_2SO_4 + 75% KCl, and 100% KCl. The field experiment had three replications and was set up in a split-plot design. This experiment included 10 treatments which were the combinations between 2 planting methods and 5 potassium treatments. The planting methods were laid out in the main plots, while potassium fertilizer types were distributed randomly in the sub-plots. The onion seeds were purchased from the Agricultural Research Center, Cairo, Egypt. The soil employed for the planting was medium-to clay-textured. Before the crop planting, soil samples were taken from the 0–20 cm layer. The physical and chemical properties of the soil are shown in Table 1, while the irrigation water source is the Nile River.

Table 1. Physical and chemical properties of the 0–20 cm soil layer in the experimental soil before onion cultivation.

Physical and chemical Properties							
Sand (%)	**Silt (%)**	**Clay (%)**	**Texture**	**pH**	**Ca^{++} (meq/l)**	**Mg^{++} (meq/l)**	**K^{+} (meq/l)**
23.30	36.00	40.70	Clay	7.43	0.61	1.77	1.14
Na^{+} (meq/l)	**Cl^{-} (meq/l)**	**CO_3^{--} (meq/l)**	**HCO_3^{-} (meq/l)**				
0.56	0.59	0	0.29				

Data presented as averages for the both growing seasons

Before planting, the soil was plowed and leveled, and the beds were raised. The phosphorus fertilizer was applied in the form of triple superphosphate at a rate of 148 kg P_2O_5 ha^{-1}. The fertigation technique was used to apply the other nutrients, including potassium, once a week. Fertilization started 15 days after planting and lasted till one month before harvest. The onion crop was managed for phytosanitary and weed control, as well as other agronomic practices, according to onion producers and the Egyptian Agriculture Ministry's recommendations. With a mean flow rate of 4 L h^{-1}, the drip irrigation system was employed with two lines per bed 45 cm apart and pressure-compensating drippers 30 cm apart. Irrigation was applied once or twice weekly based on the temperature, and the water requirements were calculated based on crop evapotranspiration (Allen *et al.*, 1998). The experimental plot consisted of three beds 1 m wide and 5 m long, each having six planting rows spaced by 15 cm and 10 cm between plants (Kumar *et al.*, 2018). In the direct seeding process, a hand-rolling seeder was utilized to plant 3 to 4 onion seeds per pit. After 45-50 days from sowing seeds, the seedlings were thinned, leaving just one seedling per pit. While for the second planting method, transplanting, the seedlings obtained through thinning were utilized. The seedlings were transplanted at the same spacing, 15 X 10 cm, as the prior raised beds. The second factor is the type of potassium fertilizer used. Based on soil analysis, guidelines of onion producers and the Egyptian Agriculture Ministry recommendations, a potassium amount of 178 kg K_2O ha^{-1} (356 kg K_2O as K_2SO_4 or as KCl) was proposed to meet the onion requirements.

2.1. Data recorded

2.1.1. Vegetative growth characteristics

A sample of ten plants from the four inner rows of each experimental plot was randomly taken to record the vegetative characteristics. After 90 days of planting, the plant length was measured from the base of the stem to the tip of the longest leaf. In addition, leaf number per plant was counted, and leaf length and leaf diameter were measured. Afterward, the plant samples were collected, then the plant samples were oven dried at 70°C until constant weight to record the shoot and root dry weight. Also, root to shoot ratio and bolting ratio were recorded.

2.1.2. SPAD readings

The leaf greenness of the plants was measured by a portable chlorophyll meter (SPAD–502, Konica Minolta Sensing, Inc., Japan), which can be used to estimate total chlorophyll amounts in leaves of plants (Neufeld *et al.*, 2006). In each experimental plot, SPAD reading was determined on six healthy, fully-developed leaves per plot three times throughout the season which was then averaged.

2.1.3. Yield and bulb quality attributes

Plant neck thickness, bulb diameter, average bulb weight, bulb dry weight, bulb total soluble content, total bulb yield and marketable bulb yield were taken at the harvesting date. Also, the harvest index was derived by dividing the total fresh bulb weight by the total fresh biomass weight, then multiplying the result by 100. While the bulbing ratio was calculated using Mann's (1952) formula: Bulbing ratio = Neck diameter/Bulb diameter at the end of the growing season.

In addition, the total bulb yields, marketable and unmarketable bulb yields, were calculated for each plot. The small-diameter, split and bolted bulbs, the mechanically and pathologically damaged bulbs, and other defective bulbs were all regarded as unmarketable.

Mineral analysis of onion leaves and bulbs

The mineral content of leaves and bulb's dry matter were assayed. After 90 days from planting, the N, P, K, and Cl percentages in the leaves were analyzed, while N and S percentages in the bulb were tested at the time of harvest leaf samples. Ten leaves and five onion bulbs from each plot were chosen for elements analysis. After drying the plant samples (leaves and bulbs) at 70 C$^{\circ}$ until constant weight, the dried samples were ground to fine powder to pass a 1 mm sieve. Afterwards, 0.1 g of the dried samples was taken and wet digested as described by (Thomas *et al.*, 1967), by using a mixture of sulphuric acid (H_2SO_4 98%) and hydrogen peroxide (H_2O_2 30%). The mineral content of leaves was assayed in the digested solutions. Total nitrogen was determined using Kjeldahl method as described by (Fixen and Grove, 1990). Colorimetrically, phosphorus content was measured by using spectrophotometer using the ascorbic acid method as described by (AOAC, 2005). Also, potassium was measured by flame photometer as described by (Knudsen *et al.,* 1983). Chloride was measured by Mohr's method as described by (AOAC, 2005). Moreover, Sulphur was assayed by magnesium nitrate method as described by (AOAC, 2005).

2.2. Statistical analysis

The collected data were subjected to homogeneity test (Levene's test) prior to analysis of variance (ANOVA). Since the outputs proved that the homogeneity and normality of the data are satisfied for running further a 2–way ANOVA, the combined ANOVA for the data of the two seasons was performed. Then data were subjected to statistical analysis of variance procedure using two-way-ANOVA of the CoStat package program (Microcomputer Program Analysis, Version 6.303; CoHort Software, CA, USA). Duncan's multiple range test at 5% level of probability was employed to compare the significant differences among means of the treatments (Waller and Duncan, 1969).

3. RESULTS

Table (2) shows the response of onion plants to various planting methods, seed sowing, and seedling transplantation, as well as the use of five different potassium fertilizer combinations of K_2SO_4 and KCl. Planting onion with direct seed improved onion plant length, leaf number, leaf length, leaf diameter, leaf chlorophyll index, shoot dry weight, and root dry weight compared to seedling transplantation. Nevertheless, the root-to-shoot ratio and bolting ratio are higher with seedling transplantation than with direct seed sowing. Onion plants fertilized with a mix of K_2SO_4 and KCl had diverse responses to the parameters examined based on the percent of both. With K_2SO_4, plant length, leaf number, leaf length, leaf chlorophyll index, and dry weight of both shoot and root increased but decreased as the KCl % increased. The lowest values were linked to the use of 100% KCl fertilizer. However, a higher KCl ratio was linked to larger leaf diameter, root-to-shoot ratio, and bolting ratio values. As a result, the highest values of these three traits were attained when all potassium requirements were applied in the KCl form. The leaf chlorophyll index was highest with a potassium fertilizer mix of 75% K_2SO_4 and 25% KCl, then dropped as the KCl ratio increased. When plants were supplied with potassium requirements in the K_2SO_4 form, the chlorophyll index value stood between those fertilized by mixes of KCl and K_2SO_4 or absolute KCl. Also, for all K_2SO_4 and KCl ratios, results showed that all onion plant traits as onion plant length, leaf number, leaf length, leaf diameter, leaf chlorophyll index (SPAD reading), shoot dry weight, and root dry weight, were higher when planting onion by sowing seed directly than planting by seedling.

Meanwhile, at all K_2SO_4 and KCl ratios, the onion plant grown from direct seed sowing had a lower root-to-shoot ratio and bolting percentage than the seedling plantation.

Table 2. Effect of planting method and potassium fertilizer form on onion vegetative growth after 90 days of planting as a combined analysis of the two growing seasons 2019-2020 and 2020-2021.

Treatments		Plant length (cm)	No. of leaves	Leaf length (cm)	Leaf diameter (cm)	Leaf chlorophyll index	Shoot dry weight (g)	Root dry weight (g)	Root to shoot ratio	Bolting ratio
Planting method										
Seeding		45.45a	9.10a	34.12a	1.20a	49.28a	10.59a	1.29a	0.12b	1.68b
Seedling		38.86b	7.92b	32.13b	1.13b	48.31b	7.35b	0.99b	0.13a	3.13a
Potassium fertilizer form										
100% K_2SO_4 + 0% KCl		44.86a	10.07a	37.80a	1.12d	50.00c	11.40a	1.34a	0.12c	1.25d
75% $K2_SO4$ + 25% KCl		43.70b	9.32b	36.96b	1.12d	54.15a	10.70b	1.31a	0.12c	1.40d
50% $K2_SO4$ + 50% KCl		41.48c	8.26c	33.50c	1.15c	52.14b	9.16c	1.17b	0.13b	2.11c
25% $K2_SO4$ + 75% KCl		41.22c	7.75d	31.11d	1.18b	46.63d	7.69d	1.03c	0.13b	3.16b
0% K_2SO_4 + 100%KCl		39.49d	7.15e	26.26e	1.24a	41.06e	5.89e	0.86d	0.15a	4.13a
Planting method X Potassium fertilizer form										
Seeding	**100% K_2SO_4 + 0% KCl**	47.63a	10.50a	39.10a	1.16d	50.58c	13.18a	1.49a	0.11e	0.86f
	75% K_2SO_4 + 25% KCl	46.87b	9.83b	38.13b	1.15d	54.87a	12.05b	1.44a	0.12d	0.97f
	50% K_2SO_4 + 50% KCl	44.50c	8.80c	34.53e	1.18cd	52.81b	10.49c	1.32b	0.13c	1.48e
	25% K_2SO_4 + 75% KCl	44.40c	8.47c	31.77g	1.22b	47.03e	9.45d	1.21c	0.13c	2.21d
	0% K_2SO_4 + 100%KCl	43.83c	7.90d	27.07i	1.28a	41.13f	7.76e	1.02d	0.13c	2.90c
Seedling	**100%K_2SO_4 + 0% KCl**	42.09d	9.63b	36.51c	1.09e	49.42d	9.63d	1.20c	0.12d	1.64e
	75% K_2SO_4 + 25% KCl	40.53e	8.79c	35.78d	1.09e	53.43b	9.35d	1.18c	0.13c	1.82e
	50% K_2SO_4 + 50% KCl	38.46f	7.73d	32.46f	1.11e	51.47c	7.83e	1.01d	0.13c	2.74c
	25% K_2SO_4 + 75% KCl	38.04f	7.04e	30.45h	1.15d	46.24e	5.92f	0.86e	0.14b	4.10b
	0% K_2SO_4 + 100% KCl	35.15g	6.42f	25.45j	1.20bc	40.98f	4.02g	0.69f	0.17a	5.36a

It's worth noting that, regardless of planting method, onion plants responded similarly to K2SO4 and KCl ratios. Nevertheless, direct seed sowing produced more vigorous plants than seedling sowing.

Table (3) displays the effect of planting methods (seed sowing and seedling transplant), as well as potassium fertilizers (K_2SO_4 and KCl) on onion bulb yield and related characteristics. Onion growth methods significantly impacted total and marketable dry bulb yield, as well as relevant traits like neck thickness, average bulb weight, bulb diameter, bulb dry matter percent, and bulb TSS content.

When comparing planting onion by direct seed sowing to planting seedlings, all of the characteristics were significantly greater with direct seed sowing. These characteristics were greatly enhanced by fertilizing with pure K_2SO_4 or a mixture of 75% K_2SO_4 and 25% KCl. But all of these characteristics were significantly reduced as the percentage of KCl increased in the mixed potassium fertilization (K_2SO_4 + KCl). The combination of planting methods with mixed potassium fertilizer of K_2SO_4 and KCl substantially impacted onion dry bulb production and related traits. When fertilized with a mix of K2SO4 and KCl potassium forms, onion plants grown from direct seed sowing outperformed that grown from seedlings. Direct seed sowing and fertilization interactions with either pure K2SO4 or a mixture of 75% K2SO4 and 25% KCl resulted in the highest dry bulb yield measurements. Plants developed from seedlings and subsequently fertilized with KCl potassium type had the least significant values of these characteristics.

Table 3. Effect of planting method and potassium fertilizer form on onion bulb properties and yield as a combined analysis of the two growing seasons 2019-2020 and 2020-2021

Treatments		Neck thickness (cm)	Average bulb weight (g)	Bulb diameter (cm)	Bulb dry matter %	Bulb TSS %	Total bulb yield	Marketable bulb yield	Harvest index %
Planting method									
Seeding		1.31a	90.85a	5.97a	13.97a	12.14a	18.11a	16.40a	72.41a
Seedling		1.18b	79.59b	4.84b	12.43b	11.48b	15.14b	14.39b	69.12b
Potassium fertilizer form									
100% K_2SO_4 + 0% KCl		1.43a	96.78a	6.36a	13.86a	12.22a	19.00a	18.20a	75.61a
75% K_2SO_4 + 25% KCl		1.39a	94.06b	6.13a	13.81a	12.06ab	18.50b	17.42b	74.96a
50% K_2SO_4 + 50% KCl		1.26b	87.84c	5.39e	13.33b	12.00ab	17.39c	15.90c	72.58b
25% K_2SO_4 + 75% KCl		1.14c	80.23d	4.84c	12.81c	11.58b	15.29d	13.71d	68.59c
0% K_2SO_4 + 100%KCl		1.01d	67.20e	4.31d	12.18d	11.19c	12.93e	11.73e	62.11d
Planting method X Potassium fertilizer form									
Seeding	**100% K_2SO_4 + 0% KCl**	1.51a	102.00a	6.83a	14.35a	12.50a	20.62a	19.41a	77.87a
	75% K_2SO_4 + 25% KCl	1.48a	99.53a	6.67a	14.30a	12.27a	20.09a	18.55b	77.09a
	50% K_2SO_4 + 50% KCl	1.34b	93.26b	5.93b	14.00b	12.40a	18.92b	16.96c	74.00b
	25% K_2SO_4 + 75% KCl	1.19c	86.23d	5.53b	13.86b	11.90ab	16.70d	14.47d	69.96c
	0% K_2SO_4 + 100%KCl	1.01d	73.25f	4.87c	13.31c	11.63ab	14.21f	12.60e	63.14e
Seedling	**100%K_2SO_4 + 0% KCl**	1.36b	91.55bc	5.88b	13.37c	11.94ab	17.38c	16.99c	73.34b
	75% K_2SO_4 + 25% KCl	1.30b	88.59cd	5.60b	13.32c	11.85ab	16.91cd	16.30c	72.82b
	50% K_2SO_4 + 50% KCl	1.17c	82.42e	4.85c	12.66d	11.61ab	15.86e	14.84d	71.15c
	25% K_2SO_4 + 75% KCl	1.09cd	74.23f	4.14d	11.77e	11.26bc	13.88f	12.94e	67.21d
	0% K_2SO_4 + 100% KCl	1.00d	61.16g	3.75d	11.04f	10.74c	11.65g	10.85f	61.09f

The obtained results are in good agreement with those reported by (Ahmed and

Hassan, 1978), who stated that the direct seeding method showed a higher yield (14.5 ton/ha) as compared with the transplanting method (6.6 ton/ha) of Nasi, Shendi Red and Dongola White Imp. onion cultivars. On the contrary, others revealed that cultivating onions with sets or transplants showed higher yield than direct seeding planting method on Bombay Red, Nasik Red and Adama

Red cultivars (Ketema et al., 2013), and on Azar-Shahr and Horand cultivars (Massiha et al., 2001). Similarly, on other vegetable crops, results showed that the cultivation of the plants by seedlings gave higher vegetative growth and yield than those planted by direct seeds on globe artichoke (Leskovar and Othman, 2021).

Data presented in Table 4 showed that the planting method, direct seeding and seedlings transplanting, had a significant impact on the nitrogen (N), phosphorous (P), potassium (K), and chloride (Cl) content of the onion leaves. In the case of sowing seeds directly, the leaf N, P, and K content were higher than at transplant seedlings. On the other hand, planting seedlings gave the highest value of leaf Cl content. While fertilizing onion plants with potassium fertilizers (K_2SO_4 and KCl) and their mixtures, the leaf content of N, P, and K was higher. Nevertheless, the leaf content of Cl was lower when onion plants received all of their potassium requirements in both K_2SO_4 form and a 75% K_2SO_4 + 25% KCl mixture. The findings revealed that by increasing the percentage of KCl in the fertilizer mixture, the onion leaf N, P, and K contents declined, while the Cl level increased. The amount of N, P, K, and Cl in onion leaves was significantly influenced by the combination of potassium fertilizers and the planting method. The impact of potassium fertilizers, K_2SO_4 and KCl, on onion leaf content of these elements was unchanged by planting method. Meanwhile, by planting direct seeds rather than seedlings, the positive effect of potassium fertilizers (increased N, P, and K levels) was amplified, while the negative impact was mitigated by decreasing the Cl level.

Table 4. Effect of planting method and potassium fertilizer form on onion leaf and bulb nutrients content as a combined analysis of the two growing seasons 2019-2020 and 2020-2021

Treatments		Leaf N %	Leaf P %	Leaf K %	Leaf Cl %	Bulb N %	Bulb S %
Planting method							
Seeding		0.97a	0.39a	1.35a	0.36a	1.01a	87.12a
Seedling		0.94b	0.38b	1.26b	0.38b	0.98b	86.59b
Potassium fertilizer form							
100% K_2SO_4 + 0% KCl		1.06a	0.44a	1.64a	0.25d	1.07a	92.28a
75% K_2SO_4 + 25% KCl		1.04a	0.43b	1.61b	0.25d	1.06b	91.21a
50% K_2SO_4 + 50% KCl		0.98b	0.40c	1.41c	0.35c	1.02c	88.69b
25% K_2SO_4 + 75% KCl		0.91c	0.35d	1.15d	0.45b	0.96d	84.78c
0% K_2SO_4 + 100%KCl		0.80d	0.31e	0.71e	0.57a	0.88e	77.33d
Planting method X Potassium fertilizer form							
Seeding	**100% K_2SO_4 + 0% KCl**	1.08a	0.45a	1.70a	0.24e	1.07a	92.65a
	75% K_2SO_4 + 25% KCl	1.06a	0.44ab	1.68a	0.25e	1.06ab	91.55ab
	50% K_2SO_4 + 50% KCl	0.99cd	0.41d	1.47d	0.33d	1.03bc	88.97b
	25% K_2SO_4 + 75% KCl	0.90e	0.36f	1.18f	0.42bc	0.98d	84.96c
	0% K_2SO_4 + 100% KCl	0.80f	0.31h	0.74h	0.57a	0.92e	77.49d
Seedling	**100% K_2SO_4 + 0% KCl**	1.03b	0.43bc	1.59b	0.25e	1.07a	91.91ab
	75% K_2SO_4 + 25% KCl	1.01bc	0.42cd	1.54c	0.25e	1.05ab	90.87ab
	50% K_2SO_4 + 50% KCl	0.97d	0.39e	1.36e	0.37cd	1.01c	88.41b
	25% K_2SO_4 + 75% KCl	0.91e	0.34g	1.12g	0.47b	0.94e	84.60c
	0% K_2SO_4 + 100% KCl	0.79f	0.30h	0.68i	0.57a	0.85f	77.18d

The nitrogen (N) and sulfur (S) content of dry bulbs as a chemical quality indicator appeared to be significantly influenced by the planting methods and the potassium fertilizers, K2SO4 and KCl. Direct seeding of onions increased the N and S content in the dry bulb compared to planting with seedlings. The highest significant values of N and S in bulbs were recorded at applying 100% K2SO4 or a mixture of 75% K2SO4 and 25% KCl. However, the lowest significant values were attained when the complete potassium requirement was met by 100% KCl. Regardless of the planting method, K2SO4 and KCl, as well as their combination, continue to have the same impact on the N and S content of onion bulbs.

4. DISCUSSION

Concerning the planting method, it has been found that cultivating onions by direct seeding method at an appropriate time enhanced the establishment of the onion plants after cultivation as well as decreased the bolting of the plants, hence the early cultivation increased the bolting, while the late cultivation did not give the suitable period for growing and developing (Boyhan *et al.,* 2005). Also, it increased the total yield as compared with the other cultivating methods (Boyhan *et al.,* 2008). Moreover, the type, structure and growth of the root differs according to the planting method. The seedlings transplanting gave fibrous, shallow, poor spread and sparsely branched root system that only distributed at the top soil surface. However, the direct seeding planting method produces at first a tap root (primary root) that penetrates the soil surface and go deeper than the seedlings, then it gives branched lateral roots, and hair roots, then several new roots were developed near the base of the onion stem. As shown in Table 2, the dry weight of roots at the direct seeding planting method is higher than that recorded at seedlings transplanting method. Subsequently, the more spread and growth of the root system at the direct seeding planting method, which is more strong and efficient than the fibrous roots of the transplanted plants at nutrients uptake and acquisition. So the more vigorous onion plants at direct seeding planting method may be imputed to the larger growth of the root system that was reflected on the vegetative growth in terms of stem, leaf and root dry weight (Leskovar *et al.,* 1990) as compared to seedlings transplantation method. Accordingly, as a result of the large root system and the vigorous vegetative growth of the onion plants as shown in Table 2, the photosynthesis process and carboxylation efficiency and carbohydrates accumulation was higher in direct seeding than seedlings transplanting method, and that was clearly reflected on the yield and quality parameters of onion cv. Giza 9 as mentioned in Table 3.

On the other hand, the humble growth of transplanted plants may be attributed to the transplanting shock that faces the seedlings at the field after cultivation, which delays the establishment of transplants in the field. This shock may be as a result of drying out of plant roots between digging and transplanting, resulting in root damage and/or death (Lee *et al.,* 2021). Conversely, the direct-seeded plants don't been affected by the transplanting shock and were successfully established at the field after the sowing and germination of the seeds, and this reason can also clarify the vigorous growth of the direct-seeded plants.

Interestingly, onion is relatively sensitive to salt stress (Shannon and Grieve, 1999), the application of potassium chloride provides surplus amount of K to plants but associated with salinity stress. This salinity stress may cause root shrinkage and inhibit the plant development (Kiełkowska, 2017). Although the soil of the present study was not saline, a single application of the seasonal KCl dose often causes a transient salt stress, which may negatively affect early plant development.

Chloride ion uptake correlates with the water flow, thereby fertilizing the plants with KCl fertilizer increases the cl^- ions concentration in the plant cells (Geilfus, 2018). The chloride ions impede plant growth, hence it interrupts various physiological process; inhibition of enzymes at the photosynthesis process, disturbance of membrane selective permeability that leads to a decline of nitrogen and phosphorus uptake and disturbance at the cellular water relationships (Grattan and Grieve, 1999). In addition, mainly the potassium, chloride ions, malate and sugars accumulate at guard cells and control the stomata opening in the plants, hence the water flow in the plant *via* transpiration pull (Jezek and Blatt, 2017). By increasing the level of Cl^- ions in the plant cells, it interrupts the guard cells function at stomata closure, thereby the plants dehydrate and stressed (Ozkan *et al.*, 2018).

Using KCl as a source of potassium significantly enhanced the yield and quality of onion bulbs and other crops (Mohr and Tomasiewicz, 2012; Cabral Filho *et al.*, 2022; Chen *et al.*, 2022). Hence, it proves that the onion yield and quality depended on a considerable K supply (Ozkan *et al.*, 2018). However, using potassium sulphate revealed more significant values for yield and quality (Wilmer *et al.*, 2022), which can be attributed to the sensitivity of onion to salt stress caused by chloride ions. In addition, the Application of moderate to high rates of KCl reduced petiole NO_3 concentration due to antagonism between NO_3 and Cl anions in potato plant cv. Russet Burbank (Mohr and Tomasiewicz, 2012).

4. CONCLUSION

The current research shows that planting onion *via* direct seed improves growth, dry bulb production, and quality when compared to seedlings transplantation. It also highlights the significance of adequate K supply in achieving healthy plants, high yields, and good onion quality. It is preferable to provide onion plants all of their potassium in the form of K_2SO_4 rather than KCl. There were no negative impacts from using KCl fertilizer to meet less than half of the potassium demand, especially when the soil and irrigation water had low chloride content. In terms of water and potassium use efficiency, direct seeding outperformed seedling planting.

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الملخص العربى

تأثر محصول وجودة أبصال البصل بطريقتي الزراعة بالبذور والشتلات وكذلك بصورة السماد البوتاسي بسلفات البوتاسيوم وكلوريد البوتاسيوم

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إن تطبيق الأساليب الزراعية الجيده لزيادة إنتاجية المحاصيل الغذائية تعتبر ضرورية لتعزيز الأمن الغذائي بسبب نضوب الموارد الأرضية وزيادة الطلب العالمي على الغذاء ونتيجة لذلك يهدف هذا البحث الى البحث عن أنسب طرق إنتاج محصول البصل في مصر من خلال استخدام نوعين من سماد البوتاسيوم هما كلوريد البوتاسيوم (KCl) وسلفات البوتاسيوم (K_2SO_4) كلا بمفرده أو بخلطهما معًا بنسب مختلفه لتحقيق احتياجات عنصر البوتاسيوم المطلوبه لزراعة البصل فى الأرض القديمه بمحافظة القليوبيه ، بالإضافة إلى طريقتين مختلفتين للزراعة هما الزراعه بالبذور مباشرة والزراعه بالشتلات وقد تم تجميع البيانات على خصائص النمو الخضرى ومحصول وجودة الأبصال الجافه للبصل صنف جيزة ٩ خلال مواسم الشتاء المتتالية ٢٠١٩/٢٠٢٠ و ٢٠٢٠/٢٠٢١ وقد أظهرت النتائج أن زراعة البصل بالبذور مباشرة قد أدى إلى نمو نباتي أفضل ، وإنتاجية وجوده أعلى من الأبصال الجافة مقارنة بزراعة الشتلات وبمقارنة مصدري عنصر البوتاسيوم (سلفات البوتاسيوم وكلوريد البوتاسيوم) فقد أوضحت النتائج أن تسميد محصول البصل بالبوتاسيوم على صورة K_2SO_4 قد أعطى أفضل البيانات على النمو الخضرى ومحصول وجودة الأبصال وذلك مقارنة بسماد KCl وأيضا مع ارتفاع نسبة سماد KCl في مخاليط أسمدة البوتاسيوم المستخدمه فى التجربه يضعف نمو نباتات البصل وينخفض محصول الأبصال ومن ناحية أخرى فقد ظهر أن التأثير السلبي للكلوريد كان أقل عند زراعة البصل بالبذور مباشرة مقارنة بالشتلات ومن الجدير بالذكر أن تسميد محصول البصل بسماد KCl حتى ٢٥٪ من احتياجاتها من البوتاسيوم لم يسبب انخفاض معنوى في نمو النبات أو محصول الأبصال وذلك عند زراعة البصل بالبذور المباشرة دون الزراعه بالشتلات وعلى ذلك فإن النتائج توضح أفضلية زراعة البصل بالبذور مباشرة وأيضا أفضلية سماد سلفات البوتاسيوم لكن من الممكن استخدام نسبه من سماد كلوريد البوناسيوم حتى ٢٥% من احتياجات البوتاسيوم دون تأثير سلبى معنوى فى حالة الزراعه بالبذره مباشرة وذلك تحت ظروف مماثله من حيث التربه وظروف البيئه.