*Horticulture Research Journal, 2 (4), 116-132 , December 2024, ISSN 2974/4474*

# Potential Impact of Gypsum Supplementation and Foliar Spraying with Different Sources of Potassium on Yield and Quality of Carrot

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## ABSTRACT

The current research was conducted during the two winter seasons of 2020/2021 and 2021/2022 at Shabrawish Village, Aga, Dakahila Governorate, to investigate the effect of agriculture gypsum addition to the soil at the rate of 1 t/fed., with foliar application of different sources of potassium at a dose of 4000 ppm $K_2O$ (potassium sulfate, potassium citrate, monopotassium phosphate, potassium thiosulfate, potassium silicate) and their interaction on growth, yield and root quality of carrot, Fire Wedge F1 Hybrid. Results indicated that agriculture gypsum addition to the soil had significant increased growth parmeter, i.e. plant height, number of leaves/plants, and fresh and dry weight of shoots. Furthermore, root length, root diameter, fresh and dry weight of roots, total yield (t/fed.) and percent of NPK, chlorophyll a, b and total chlorophylls a + b content in the leaves. In addition, NK, total soluble solids (TSS) and ascorbic acid (vitamin C) contents in the roots in both seasons. Similarly, foliar application with different sources of potassium significantly increased vegetative growth characters, root yield and its components, chemical contents and root quality parameters in both seasons. Foliar spraying with potassium thiosulphate and monopotassium phosphate was more effective than other sources of potassium. In general, the highest values of all the aforementioned study traits were recorded with those plants received agriculture gypsum combination with foliar spraying of potassium thiosulphate or monopotassium phosphate.

**Keywords: Carrot- Gypsum potassium thiosulphate- Monopotassium phosphate-Yield**.

## INTERODUCTION

Carrot (*Daucus carota* L.) is a very important vegetable of winter season, carrots are consumed as fresh, after cooking and are very nutritive vegetables, during it is a good source of carbohydrates, carotenes, vitamins, polyphenols, flavonoids, minerals and fibers (Que et al., 2019). Agriculture gypsum is a natural source of calcium (Ca) and sulfur (S) that recommended for application in agricultural soils to improve soil quality and growth of plants (Tirado-Corbal et al., 2017). In plants, calcium supplementation can improve growth parameters, including root length, shoot biomass, and total yield (Aparna et al., 2023). Sulphur improved the content and yield of protein in carrot and radish (Singh et al., 2016). Uddin et al. (2021) reported that the higher rate (150 kg/ha) of gypsum fertilizer increased 46.5% higher yield over control treatment on kohlrabi. Potassium application could be more effective for carrot optimum yield and quality enhancement (Ahmad et al., 2021). Through reproductive growth stages, competition for photo assimilates between developing root and vegetative organs can reduce root growth activity and K uptake (Ho,1988). Thus, soil-derived K, which is vital for root growth, yield and quality is not always proper during the critical root development stage also, competition for binding places on roots from cations such as magnesium and calcium (Engels and Marschner, 1993), so lead to poor fruit quality, and yield (Lester et al., 2006). The unwise and random use of fertilizers also results in soil salinity, leading to a decrease in crop productivity (Cai, 2019). Therefore, it is necessary to adopt technologies that could improve crop production, and soil fertility. Especially in heavy clay where K is unavailable for the plants (Marchand and Bourrie, 1999). The foliar spraying fertilization method is more economical and efficient than the soil fertilization. However, carrot yield, biochemical composition, and vegetative development were all enhanced by foliar application of additional K sources (Omar and Ramadan, 2018). Little amounts of fertilizers can be applied per hectare it decreases the applicant passage, soil compactness problem and thus the groundwater pollution (Shaban et al., 2018). Potassium has several functions in plant growth, it is vital for photosynthesis, enzymes activity to metabolize carbohydrates, for the building of amino acid and proteins, promoting cell division and growth, in addition to transport of sugars produced by photosynthesis to storage organs such tubers, roots and fruits (EL-Gamal et al., 2016). Due to their unique properties and modes of action on vegetal metabolism, various potassium sources may have varying effects on yield and quality (Schonherr and Luber, 2001). Foliar spraying by potassium sulfate at dose of 1.5 ml/l increased the growth, yield and quality of carrot plants El-Tohamy et al. (2011). Metwaly et al. (2020) recorded that foliar feeding with potassium citrate (1000 ppm) gave the highest dry matter of garlic bulbs. Baddour and Masoud (2022) obtained that foliar spraying by monopotassium phosphate at a dose of (2000 ppm) gave the higher dry matter in the tuber percent and specific gravity of potato crop. Potassium thiosulphate improved plant growth, chemical constituents, yield and quality of garlic (Shafeek et al., 2016). Foliar application plants with potassium silicate improved yield and its attributes, overall fruit quality (El Nagy et al., 2020) on sweet potato.

The objective of this research was to investigate the effect of addition agriculture gypsum to soil and foliar spraying with different sources of potassium on growth, yield and quality of carrot.

## MATERIALS AND METHODS

Two field trials were carried out during the winter seasons of 2020/21 and 2021/22 at Shabrawish Village, Aga, Dakahila Governorate, Egypt to investigate the effect of addition agriculture gypsum to soil and foliar spraying with different sources of potassium on growth, yield and quality of carrot.

**Table (1). Some physical and chemical properties of the experimental soil surface layer (at the depth of 0-30) before planting in 2020/21 and 2021/22 seasons.**

| | |
|---|---|
| **Physical characteristics** | |
| Texture | Clayey |
| Sand (%) | 23.05 |
| Silt (%) | 17.43 |
| Clay (%) | 59.52 |
| Electrical conductivity (dS.m-1) | 1.62 |
| pH (1:2.5 soil: water) | 7.9 |
| Anion exchange capacity (meq 100 g-1 soil) | |
| $HCO_3^-$ | 0.53 |
| $CL^-$ | 0.41 |
| $SO_4^-$ | 1.35 |
| **Chemical characteristics** | |
| $CaCO_3$ (%) | 1.74 |
| Organic matter (%) | 1.45 |
| Available nutrients (ppm) | |
| N (ppm) | 72.1 |
| P (ppm) | 14.6 |
| K (ppm) | 68.4 |
| Fe | 3 |
| Zn | 1.5 |
| Mn | 1.4 |
| Cation exchange capacity (meq 100 g-1 soil) | |
| $Ca^{2+}$ | 1.13 |
| $Mg^{2+}$ | 0.88 |
| $K^+$ | 0.85 |
| $Na^+$ | 1.06 |

**Experimental Design:**

Seeds of Carrot (*Daucus carota* L.) F1 Hybrid Fire wedge (produced by Takii seeds company, Japan imported by Seif Gaara Co., Egypt) were sown on 5th and 12th October during 2020 and 2021 seasons respectively, in the upper bed at an approximate planting depth of 0.5 cm, with a spacing of 4-5 cm between plants in rows that were 20 cm apart. Each plot area was 21.6 m² (the plot consisted of three beds, each was 6 m in length and 1.2 m in wide). Common cultural practices concerning carrot production, such as surface irrigation, fertilization, weed control and pest management, were conducted whenever necessary according to the recommendation of the Egyptian Ministry of Agriculture and Land Reclamation. The present experiment included twelve treatments, which were the combinations of two gypsum ($CaSO_4 . 2H_2O$) application treatments (with and without), and five potassium sources as foliar spraying beside unsprayed treatment (control). These treatments were arranged in a split plot in a complete randomized block design with three replications. Gypsum ($CaSO_4$) application was arranged in the main plots and the potassium sources were randomly arranged in the sub plots, as follow:

**a. Main plots (fertilization treatments):**

- **Without (G0).**
- Gypsum ($CaSO_4$) application at a rate of 1 ton/feddan.

**b. Sub-plots (Anti-stress treatments):**

- Control, only sprayed with tap water.
- Potassium sulfate (PS, 50% $K_2O$), applied at concentration of 8g/l.
- Potassium citrate (K Cit, 38% $K_2O$), applied at concentration of 10.52g/l.
- Monopotassium phosphate (MKP, 52% $P_2O_5$ - 34% $K_2O$), applied at concentration of 11.76g/l.
- Potassium thiosulfate (KTS, 36% $K_2O$ - 25% S), applied at concentration of 11.11g/l.
- Potassium silicate (K Sil, 28% $K_2O$), applied at concentration of 14.28 g/l.

Foliar application with potassium source at a rate of 4000 ppm $K_2O$ for each type were started 35 days after sowing and repeated twice every 15 days. Agriculture gypsum (purity 75%, sulfur 18%, calcium 22%) was obtained from Abo Zaabal Co., Egypt.

During the soil preparation process, mineral fertilizers were added as follows: calcium super phosphate (12.5% $P_2O_5$) at a rate of 40 kg P2O5/feddan mixed with agriculture gypsum at a rate of 1 tons/feddan to the surface soil layer (0-30 cm), ammonium nitrate (33.5% N) as a source of nitrogen at a rate of 60 kg N/fed., as three equal portions at 5, 7, and 9 weeks from the date of seeding, and potassium sulfate (50 % $K_2O$/fed.) at a rate of 50 Kg $K_2O$/feddan divided into two equal portions, one before planting and the second with the final rate of nitrogen fertilizer. The Ministry of Agriculture's recommendations led to the addition of agricultural techniques.

Data recorded:

**Vegetative growth parameters:**

Ten plants were taken randomly from each plot at 80 days after sowing date in both seasons to determine: plant height (cm), number of leaves/plant, fresh weight (g)/and dry weight (g) of shoot/plant.

**Yield and its components:**

At harvest time (120 days after sowing), the following date was recorded: root length (cm), root diameter (cm), root fresh weight/ plant (g), total root fresh weight (t/fed.), and root dry matter/plant (g).

For estimation of root dry mater, roots were dried at 70 °C until constant weight.

**Root quality:**

At harvest time, total soluble solids (TSS) in the root extract were determined by hand refractometer, Ascorbic acid (Vitamin C) content in fresh roots was estimated as mg/100 g F.W. by titration with 2,6 dichlorophenol indophenol blue dye according to Jacobs (1951).

Chemical contentious:

The percent NPK content in the leaves were determined in the 5th leaves from the plant top at 80 days after sowing date in addition NPK content in roots were estimated at harvesting time. Total NPK were determined according to the methods described by (Bremner and Mulvaney, 1982). The chlorophyll content a, b and total chlorophylls (a + b) in the fresh recently expanded leaves were determined calorimetrically as described in A.O.A.C. (1990).

**Statistical Analysis**:

All data were statistically analyzed using the technique of analysis of variance according to Snedecor and Cochran (1989) and means were compared using by L.S.D at 5% level.

# RESULTS AND DISCUSSION

**Vegetative growth parameters:**

**Effect of agriculture gypsum:-**

Data in **Table (2)** revealed that the addition agriculture gypsum gave a significant increase in vegetative growth parameters, in terms of plant height, number of leaves, fresh weight and dry weight of shoot/ plant in both seasons. These results could be due to incorporation of gypsum mixed with the soil resulting in enhanced physical and chemical properties, addition of Ca and sulphate modifies the P absorption and release capacities of soils through their impacts on P adsorption and precipitation processes which favor plant growth (Delgado et al., 2002). In plants calcium being a main component of cell wall, plays a vital role in cell division and cell elongation (Hepler, 1994 and Ayyub et al., 2012) and cell Wall integrity which in turn improve vegetative growth of carrot (Aparna et al., 2023). Furthermore, vegetative growth increased through gypsum application ascribed to S is an important element for synthesis of proteins and chlorophyll which demanded for plant growth and development (Ghosh et al., 2007).

**Effect of foliar application of potassium sources**

Data in **Table (2)** showed that foliar application of potassium sources on vegetative growth parameters of carrot at 80 days after sowing date were significantly affected by different sources of potassium with foliar feeding in the two seasons. The highest values of plant height, number of leaves, and dry weight of shoot/plant were recorded in both seasons and fresh weight of shoot/ plant in the first season were obtained with foliar feeding potassium thiosulfate (KTS), while monopotassium phosphate gave the highest values of fresh weight of shoot/ plant in the second season. These increase due to potassium source (KTS) might be reference to this formalization contain K and S of the comparable and consistent synergetic accomplishment, congregation with organic moiety, contain powerful K and S feeding for greater growing of proteins carbohydrates, and energy synthesis (Marschner 1995), besides that the function of K in nutrients translocation, promoting phytohormone acting as an activator to enzymatic anti-oxidant enzymes, root generation and leaves growth (El-Gamal et al., 2016).

**Effect of the interaction agriculture gypsum addition and foliar application of potassium sources:**

Data presented in **Table (2)** indicate that the interaction agriculture gypsum to the soil and foliar feeding of potassium sources had significant on growth parameters of carrot at 80 days after sowing date planting in both seasons. The heights values were obtained with addition agriculture gypsum with foliar addition of potassium thiosulfate in the two seasons, except fresh weight of shoot in the second season was recorded with monopotassium phosphate.

**Table (2). Vegetative growth parameters of carrot at 80 days after sowing date as affected by gypsum addition, foliar application of potassium sources and their interactions during the winter seasons 2020/2021 and 2021/2022.**

| Characteristics / Treatments | Plant height (cm) | | No. of leaves/plant | | Fresh weight of shoot (g) | | Dry weight of shoot (g) | |
|---|---|---|---|---|---|---|---|---|
| | 2020/21 | 2021/22 | 2020/21 | 2021/22 | 2020/21 | 2021/22 | 2020/21 | 2021/22 |
| **Agriculture gypsum** | | | | | | | | |
| **Without** | 54.64 | 51.52 | 11.22 | 10.99 | 34.28 | 33.66 | 18.13 | 17.52 |
| **With** | 62.54 | 60.24 | 11.76 | 11.26 | 46.97 | 46.86 | 24.67 | 23.37 |
| **F-test** | ** | ** | * | * | ** | ** | ** | ** |
| **Foliar application of potassium sources** | | | | | | | | |
| **Control** | 51.37 | 46.68 | 8.85 | 8.5 | 32.42 | 31.7 | 13.54 | 12.68 |
| **Potassium sulfate** | 55.08 | 51.71 | 10.01 | 9.98 | 37.28 | 36.94 | 16.61 | 16.33 |
| **Potassium citrate** | 57.02 | 54.54 | 11.47 | 11.39 | 38.93 | 38.4 | 20.91 | 19.97 |
| **Mono potassium phosphate** | 61.35 | 59.7 | 12.33 | 11.91 | 44.43 | 47.33 | 24.99 | 25.3 |
| **Potassium thiosulfate** | 66.07 | 64.45 | 13.52 | 12.95 | 47.44 | 45.37 | 27.18 | 24.89 |
| **Potassium silicate** | 60.63 | 58.21 | 12.76 | 11.99 | 43.25 | 41.83 | 25.18 | 23.49 |
| **LSD at 5%** | **1.54** | **1.12** | **0.38** | **0.29** | **1.03** | **0.75** | **1.02** | **2.15** |
| **The interaction between gypsum addition & foliar application of potassium sources** | | | | | | | | |
| **Without gypsum** | | | | | | | | |
| **Control** | 49.61 | 43.93 | 8.27 | 7.88 | 31.02 | 30.07 | 12.12 | 10.7 |
| **Potassium sulfate** | 51.9 | 48.15 | 10.1 | 10.15 | 32.97 | 32.32 | 14.4 | 14.1 |
| **Potassium citrate** | 52.18 | 49.63 | 11.01 | 10.9 | 33.33 | 32.97 | 16.42 | 16.18 |
| **Mono potassium phosphate** | 57.46 | 54.3 | 11.98 | 11.89 | 35.63 | 35.77 | 21.85 | 22.83 |
| **Potassium thiosulfate** | 61.27 | 59.7 | 13.4 | 13.12 | 37.42 | 36.53 | 23.3 | 21.27 |
| **Potassium silicate** | 55.4 | 53.4 | 12.55 | 11.97 | 35.3 | 34.32 | 20.68 | 20.02 |
| **With gypsum** | | | | | | | | |
| **Control** | 53.13 | 49.43 | 9.43 | 9.12 | 33.82 | 33.33 | 14.97 | 14.65 |
| **Potassium sulfate** | 58.27 | 55.27 | 9.92 | 9.82 | 41.6 | 41.57 | 18.82 | 18.55 |
| **Potassium citrate** | 61.85 | 59.45 | 11.93 | 11.88 | 44.53 | 43.83 | 25.4 | 23.75 |
| **Mono potassium phosphate** | 65.25 | 65.1 | 12.67 | 11.92 | 53.22 | 58.9 | 28.13 | 27.77 |
| **Potassium thiosulfate** | 70.87 | 69.2 | 13.63 | 12.78 | 57.47 | 54.2 | 31.05 | 28.52 |
| **Potassium silicate** | 65.87 | 63.02 | 12.97 | 12.02 | 51.2 | 49.33 | 29.67 | 26.97 |
| **LSD at 5%** | **2.18** | **1.59** | **0.54** | **0.41** | **1.46** | **1.06** | **1.43** | **3.04** |

## Yield and its components:

### Effect of agriculture gypsum:

Data illustrated in **Table (3)** showed that root length, root diameter, fresh weight and dry weight of roots as well as total yield were significantly with addition agriculture gypsum to soil, due to better utilization of soil moisture under calcium saturation which has advantageous effect on aggregation which helps in stabilizing of soil building for root growth water and air movement to receive good yield (Shedge et al., 2018). Thus, the beneficial effect of sulfur on nitrogen uptake by carrot crops resulting in promoted nitrogen availability associated with increase in crop yields (Singh et al., 2016). In plants Ca improve the higher uptake of phosphorus plays a role in cell enlargement, growth and development (Ilyas et al., 2014) furthermore, a role of Ca in cell wall extensibility, which helped to form strong cell walls and highly organized cells, co-enzymatic for several biological process in plants resulting in improvement of plant growth and dry matter accumulation overall yield (Ashraf et al., 2019).

The response to sulfur may be ascribed to improved nutritional management as a result of S supply which might have favorable effect on the growth translocation of more photosynthate towards root consequently, accumulation of more dry matter in edible roots of carrot and yield (Singh et. al., 2016).

**Effect of foliar application of potassium sources**:

Data in **Table (3)** Illustrated clearly that root length, root diameter, fresh and dry weight of root/plant were significantly augment with foliar feeding of potassium sources in both seasons. The maximum values of root length, root diameter, in both seasons, fresh weight of root in second season and total yield of root carrot in first season were obtained when plant feeding with potassium thiosulfate (KTS), while the greatest of fresh weight of root in the first season and dry weight of root in the two seasons while, total yield of root in the second season were observed with foliar application of monopotassium phosphate, due to potassium plays a vital role in turgor maintenance, photophosphorylation, photoassimilate transport from source tissues within phloem to sink tissues, and enzyme activation in plants that are considered important for plant growth and yield (Marschner, 1995 and Usherwood, 2000), these results are in agreement with the results of (Haque et al., 2019) and (Salim et al., 2022) on carrot. The increment of root weight, diameter and dry matter accumulation in root by potassium addition ultimately, resulting in increased total yield (Pal et al., 2016) on cucumber, additionally, applied plants with S through the thiosulphate (as foliar spray) impact the yield of the crop as it induces many physiological functions as synthesis of various proteins, co-enzymes and vitamins (Choudhary, 2015). These results are agreed with those reported by regarding thiosulphate, (Fekry, 2017 and Metwaly et. al., 2020) on garlic.

The presence of phosphate in monopotassium phosphate fertilizer improved the response of the plant to the applied rate thus the highest response addition compared to other treatments K increased P content in the plants which ultimately reflect on plant growth and production vegetative growth was positively associated with dry matter production (Ahmed, 2003), as well as phosphorus level in plant (Valenzuela and Gallardo, 2001). Therefore, phosphorus uses efficiency of carrot cultivars development, it favors the root system, improving the absorption of water and nutrients, resulting in producing great biomass, thus, greater input of photosynthates that enhance positive impacts of this nutrient in the carrot root yield (Jesus et al., 2021).

**Effect of the interaction between agriculture gypsum addition and foliar application of potassium sources**:

It is evident from **Table (3) and Fig.(1)** that the interaction effects between agriculture gypsum and foliar application of potassium sources was significant on yield and its components of carrot in both seasons **(Table 3)** and average of both seasons **(Fig.1).** The highest values of root length, root diameter and total yield in the first season, were obtained when carrot plants addition agriculture gypsum to the soil with foliar spraying potassium thiosulfate (KTS), while the highest values of root length, root diameter, fresh weight of root and total yield (t/fed.) were recorded with monopotassium phosphate in the second season and dry of root in both seasons.

**Table (3). Yield and its components of carrot at harvesting time as affected by gypsum addition, foliar application of potassium sources and their interactions during the winter seasons 2020/2021 and 2021/2022.**

| Characteristics | Root length (cm) | | Root diameter (cm) | | Fresh weight of root (g) | | Dry weight of root (g) | | Total yield (ton/fed.) | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Treatments** | **2020/21** | **2021/22** | **2020/21** | **2021/22** | **2020/21** | **2021/22** | **2020/21** | **2021/22** | **2020/21** | **2021/22** |
| | | | | | **Agriculture gypsum** | | | | | |
| **Without** | 12.27 | 13.04 | 2.59 | 2.54 | 142.35 | 145.62 | 19.73 | 19.08 | 19.21 | 18.29 |
| **With** | 16.50 | 16.56 | 2.86 | 2.81 | 157.79 | 159.37 | 22.52 | 22.04 | 21.38 | 20.80 |
| **F-test** | * | ** | ** | ** | ** | ** | ** | ** | ** | ** |
| | | | | | **Foliar application of potassium sources** | | | | | |
| **Control** | 11.54 | 11.77 | 1.87 | 1.84 | 107.12 | 109.89 | 16.98 | 16.39 | 17.32 | 16.94 |
| **Potassium sulfate** | 13.67 | 13.69 | 2.53 | 2.52 | 149.99 | 152.10 | 20.16 | 19.59 | 19.21 | 18.86 |
| **Potassium citrate** | 14.95 | 14.96 | 2.64 | 2.55 | 154.29 | 157.75 | 21.56 | 21.22 | 20.15 | 19.35 |
| **Mono potassium phosphate** | 15.70 | 16.74 | 3.19 | 3.17 | 168.03 | 165.13 | 24.01 | 24.19 | 21.76 | 21.86 |
| **Potassium thiosulfate** | 17.09 | 16.48 | 3.33 | 3.24 | 163.83 | 170.61 | 23.67 | 22.46 | 23.21 | 20.99 |
| **Potassium silicate** | 13.36 | 15.14 | 2.81 | 2.73 | 157.15 | 159.48 | 20.35 | 19.51 | 20.14 | 19.28 |
| **LSD at 5%** | **2.64** | **0.38** | **0.10** | **0.12** | **2.49** | **1.76** | **0.57** | **0.52** | **0.56** | **0.58** |
| | | | | | **The interaction between gypsum addition & foliar application of potassium sources** | | | | | |
| | | | | | **Without gypsum** | | | | | |
| **Control** | 9.93 | 10.38 | 1.78 | 1.77 | 96.03 | 100.30 | 15.77 | 14.78 | 16.40 | 15.88 |
| **Potassium sulfate** | 12.05 | 12.23 | 2.40 | 2.40 | 146.40 | 148.23 | 19.10 | 18.58 | 18.42 | 18.00 |
| **Potassium citrate** | 13.03 | 13.15 | 2.47 | 2.38 | 148.83 | 153.50 | 19.74 | 19.55 | 19.20 | 18.25 |
| **Mono potassium phosphate** | 13.98 | 13.93 | 3.04 | 2.92 | 154.17 | 156.57 | 21.53 | 22.48 | 20.48 | 19.77 |
| **Potassium thiosulfate** | 14.97 | 14.95 | 3.17 | 3.12 | 156.47 | 160.75 | 22.07 | 20.05 | 21.67 | 19.78 |
| **Potassium silicate** | 9.67 | 13.57 | 2.72 | 2.65 | 152.20 | 154.37 | 20.15 | 19.03 | 19.10 | 18.05 |
| **With gypsum** | | | | | | | | | | |
| **Control** | 13.15 | 13.15 | 1.96 | 1.92 | 118.20 | 119.48 | 18.20 | 18.00 | 18.23 | 17.99 |
| **Potassium sulfate** | 15.28 | 15.15 | 2.67 | 2.63 | 153.58 | 155.97 | 21.23 | 20.60 | 20.00 | 19.72 |
| **Potassium citrate** | 16.87 | 16.77 | 2.82 | 2.72 | 159.75 | 162.00 | 23.38 | 22.88 | 21.10 | 20.45 |
| **Mono potassium phosphate** | 17.41 | 19.55 | 3.35 | 3.42 | 181.90 | 173.70 | 26.48 | 25.90 | 23.03 | 23.95 |
| **Potassium thiosulfate** | 19.22 | 18.00 | 3.49 | 3.36 | 171.20 | 180.47 | 25.27 | 24.87 | 24.75 | 22.20 |
| **Potassium silicate** | 17.05 | 16.72 | 2.90 | 2.80 | 162.10 | 164.60 | 20.55 | 19.98 | 21.17 | 20.50 |
| **LSD at 5%** | **3.73** | **0.54** | **0.14** | **0.17** | **3.52** | **2.48** | **0.80** | **0.73** | **0.80** | **0.82** |

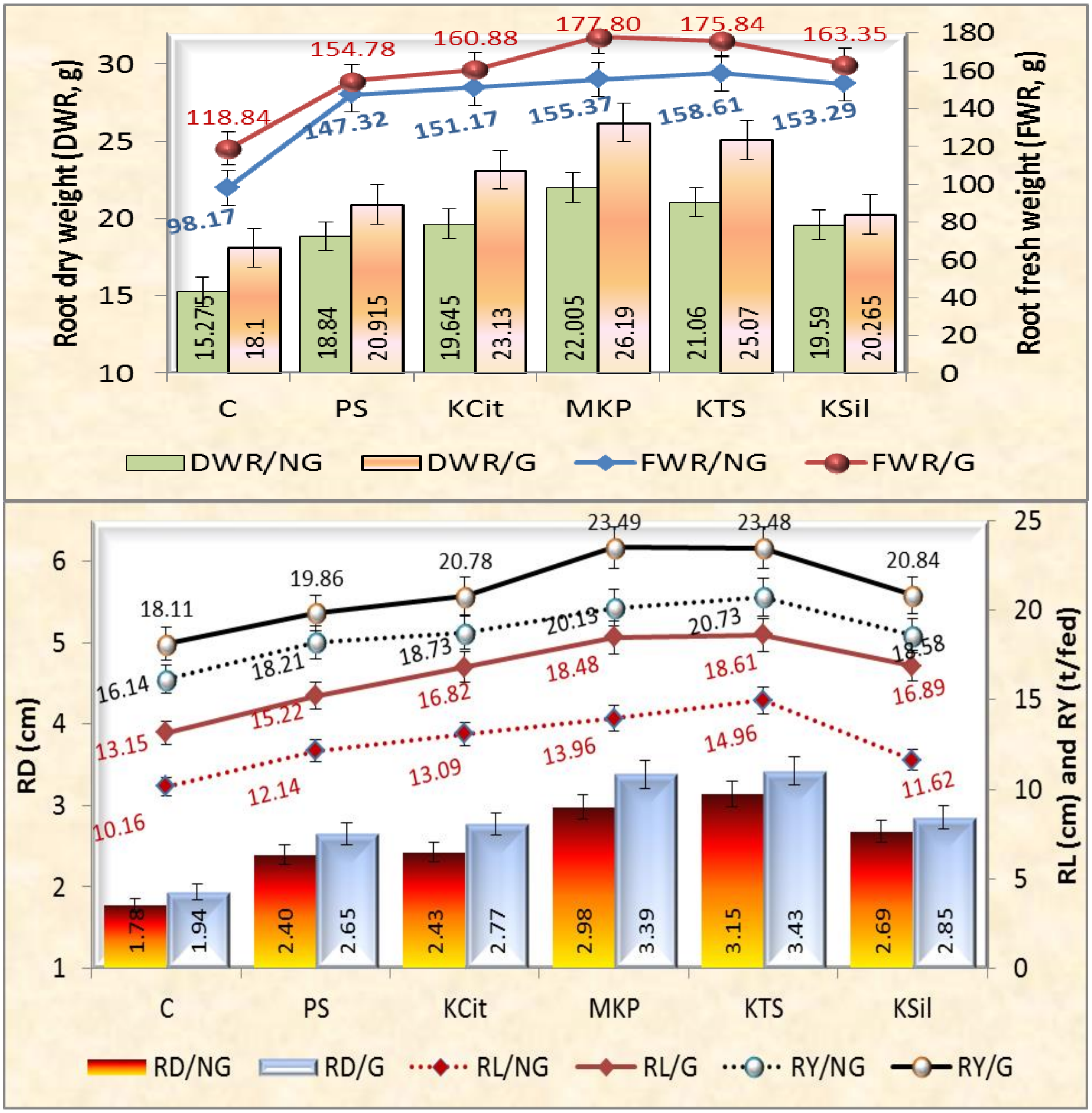


**Fig. (1). Yield and its components of carrot as affected by interaction effects between gypsum addition and foliar spray of potassium sources root length (cm, RL); root diameter (cm, RD); fresh weight of root (g, FWR); dry weight of root (g, DWR); total yield (ton/fed., RY).**

## Chemical constituents:

### Effect of agriculture gypsum:

Data in **Table (4)** showed that application of agriculture gypsum gave a significant increase Percent of P and content chlorophyll b and total chlorophylls (a + b) of carrot in two seasons, while percent N, K in the two season respectively, chlorophyll a in the first season in the leaves of carrot at 80 days after sowing date, these results are agreement with those obtained by (Badawi et al., 2020), on sweet pepper, (Al-Harbey 2020) on tomato due to gypsum being direct source of second nutrients (Ca and S) for plants and enhancement soil physical and chemical properties, improve deep root systems that enhance nutrient absorption from soil minerals into plants, such as N P K

(Kamal, 2008) on pepper and El-Said (2009) on tomato, Ca improve the uptake of nitrogen in nitrate form and reduced the loss of nitrogen (Banijamali et al., 2008) that resulting in good photosynthesis, furthermore, it's may be ascribed to the sufficient S application which is demand for better nutrient availability and uptake might have led to increased chlorophyll in plant (Kalpana et al., 2015), These results are in agreement with results of Uddin et al. (2021) on kohlrabi.

**Effect of foliar application of potassium sources:**

Data in **Table (4)** clearly illustrate that foliar spraying with sources significantly affected the contents NPK, chlorophyll a, b and total chlorophylls a + b in the leaves of carrot at 80 days after sowing date in both growing seasons. The highest values of these macronutrients and chlorophylls contents in the leaves were recorded with plant foliar feeding by monopotassium phosphate in both seasons. Results may be ascribed to the function of potassium in plant metabolism and normally important regulatory procedure in the plant. Besides, potassium foliar was spraying significantly increasing N, P and K concentrations in plant leaves. The speedy uptake of these elements by the plant surface, mostly the leaves and their translocation through the plant parallel results were gained by Shafeek et al. (2016) on garlic. Foliar spraying with various nutrients encourages root uptake of the same elements or nutrients through the foliar by enhancing root development and movement of nutrients from leaves to content of phosphorus and potassium content (El-Fouly and El-Sayed, 1997). Salim et al. (2014) indicate that, K sources foliar supply improved chlorophylls and NPK concentrations of potato leaves. ascribed to the foliar feeding of mono potassium phosphate which increased K and P concentration. This result harmony with this gained by (Sajyan et al., 2018) on tomato. The supply of phosphorus is usually related to a significant increase in number and mass of roots thus uptake of higher concentration of mineral nutrients from soil including N reflecting in improved growth and total chlorophylls Hegazi et al. (2017) on sweet pepper.

**Effect of the interaction between agriculture gypsum addition and foliar application of potassium sources.**

The effect of the interaction of agriculture gypsum and foliar spraying of potassium sources on percent of NPK, chlorophyll a, b and total chlorophylls content in the leaves of carrot at 80 days after sowing date in **Table(4).** The interaction had a positive significant effect on Percent NPK, chlorophyll a, b and total chlorophylls (a + b) in the two seasons study.

**Table (4). Percent of NPK, chlorophyll a, b and total chlorophylls a + b contents in the leaves of carrot at 80 days after sowing date as affected by addition gypsum, foliar application of potassium sources and their interaction during the winter seasons 2020/2021 and 2021/2022.**

| Characteristics / Treatments | Leaves minerals% | | | | | | Leaves chlorophyll contents | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | | P | | K | | Chlorophyll a | | Chlorophyll b | | Total chlorophyll a+ b | |
| | 2020/21 | 2021/22 | 2020/21 | 2021/22 | 2020/21 | 2021/22 | 2020/21 | 2021/22 | 2020/21 | 2021/22 | 2020/21 | 2021/22 |
| **Agriculture gypsum** | | | | | | | | | | | | |
| **Without** | 2.23 | 2.16 | 0.273 | 0.269 | 2.56 | 2.48 | 0.818 | 0.829 | 0.504 | 0.512 | 1.322 | 1.341 |
| **With** | 2.31 | 2.28 | 0.356 | 0.306 | 2.65 | 2.57 | 0.829 | 0.838 | 0.516 | 0.521 | 1.345 | 1.359 |
| **F-test** | **N. S** | ** | ** | ** | ** | **N. S** | * | **N. S** | ** | ** | ** | * |
| **Foliar application of potassium sources** | | | | | | | | | | | | |
| **Control** | 2.09 | 2.03 | 0.268 | 0.256 | 2.30 | 2.24 | 0.789 | 0.799 | 0.471 | 0.477 | 1.26 | 1.276 |
| **Potassium sulfate** | 2.22 | 2.17 | 0.296 | 0.274 | 2.59 | 2.53 | 0.811 | 0.817 | 0.495 | 0.502 | 1.306 | 1.318 |
| **Potassium citrate** | 2.30 | 2.25 | 0.309 | 0.296 | 2.65 | 2.56 | 0.831 | 0.842 | 0.517 | 0.525 | 1.348 | 1.366 |
| **Mono potassium phosphate** | 2.41 | 2.36 | 0.352 | 0.310 | 2.79 | 2.67 | 0.851 | 0.861 | 0.540 | 0.545 | 1.392 | 1.406 |
| **Potassium thiosulfate** | 2.40 | 2.35 | 0.336 | 0.301 | 2.70 | 2.61 | 0.849 | 0.859 | 0.542 | 0.549 | 1.390 | 1.408 |
| **Potassium silicate** | 2.21 | 2.17 | 0.324 | 0.288 | 2.59 | 2.52 | 0.810 | 0.824 | 0.494 | 0.501 | 1.304 | 1.325 |
| **LSD $_{at\ 5\%}$** | **0.04** | **0.03** | **0.007** | **0.008** | **0.04** | **0.03** | **0.007** | **0.007** | **0.004** | **0.005** | **0.007** | **0.009** |
| **The interaction between gypsum addition & foliar application of potassium sources** | | | | | | | | | | | | |
| **Without gypsum** | | | | | | | | | | | | |
| **Control** | 2.05 | 1.95 | 0.251 | 0.247 | 2.25 | 2.16 | 0.784 | 0.794 | 0.465 | 0.471 | 1.249 | 1.265 |
| **Potassium sulfate** | 2.18 | 2.12 | 0.269 | 0.260 | 2.55 | 2.51 | 0.801 | 0.811 | 0.483 | 0.490 | 1.285 | 1.301 |
| **Potassium citrate** | 2.28 | 2.21 | 0.270 | 0.276 | 2.61 | 2.52 | 0.827 | 0.837 | 0.515 | 0.527 | 1.342 | 1.364 |
| **Mono potassium phosphate** | 2.35 | 2.30 | 0.290 | 0.286 | 2.73 | 2.63 | 0.847 | 0.866 | 0.536 | 0.545 | 1.384 | 1.412 |
| **Potassium thiosulfate** | 2.34 | 2.26 | 0.284 | 0.281 | 2.65 | 2.56 | 0.841 | 0.851 | 0.529 | 0.537 | 1.370 | 1.388 |
| **Potassium silicate** | 2.19 | 2.14 | 0.275 | 0.265 | 2.54 | 2.47 | 0.807 | 0.817 | 0.494 | 0.501 | 1.301 | 1.318 |
| **With gypsum** | | | | | | | | | | | | |
| **Control** | 2.13 | 2.11 | 0.286 | 0.266 | 2.35 | 2.33 | 0.795 | 0.804 | 0.476 | 0.483 | 1.271 | 1.288 |
| **Potassium sulfate** | 2.26 | 2.22 | 0.324 | 0.287 | 2.63 | 2.56 | 0.821 | 0.822 | 0.506 | 0.513 | 1.327 | 1.335 |
| **Potassium citrate** | 2.33 | 2.29 | 0.348 | 0.316 | 2.70 | 2.60 | 0.835 | 0.846 | 0.519 | 0.522 | 1.355 | 1.368 |
| **Mono potassium phosphate** | 2.47 | 2.42 | 0.415 | 0.335 | 2.84 | 2.72 | 0.855 | 0.856 | 0.544 | 0.545 | 1.400 | 1.401 |
| **Potassium thiosulfate** | 2.47 | 2.43 | 0.388 | 0.321 | 2.75 | 2.65 | 0.857 | 0.867 | 0.554 | 0.562 | 1.411 | 1.429 |
| **Potassium silicate** | 2.23 | 2.20 | 0.373 | 0.310 | 2.64 | 2.57 | 0.813 | 0.831 | 0.495 | 0.502 | 1.307 | 1.332 |
| **LSD $_{at\ 5\%}$** | **0.05** | **0.04** | **0.011** | **0.011** | **0.05** | **0.05** | **0.010** | **0.010** | **0.006** | **0.007** | **0.011** | **0.011** |

## Root quality:

### Effect of agriculture gypsum addition on root quality:

Data recorded in **Table (5)** Indicated that addition of agriculture gypsum to the soil significantly increase in the percent of NK, total soluble solids (TSS) and ascorbic acid (vitamin C) contents in in roots carrot in both seasons, while percent of P insignificantly affected in the two seasons. The increments in mineral content in the root's carrot might be attributed to their enhancing impact on root and foliage growth of plants that associated with the potentiality of nutrient up take and bio assimilation process of the whole metabolic machinery, (El-Said, 2009) on tomato, in plant Ca affects photosynthetic physiology, absorption and transportation of mineral elements by plants (Niu et al., 2018), S stimulation of enzymes, nucleic acids and forms a part of biotin and thiamine, as a plant nutrient, has the strongest impact on yield and quality of vegetable crops (Singh et al., 2016) These results are in agreement with finding of (Al-Harby et al., 2020) on tomato.

**Effect of foliar application of potassium sources:**

Data in **Table (5)** revealed that foliar application by potassium sources significantly increased of percent NPK, total soluble solid (TSS) and ascorbic acid (vitamin C) in roots of carrot compared with untreated in both growing seasons. The higher percentage of PK and vitamin C were record when plants were foliar fed by monopotassium phosphate in the two seasons study and N and total soluble solid with potassium thiosulfate in the second season respectively. These effects could be attributed to K has a main role in translocation of photo assimilates, sugars and other soluble solids which in turn increased total soluble solid, ascorbic acid and protein from sinks to root enhanced crops quality (Shikha et al., 2016 and Ahmed et al., 2021) on carrot.

The superiority of mono potassium phosphate may be ascribed to its impact on photosynthetic assimilates through photosynthetic process so effect on the chemical content of root (Sajyan et al., 2018), phosphorus has important function in photosynthesis carbohydrate ester, phospholipids, ATP, ADP phosphorylated proteins and sugars, plant metabolism improving root size and its quality (Reis Gonçalves et al., 2019) on carrot.

**Effect of the interaction between agriculture gypsum addition and foliar application of potassium sources:**

Results in same **Table (5)** showed that the effect of the interaction between agriculture gypsum and foliar feeding of potassium sources on NPK, TSS and ascorbic acid vitamin C) contents in the root of carrot plants cause significant increase on percentage NPK and total soluble solid and ascorbic acid in the two growing seasons.

It is clearly noted that all foliar treatments with potassium sources combined with the soil gypsum application gave statistically equivalent or increase values in all Root quality traits as compared to the corresponding control. However, Mono potassium phosphate (MKP) and Potassium thiosulfate (KTS) each combined with gypsum were the most abundant for the five root quality traits in the two **(Table 4)** and average **(Fig. 2)** of both seasons with no significant differences between them in N in 1st season and both P and ASA in both seasons.

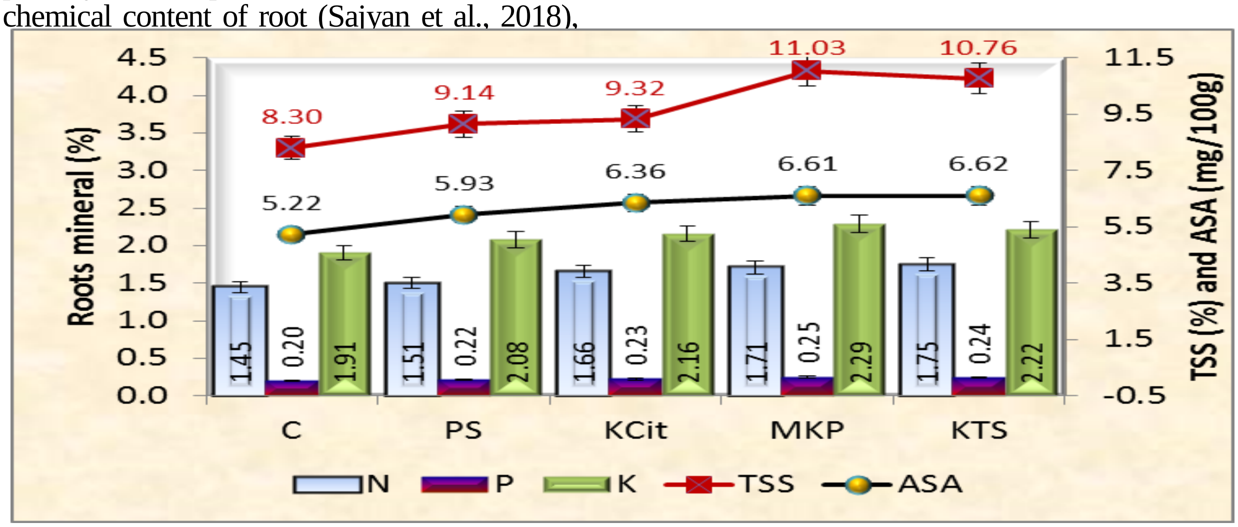


**Fig. (2). Percent of NPK, total soluble solid (TSS) and ascorbic acid (ASA) contents in carrot roots at harvesting time as affected by interaction treatments between gypsum addition and foliar spray of potassium sources in average of both seasons.**

Moreover, MKP (Mono potassium phosphate) combination with gypsum was the highest, resulting in an increment percentage in average of both seasons (Fig.3) by 42.51%, 30.02%, 21.69% and 21.16% in descending order for TSS, ASA, P and K over the corresponding control (without any treatment of gypsum in soil or potassium foliar spray), respectively followed by KTS for the same traits order by 39.0%, 30.2%, 17.6% and 17.2%. Reverse trend was observed for Nitrogen content (N) in the roots, where KTS with gypsum interaction had the highest effect (24.1%) followed by MKP (21.3%).

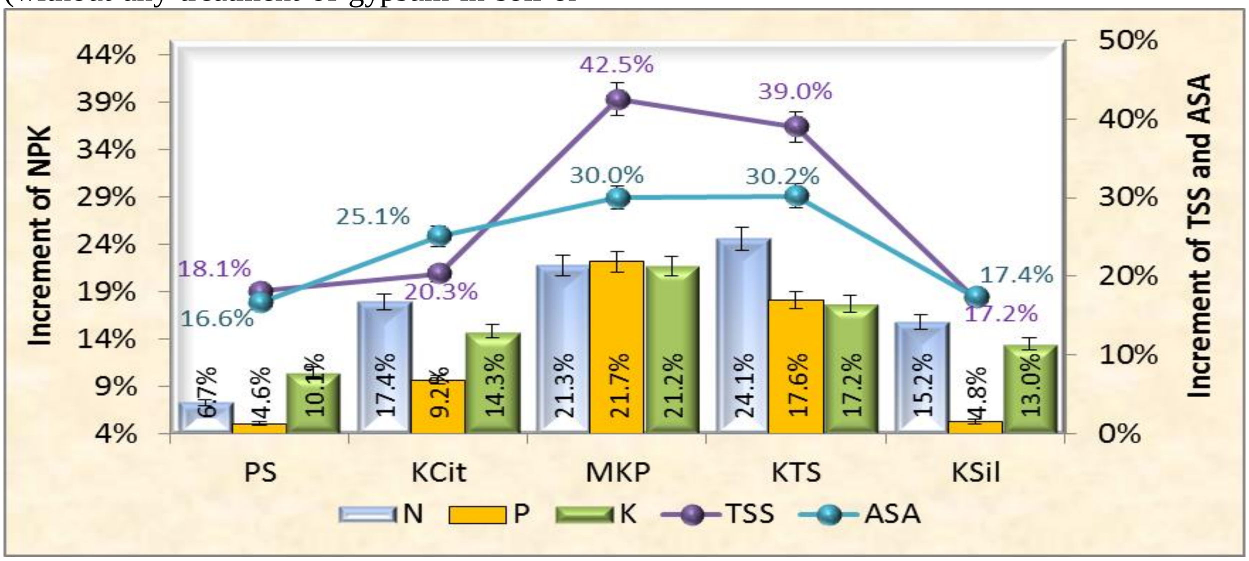


**Fig. (3). NPK, total soluble solid (TSS) and ascorbic acid (ASA) contents of carrot roots (average of two seasons) as affected by the interaction treatments between gypsum addition and foliar spray of potassium sources in average of both seasons.**

## CONCLUSION:

Generally, the results indicated that addition of agriculture gypsum to the soil had significant effect on both the growth and yield of carrot while, foliar spraying with potassium sources led to stimulate growth, increasing yield as well as enhancing biochemical constituents and some quality traits of carrot plant. Potassium thiosulphate and mono potassium phosphate were more effective than other treatments on promising the vegetative growth parameters and yield components.

It can be concluded that gypsum addition to soil as amendment at a rate of (1 ton /fed.,) with foliar spraying of potassium thiosulphate (KTS) or mono potassium phosphate at a dose of (4000 ppm $K_2O$) was the most effective treatment on the most parameter.

**Table (5). Percent of NPK, total soluble solid (TSS) and ascorbic acid (vitamin C) contents in carrot roots at harvesting time as affected by gypsum addition, foliar application of potassium sources and their interactions during the winter seasons 2020/2021 and 2021/2022.**

| Characteristics / Treatments | Roots mineral % | | | | | | Roots quality | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | | P | | K | | Total soluble solid | | Ascorbic acid (mg/100g F.W.) | |
| | 2020/21 | 2021/22 | 2020/21 | 2021/22 | 2020/21 | 2021/22 | 2020/21 | 2021/22 | 2020/21 | 2021/22 |
| **Agriculture gypsum** | | | | | | | | | | |
| **Without** | 1.54 | 1.50 | 0.220 | 0.219 | 2.08 | 2.13 | 9.09 | 9.20 | 5.92 | 5.80 |
| **With** | 1.63 | 1.60 | 0.223 | 0.229 | 2.17 | 2.10 | 9.54 | 9.67 | 6.11 | 6.12 |
| **F-test** | ** | ** | N. S | N. S | ** | * | * | ** | * | ** |
| **Foliar application of potassium sources** | | | | | | | | | | |
| **Control** | 1.44 | 1.42 | 0.192 | 0.213 | 1.91 | 1.89 | 7.92 | 8.13 | 5.22 | 5.09 |
| **Potassium sulfate** | 1.49 | 1.46 | 0.215 | 0.214 | 2.07 | 2.05 | 8.82 | 8.88 | 5.73 | 5.66 |
| **Potassium citrate** | 1.63 | 1.57 | 0.220 | 0.224 | 2.14 | 2.13 | 9.03 | 9.24 | 6.33 | 6.25 |
| **Mono potassium phosphate** | 1.69 | 1.62 | 0.242 | 0.247 | 2.27 | 2.29 | 10.92 | 10.33 | 6.66 | 6.63 |
| **Potassium thiosulfate** | 1.69 | 1.66 | 0.238 | 0.236 | 2.22 | 2.20 | 10.17 | 10.91 | 6.80 | 6.42 |
| **Potassium silicate** | 1.61 | 1.55 | 0.220 | 0.211 | 2.13 | 2.12 | 9.04 | 9.14c | 5.35 | 5.71 |
| **LSD at 5%** | **0.03** | **0.02** | **0.004** | **0.020** | **0.04** | **0.04** | **0.23** | **0.34** | **0.16** | **0.12** |
| **The interaction between gypsum addition & foliar application of potassium sources** | | | | | | | | | | |
| **Without gypsum** | | | | | | | | | | |
| **Control** | 1.42 | 1.40 | 0.193 | 0.222 | 1.88 | 1.90 | 7.63 | 7.85 | 5.13 | 5.03 |
| **Potassium sulfate** | 1.46 | 1.42 | 0.217 | 0.207 | 2.01 | 2.08 | 8.43 | 8.67 | 5.50 | 5.42 |
| **Potassium citrate** | 1.58 | 1.52 | 0.221 | 0.213 | 2.00 | 2.14 | 8.78 | 9.13 | 6.20 | 6.25 |
| **Mono potassium phosphate** | 1.63 | 1.57 | 0.238 | 0.235 | 2.22 | 2.32 | 10.50 | 9.93 | 6.73 | 6.63 |
| **Potassium thiosulfate** | 1.61 | 1.61 | 0.234 | 0.226 | 2.19 | 2.21 | 10.17 | 10.47 | 6.81 | 6.38 |
| **Potassium silicate** | 1.58 | 1.48 | 0.215 | 0.211 | 2.10 | 2.12 | 9.05 | 9.17 | 5.12 | 5.07 |
| **With gypsum** | | | | | | | | | | |
| **Control** | 1.45 | 1.45 | 0.192 | 0.204 | 1.94 | 1.88 | 8.20 | 8.40 | 5.30 | 5.14 |
| **Potassium sulfate** | 1.51 | 1.50 | 0.213 | 0.221 | 2.13 | 2.03 | 9.20 | 9.08 | 5.95 | 5.90 |
| **Potassium citrate** | 1.68 | 1.63 | 0.219 | 0.234 | 2.19 | 2.13 | 9.28 | 9.35 | 6.47 | 6.24 |
| **Mono potassium phosphate** | 1.75 | 1.67 | 0.246 | 0.259 | 2.32 | 2.26 | 11.33 | 10.73 | 6.58 | 6.63 |
| **Potassium thiosulfate** | 1.78 | 1.72 | 0.242 | 0.246 | 2.25 | 2.18 | 10.17 | 11.35 | 6.78 | 6.45 |
| **Potassium silicate** | 1.64 | 1.61 | 0.224 | 0.211 | 2.16 | 2.11 | 9.03 | 9.12 | 5.58 | 6.35 |
| **LSD at 5%** | **0.04** | **0.02** | **0.006** | **0.029** | **0.05** | **0.05** | **0.32** | **0.49** | **0.22** | **0.17** |

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## الملخص العربى

# إمكانيه تاثير إضافة الجبس مع الرش الورقي بمصادر مختلفة من البوتاسيوم علي المحصول والجودة في الجزر

**سالي محمد صفوت ابو كامل شعبان والسيد محمد محمد عوض.**
**قسم بحوث الخضر- معهد بحوث البساتين -مركز البحوث الزراعية -الجيزة – مصر**

تم إجراء تجربتين خلال الموسم الشتوي 2021/2020 و2022/2021 بقرية شبراويش- مركز أجا- محافظة الدقهلية لدراسة تأثيرإضافة الجبس الزراعي إلي التربة عند معدل 1 طن للفدان مع الرش الورقي بمصادر مختلفة من البوتاسيوم وهي (سلفات البوتاسيوم، سترات البوتاسيوم، مونوبوتاسيوم فوسفات، ثيو سلفات البوتاسيوم، سيلكات البوتاسيوم) عند معدل 4000 جزء في المليون أكسيد بوتاسيوم من كل مصدر من مصادر البوتاسيوم المستخدمة وبدون رش بالإضافة إلي تفاعلاتها علي النمو والمحصول والجودة في الجزر علي هجين الجزر فيرودج F1. وأظهرت النتائج المتحصل عليها مايلي:

أدي إضافة الجبس الزراعي للتربة إلي زيادة معنوية في صفات النمو الخضري للنبات (طول النبات، عدد الأوراق/ للنبات، الوزن الطازج والجاف للعرش/ للنبات)، بالإضافة إلي (طول وقطر والوزن الطازج والجاف للجذر والمحصول الكلي للجذر في الجزر طن/فدان) وكذلك النسبة المئوية للنتروجين والفوسفور والبوتاسيوم في الأوراق، وزيادة الكلورفيل أ، ب والكلورفيل الكلي أ + ب في الأوراق، بالإضافة محتوي الجذر من النتروجين والبوتاسيوم والمواد الصلبة الكلية وفيتامين (C) في كلا موسمي الزراعة. كما أدت الإضافة الورقية بمصادر البوتاسيوم المختلفة إلي زيادة معنوية في صفات النمو الخضرية والمحصول الكلي ومكوناته والمحتوي الكيماوي للأوراق، وصفات الجودة للجـذر في الجـزر في كلا موسمي الزراعة. وكانت أحسن النتائج المتحصل عليها هي الرش الورقي بثيوسلفات البوتاسيوم ومونوبوتاسيوم فوسفات أكثر فاعلية عن باقي المصادر الأخري.