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Research Article

Effect of potassium through polyhalite on growth and yield of onion Var. CO(ON) 6

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Abstract
Plants require nutrients to grow, so polyhalite is utilized as a natural fertilizer. Its reduced carbon footprint makes it useful in organic farming as well. Because of this context, A field experiment was carried out at the farmer's field in Mattiyampatti village, Dharmapuri district, Tamil Nadu, to evaluate the effect of polyhalite as a potassium source on growth yield parameters of onion using CO(on)6 variety as a test crop during 2022-2023. The experimental soil was sandy loam in texture (Typic Ustropept) with pH of 7.56 and EC of 0.24 dS m^{-1}. The experiment was laid out in randomized block design consisting of twelve treatments and three replications. The recommended dose of nitrogen (60 kg ha^{-1}) and phosphorus (60 kg ha^{-1}) were applied as urea and single super phosphate, respectively. The polyhalite and muriate of potash were used as a potassium source at different levels (10 to 50 kg K_2O ha^{-1}) per the treatment schedule. The present study revealed that polyhalite application performed better than muriate potash in all parameters. With respect to the level of applications 40 kg K2O ha^{-1} as polyhalite registered the maximum growth attributes such as plant height (66.4 cm), number of leaves per plant (34.3), root length (9.63 cm), number of tillers $plant^{-1}$ (4.78) and chlorophyll content (59.3 SPAD readings), and yield attributes such as number of bulb $plant^{-1}$ (6.64), single bulb weight (9.69 g), bulb length (4.00 g), neck diameter (3.94 g) and neck thickness (13.82 mm). The minimum responses were observed in absolute control.

Keywords: Growth, Muriate of Potash, Onion, Polyhalite, Yield

INTRODUCTION

The onion (*Allium cepa* L.) is a bulbous vegetable and condiment crop cultivated worldwide. It is a member of the Amaryllidaceae family. Due to its flavor and aroma, it is often called as 'queen of the kitchen'. It is native to Central Asia and the Mediterranean region and is commercially grown in China, India, the USA, Turkey and Pakistan (Mahyar Dorrigiv *et al.,* 2021). Although they are considered biennials, onions are usually cultivated as annuals because of their tasty bulbs. The main edible part is the onion bulb, which is available in various sizes, shapes, and colours, from the well-known red and sweet onions to the more common white and yellow ones (Ahmed *et al.,* 2023). The crop is well-known for its ability to be stored for extended periods, enhancing its availability and usability throughout the year. Onion contributes significant nutritional value to the human diet and has medicinal properties. It is primarily consumed for its unique flavor and ability to enhance the flavor of other foods because of a volatile compound known as allyl-propyl disulphide (Getachew,

2020).

It possesses antimicrobial properties and several antioxidant compounds, mainly polyphenols such as flavonoids and sulphur-containing compounds. It is used as food, spice, and seasoning for curries. It stimulates the appetite and is used for pickling, cooking and frying. Beyond their culinary importance, onions are valued for their nutritional content, providing essential vitamins, minerals, and antioxidants. (Kumara *et al.,* 2018).

Onion cultivation is widely practised across the globe with an estimated area of 5.4 million hectares and 104.5 million tonnes of production (FAO, 2020). India, China, USA, Egypt and Turkey are the world's top five onion-producing countries. India ranks first in area (1.4 million hectares), followed by China (1.08 million hectares). India contributes 26.7 MT of world onion production, followed by China at 23.7 MT. Even though the largest onion producer, India significantly lags in productivity (Beniwal *et al.,* 2022). Tamil Nadu is cultivated in 55 thousand hectares with a production of 4 lakh t, contributing 1.79 % of India's total production. The major share of (70%) of the area in Tamil Nadu is under small onion or shallot and it is widely cultivated in the Districts of Dindigul, Tirupur, Perambalur, Trichy, Ariyalur and Namakkal. The major small onion markets are Coimbatore and Trichy. Small onion is exported to countries like Sri Lanka, Malaysia, and the Gulf (Statistical Hand Book of Tamil Nadu-2021-22).

Potassium is one of the macronutrients that is highly required for plant growth. It is a univalent cation that is called a "master cation" because plant cell sap contains its highest concentration. It serves a key and plays an essential physiological and metabolic role in plants. The onion is a shallow-rooted and potash-loving crop; hence, it requires a fairly higher amount of nutrients, so potassium must be maintained in the upper layer of the soil (Pachauri *et al.,* 2005; Kumara *et al.,* 2018).

The polyhalite layer, deposited approximately 260 million years ago, is mined from nearly 1200 meters beneath the ocean surface along the north-eastern coast of England. This unique mineral addresses the soil requirements for sulfur, potassium, magnesium, and calcium. Unlike a collection of salts, polyhalite is a single crystal, and all its components are released into a solution in a balanced manner (Gokul *et al.,* 2023; Shahi *et al.,* 2018). The present study aimed to compare the effect of polyhalite, potassium sulfate (Sulphate of potassium), and potassium chloride (Muriate of potash) fertilizers on onion Var CO(ON) 6 bulb yield, nutrient uptake, and bulb quality.

MATERIALS AND METHODS

The experiment was conducted at a farmer's field in Maattiyampatti village Kaarimangalam taluk, Dharmapuri district, Tamil Nadu. It is located geographically at 12°19' N latitude and 78°14' E longitude. The soil of the farmer's field of Maattiyampatti village, Dharmapuri, Tamil Nadu, was sandy loam in texture, coming under the taxonomic classification of Typic Ustropept under the vannapatti series. The experiment soil was neutral in soil pH (7.12). It was low in organic carbon (6.5 g kg^{-1}), available nitrogen (181 kg ha^{-1}) and medium in phosphorus (14.1 kg ha^{-1}), potassium (117 kg ha^{-1}) and sulphur (12.1 mg kg^{-1}). The twelve treatments were assigned in a randomized block design with three replications. The treatment details were T_1: Absolute control, T_2: N,P, T_3: N,P + 10 kg ha^{-1} K2O as MOP, T_4: N,P + 20 kg ha^{-1} K2O as MOP, T_5: N,P + 30 kg ha^{-1} K2O as MOP, T_6: N,P + 40 kg ha^{-1} K2O as MOP, T_7: N,P + 50 kg ha^{-1} K2O as MOP, T_8: N,P + 10 kg ha^{-1} K2O as polyhalite, T_9: N,P + 20 kg ha^{-1} K2O as polyhalite, T_{10}: N,P + 30 kg ha^{-1} K2O as Polyhalite, T_{11}: N,P + 40 kg ha^{-1} K2O as polyhalite, T_{12}: N,P + 50 kg ha^{-1} K2O as Polyhalite. The recommended dose of nitrogen (60 kg ha^{-1}), phosphorus (60 kg ha^{-1}), and potassium were applied per the treatment schedule. The growth attributes (plant height, number of leaves $plant^{-1}$, root length, number of tillers $plant^{-1}$, chlorophyll content) were recorded at different growth stages. The yield attributes and yield (number of bulbs $plant^{-1}$, single bulb weight, bulb length, bulb diameter and neck thickness) were recorded at harvest.

Statistical analysis

The data pertaining to growth and yield parameters were analyzed statistically at 5% probability level in AGRES software.

RESULTS AND DISCUSSION

Plant height

The study's results indicated that the plant height of onion was significantly (5%) enhanced by the application of graded doses of potassium either through muriate of potash or polyhalite over potassium control and absolute control (table 1). The plant height ranged from 11.3 to 28.4 cm at 30 DAT, 18.3 to 44.3 cm at 60 DAT and 27.9 to 66.4 cm at harvest. Irrespective of potassium source, significantly highest plant height of 28.4, 44.3 and 66.4 cm at 30 DAT, 60 DAT and harvest, respectively were recorded with the application of 40 kg K2O ha^{-1} through polyhalite (T11) than muriate of potash. For levels of potassium application, 50 kg K2O ha^{-1} (T7 and T12), either through muriate of potash or polyhalite, recorded the highest plant height, which was on par with 40 kg K2O ha^{-1} (T6 and T11) potassium levels. The lowest plant height of 27.9 cm at harvest was recorded in absolute control (T1). The per cent increase in plant height due to different potassium treatments over absolute control ranged from 27.9 to 66.4 at harvest. Plants received more potassium and nitrogen, which might have encour-

aged vegetative growth. Polyhalite supplies four essential nutrients that promote the plant height of onion compared to other muriate of potash, which supplies only potassium. Similar results reported that the application of polyhalite improved the plant height of onion than muriate of potash application was earlier reported by Tak *et al.* (2013). The sulphur application also resulted in a significantly highest plant height of blackgram (Marko *et al.,* 2013).

Number of leaves per plant

The number of leaves plant^{-1} ranged from 7.32 to 12.5 at 30 DAT, 13.7 to 23.7 at 60 DAT and 19.6 to 34.3 at harvest (table 1). The number of leaves plant^{-1} significantly increased with potassium irrespective of potassium sources. The maximum number of leaves plant^{-1} was registered with 40 kg K2O ha^{-1} (T6) and (T11), which was on par with 50 kg K2O ha^{-1} of muriate of potash and polyhalite (T7) and (T12). Irrespective of potassium sources, polyhalite performed better than muriate of potash. Significantly highest number of leaves plant^{-1} of 12.5, 23.7 and 34.3 at 30 DAT, 60 DAT and harvest were recorded with 40 kg K2O ha^{-1} application through polyhalite (T11). Meanwhile, significantly lowest plant height of 7.32 at 30 DAT, 13,7 at 60 DAT and 19.6 at harvest were recorded with absolute control (T1). The polyhalite and muriate of potash application significantly (5%) increased leaves/ plant^{-1}. The increase in the number of leaves might be associated with the supply of essential nutrients. Polyhalite, containing magnesium, can contribute to the development of chlorophyll, thus influencing the number and health of onion leaves (Zhao *et al.,* 2020). Potassium application increased the availability of nitrogen and phosphorus, which resulted in a greater number of tillers plant^{-1} (Kumar *et al.,* 2014).

Root length

The effect of the application of graded doses of potassium through muriate of potash or polyhalite on the root length of onion was significant (table 2). The root length of onion ranged from 2.11 to 4.85 cm at 30 DAT, 3.08 to 7.08 cm at 60 DAT and 4.19 to 9.63 cm at harvest. The root length of the onion increased with potassium doses irrespective of potassium sources. Significantly highest root length of onion was 4.85, 7.08 and 9.63 cm at 30 DAT, 60 DAT and harvest, respectively, with 40 kg K_2O ha^{-1} application through polyhalite (T11). Meanwhile, the significantly lowest root length of onion 2.11 cm at 30 DAT, 3.08 cm at 60 DAT and 4.19 cm at harvest were recorded with absolute control (T1). Root length increased with the application of potassium through muriate of potash or polyhalite. The root length significantly increased due to soil application of 40 kg K2O ha^{-1} of polyhalite along with nitrogen and phosphorus. The per cent increase in root length over absolute control ranged from 4.19 to 9.63 at harvest. Calcium is a key element in cell wall structure and function and plays a role in various cellular processes. Improved cell development contributes to overall plant growth and root growth. Polyhalite supplies balanced nutrients to the plants along with the recommended dose of nitrogen and phosphorus, which promote the root growth of onion

Table 1. Influence of potassium sources on plant height and number of leaves plant^{-1} in onion

Treatments	Plant height (cm)			Number of leaves plant-1		
	30 DAT	60 DAT	Harvest	30 DAT	60 DAT	Harvest
T1 - Absolute control	11.3	18.3	27.9	7.32	13.7	19.6
T2 - K=0	14.2	22.2	33.2	8.76	15.8	22.4
T3 - 10 kg of K2O ha^{-1} as MOP	15.8	24.7	37.1	9.19	16.7	23.6
T4 - 20 kg of K2O ha^{-1} as MOP	19.0	29.7	44.5	10.0	18.4	26.2
T5 - 30 kg of K2O ha^{-1} as MOP	22.0	34.4	51.6	11.0	20.1	28.8
T6 - 40 kg of K2O ha^{-1} as MOP	25.8	40.2	60.3	12.0	22.3	32.2
T7 - 50 kg of K2O ha^{-1} as MOP	25.2	39.3	59.0	11.9	21.8	31.3
T8 - 10 kg of K2O ha^{-1} as Polyhalite	17.4	27.1	40.7	9.61	17.5	24.8
T9 - 20 kg of K2O ha^{-1} as Polyhalite	20.5	32.1	48.1	10.5	19.2	27.4
T10 - 30 kg of K2O ha^{-1} as Polyhalite	23.7	37.0	55.5	11.4	20.9	30.1
T11 - 40 kg of K2O ha^{-1} as Polyhalite	28.4	44.3	66.4	12.5	23.7	34.3
T12 - 50 kg of K2O ha^{-1} as Polyhalite	27.7	43.2	64.8	12.4	23.2	33.4
Sed	0.65	1.02	1.53	0.17	0.36	0.55
CD (p=0.05)	1.3	2.1	3.1	0.3	0.7	1.1

Table 2. Influence of potassium sources on root length, number of tillers per plant and chlorophyll content in onion

Treatments	Root length (cm)			Number of tillers plant^{-1}	Chlorophyll content	
	30 DAT	60 DAT	Harvest		30 DAT	60 DAT
T1 - Absolute control	2.11	3.08	4.19	2.08	30.2	40.0
T2 - K=0	2.43	3.54	4.82	2.40	34.8	43.1
T3 - 10 kg of K2O ha^{-1} as MOP	2.71	3.96	5.38	2.67	36.2	45.0
T4 - 20 kg of K2O ha^{-1} as MOP	3.25	4.75	6.46	3.21	39.1	48.5
T5 - 30 kg of K2O ha^{-1} as MOP	3.77	5.50	7.48	3.72	42.0	51.8
T6 - 40 kg of K2O ha^{-1} as MOP	4.40	6.43	8.75	4.35	45.9	56.4
T7 - 50 kg of K2O ha^{-1} as MOP	4.30	6.28	8.55	4.25	44.9	55.2
T8 - 10 kg of K2O ha^{-1} as Polyhalite	2.97	4.34	5.90	2.93	37.7	46.8
T9 - 20 kg of K2O ha^{-1} as Polyhalite	3.51	5.13	6.97	3.47	40.6	50.2
T10 - 30 kg of K2O ha^{-1} as Polyhalite	4.05	5.91	8.04	4.00	43.5	53.5
T11 - 40 kg of K2O ha^{-1} as Polyhalite	4.85	7.08	9.63	4.78	48.2	59.3
T12 - 50 kg of K2O ha^{-1} as Polyhalite	4.73	6.90	9.39	4.67	47.3	58.0
SEd	0.11	0.16	0.22	0.11	0.64	0.73
CD (p=0.05)	0.23	0.34	0.46	0.23	1.3	1.5

(Yermiyathu *et al.,* 2017; Shahi *et al*., 2018).

Number of tillers per plant

Application of potassium through muriate of potash or polyhalite resulted in a significant increase in tillers plant^{-1} over absolute control (table 2). The number of tillers ranged from 2.08 to 4.78 at harvest. The number of tillers increased with potassium doses irrespective of potassium sources. Irrespective of potassium sources, a significantly highest number of tillers plant^{-1} of 4.78 was registered with 40 kg K_2O ha^{-1} application through polyhalite (T_{11}). This might be attributed to the application of potassium and sulphur, which increased the protein concentration in chloroplast, which would have increased the photosynthetic efficiency of plants (Shahi *et al.*, 2018).

Chlorophyll content

Total chlorophyll content showed an increase with the application of potassium through muriate of potash or polyhalite (table 2). Total chlorophyll content significantly increased due to soil application of 40 kg K_2O ha^{-1} of polyhalite (T_{11}), nitrogen, and phosphorus. The per cent increase in chlorophyll content over absolute control ranged from 40 to 59.3 at 60 DAT. Adequate supply of potassium increases chlorophyll content in plants. The results were in line with Mfilinge *et al.* (2014) and Deshpande *et al.* (2013). Significantly, the highest chlorophyll and carotenoids content due to foliar K nutrition could be attributed to the mode of action of macro elements in enhancing the photosynthetic activity by Doss (2013) in *Vigna mungo*.

This significant influence of sulphur application on increasing growth and yield might be attributed to its role in chlorophyll synthesis (Mir et al., 2013). Potassium influences the enzyme responsible for photosynthesis, which increases the chlorophyll content of onion. This conforms with the findings of Deshpande *et al.* (2013) in onion. Sulphur is a constituent of amino acids, proteins, and vitamins, including those involved in chlorophyll synthesis. Polyhalite, a source of sulphur, can positively impact chlorophyll content by ensuring the availability of this essential component. Magnesium is a central component of the chlorophyll molecule. Polyhalite, with its magnesium content, can directly influence chlorophyll production, leading to increased chlorophyll content in plant tissues (Gowthami *et al.*, 2022).

Yield attributes and yield

There was a significant difference in yield attributes and bulb yield due to the addition of potassium through muriate of potash and polyhalite along with the recommended dose of nitrogen and phosphorus. Among the potassium sources, the yield attributes and onion yield were significantly increased by the addition of polyhalite @ 40 kg K2O ha^{-1}. They had a greater influence on the higher number of bulbs plant^{-1} than muriate of potash. The maximum number of bulbs plant^{-1} (6.64), single bulb weight (9.69 g), bulb length (4 cm), bulb diameter (3.94 cm) and neck thickness (13.82 mm) were recorded in the application of nitrogen and phosphorus and combined with 40 Kg K2O ha^{-1} as polyhalite (table 3). This treatment was on par with NP + 50 Kg K2O ha^{-1} as polyhalite. The observed increase in yield and yield attributes can be attributed to enhanced growth characters facilitated by potassium supplied through poly-

Table 3. Influence of potassium sources on yield attributes and yield in onion

Treatments	No. of bulbs plant-1	Single bulb weight (g)	Bulb Length (cm)	Bulb Diameter (cm)	Neck thickness (mm)
T1 - Absolute control	4.57	6.69	1.74	1.72	5.82
T2 - K=0	4.90	7.15	2.00	1.97	6.92
T3 - 10 kg of K2O ha^{-1} as MOP	5.14	7.50	2.24	2.20	7.72
T4 - 20 kg of K2O ha^{-1} as MOP	5.58	8.15	2.68	2.64	9.27
T5 - 30 kg of K2O ha^{-1} as MOP	5.98	8.73	3.11	3.06	10.74
T6 - 40 kg of K2O ha^{-1} as MOP	6.40	9.34	3.64	3.58	12.55
T7 - 50 kg of K2O ha^{-1} as MOP	6.35	9.27	3.55	3.50	12.27
T8 - 10 kg of K2O ha^{-1} as Polyhalite	5.37	7.84	2.45	2.42	8.47
T9 - 20 kg of K2O ha^{-1} as Polyhalite	5.79	8.45	2.90	2.86	10.01
T10 - 30 kg of K2O ha^{-1} as Polyhalite	6.16	8.99	3.34	3.29	11.53
T11 - 40 kg of K2O ha^{-1} as Polyhalite	6.64	9.69	4.00	3.94	13.82
T12 - 50 kg of K2O ha^{-1} as Polyhalite	6.58	9.61	3.90	3.85	13.46
S.Ed	0.08	0.12	0.09	0.08	0.32
CD (p=0.05)	0.17	0.25	0.19	0.17	0.66

halite. Potassium has been found to enhance photosynthetic activity, leading to increased assimilation of nutrients from leaves to bulbs. This contributes to a higher bulb weight in onions.

Additionally, potassium has been linked to increased bulb tissue pressure potential and enhanced phloem transport of calcium to bulbs. Potassium and sulfur are crucial for carbohydrate assimilation, further promoting increased bulb weight and overall yield, aligning with the findings of Sacks *et al*. (2017) and Mello *et al*. (2019) in tomatoes. Onion is a sulphur loving plants; thus supplying sulphur through polyhalite improved the synthesis of amino acids such as cysteine and methionine, which were essential for protein synthesis in bulb. As reported by Singh et al. (2018), increased neck thickness is attributed to the crop's increased uptake of NPK and sulfur, leading to increased synthesis and translocation of photosynthates to the bulbs and storage organs of the onion. Shah *et al.* (2012) reported that different doses of potassium with sulphur application significantly affected the neck diameter due to higher dry matter accumulation in the cover and neck portion of bulbs in onion. Moreover, potassium's role in promoting cell expansion contributes to the formation of large and well -shaped bulbs. Potash supports root development and enhances leaves' efficiency (Gokul *et al.,* 2023) in manufacturing sugars and starch in sugarcane (Islam *et al.,* 2008).

Furthermore, calcium and magnesium derived from polyhalite have been found to promote cell division and elongation in bulbs, leading to increased bulb diameter and length (shah *et al.* (2012) in onion and Karthikeyan *et al.* (2023) in blackgram). Magnesium, as an essential component of chlorophyll, plays a vital role in increasing photosynthates assimilation in leaves, which is then translocated to the bulbs, resulting in increased bulb weight. Polyhalite reduces pests and diseases, improving onion's growth and yield (Ahmed *et al.,* 2023).

Conclusion

In conclusion, applying polyhalite at a rate of 40 kg K_2O ha^{-1} (T_{11}) has proven highly beneficial for onion Var. CO (ON)6. This optimal dosage of polyhalite significantly contributed to improved and sustained growth characteristics, enhancing yield attributes and ultimately leading to higher onion yields. The study highlights that using polyhalite as a potassium source positively influences the growth and yield of onion than muriate of potash.

Conflict of interest

The authors declare that they have no conflict of interest.

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