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# Studies on different levels and scheduling of potassium on growth and yield of onion var. Agrifound Light Red in light-textured soil of Western UP

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## Abstract

Onion is a commercial crop and under fertilization, especially potassium is a main issue behind its lower production. By keeping this point on priority, a field experiment entitled "Studies on different levels and scheduling of potassium on growth and yield of onion (*Allium cepa* L.) var. Agrifound Light Red in light textured soil of Western UP" was conducted at Crop Research Centre of SVPUA&T Meerut U.P. during *Rabi* season of 2020-21 and 2021-22. The experiment comprised 11 treatments replicated thrice with onion cultivar Agrifound Light Red in randomized block design. The three doses of potassium *i.e.* 100, 125 and 150% of recommended doses through muriate of potash (MOP) were used with NPS except control for potassium. Polyhalite was also used in one of the treatment as a source of potassium. The data recorded during 30, 60, 90 DAT and at harvest for different parameters showed that the increasing dose of potassium improved growth and yield attribute including yield. The application of potassium through polyhalite as in $T_{11}$ (NP + K50-100% basal through Polyhalite) increased the yield by 54.21, 35.33, 21.98 and 13.59% over $T_1$, $T_2$, $T_5$, $T_8$, respectively. The pooled data showed that maximum plant height (68.53cm) number of leaves/plant (7.55) neck thickness (14.32mm), equatorial bulb diameter (70.33mm), polar diameter (64.73mm) and fresh weight of bulb (67.06g). The overall experimental findings showed that the application of higher dose of potassium than recommended is beneficial and polyhalite was superior over muriate of potash due to additional supplement of sulphur, calcium and magnesium.

**Key words:** Onion, Growth and Yield, Polyhalite, Potassium levels, Potassium scheduling

## Introduction

One of the most significant commercial vegetable crops grown widely in India is the onion (*Allium cepa* L.), which is a member of the Alliaceae family. Because it contains the volatile oil "allyl propyl disulphide," an organic molecule high in sulphur, onions are prized for their flavour and pungency. Its green leaves and bulbs can both be eaten raw and used to prepare a range of dishes. It is one of the Alliums that is most widely planted and liked. The underground stem of an onion, which has larger, meatier leaves, is its feeding organ. The bulb contains 38 calories, 11.0 g of carbohydrates, 1.2 g of proteins, 0.6 g of fibre, 86.8 g of water, 1.2 g of protein, 0.08 g of thiamine, 0.01 g of riboflavin, and 0.2 g of niacin per 100 g of edible portion. It also contains minerals like phosphorus (39 mg), calcium (27 mg), sodium (1.0 mg), iron (0.7 mg), and potassium 1.5mg. (Kumara et al. 2018).

In India, onion is being grown in an area of 1.20 million hectare with the annual production of 19.40 million tons and the productivity of 16.1t $ha^{-1}$. Maharashtra stands first in production of onion followed by Karnataka, Gujarat, Bihar, Madhya

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Pradesh, Andhra Pradesh, Rajasthan, Haryana, Uttar Pradesh and Tamil Nadu in our country. In Uttar Pradesh, onion is cultivated in an area of 11734.00 hectare with production of 167327 tons and the average productivity is 15.10 t $ha^{-1}$. In Meerut district, onion cultivated in area of 12 hectare with production of 171t $ha^{-1}$ and the average productivity is 14.25 t $ha^{-1}$(Anonymous, 2020). The nutrient management practices play an important role in higher production of commercial crops like onion. The application of nitrogen and phosphorous is not enough to meet the higher production of quality onion. The requirement of potassium and sulphur is also essential for better crop growth because potassium is essential for the xylem, which distributes water and other essential nutrients throughout the plant. Since onions are a crop with shallow roots that prefers potassium, a higher level of nutrients, particularly potassium, must be maintained in the top layer of soil. For the production of onions, a strong amount of fertiliser is typically advised. Onion is a strong potash-responsive crop, just like other tuber and root crops. Potassium aids in a variety of metabolic processes, including the production and transport of sugars and carbohydrates, the synthesis of proteins, the development of pest and disease resistance, the activation of numerous enzymes, the prevention of stalk and stem breakage under stress conditions, storage quality, and increased bulb size and bulb yield.

The way potassium fertilisers are applied has a significant impact on how well the crop uses them. Potassium makes up an average of 2.6% of the earth's crust (Schroeder 1978) When applying potassium to onions during its growing season, timing is crucial for the development of their bulbs. In comparison to a single treatment of the same quantity of nitrogen and potassium, a split application results in a heavier winter onion bulb. Because of its impact on storage quality, bulb size, bulb quantity, and yield per plant, K is regarded as a very essential factor in onions (Bekele 2018). K is essential for the xylem, which distributes water and other essential nutrients throughout the plant, in a manner similar to this. Thus, maintaining development and quality of onions requires administration of a sufficient amount and source of K at key growth stages. The soil must be supplemented with nutrients after the onion crop in order to keep the soil fertile. According to Tandon and Tiwari (2008), lower nutrient rates of 100 kg N, 50 kg P2O5 (30 kg P), and 50 kg K2O (41 kg K) $ha^{-1}$ are typically used, notably for K. For a 40mt $ha^{-1}$ bulb yield, this amounts to 120 kg N, 50 kg P, and 160 kg K per $ha^{-1}$ (Deshpande et al. 2013).

Except the conventional source of potassium, a new source of potassium i.e. Poly4 is also becoming popular now a days for commercial crops like sugarcane, potato anion etc. Poly4 is a multi-nutrient and low-chloride fertilizer suitable for organic farming. Derived from a naturally occurring mineral polyhalite, POLY4 contains four (14% K2O, 17% CaO, 6% MgO and 19% S) of the six essential macro nutrients required for plant growth. This fertilizer also works as slow release fertilizer and supplied sulphur in adequate amount that no need to add sulphur from any other external source. Considering all the above points a field experiment was conducted to investigate the optimum level of potash for the better growth and development as well as higher production of onion crop.

## Materials and Methods

**Experimental site and location:** The experiment entitled "Studies on different levels and scheduling of potassium on growth and yield of onion (*Allium cepa* L.) var. Agrifound Light Red in light textured soil of Western UP" was carried out at Crop Research Centre in Sardar Vallabhbhai Patel University of Agriculture and Technology in Meerut, Uttar Pradesh during Rabi 2020–2021 and 2021–2022. The farm is located at latitude 29.08'N and longitudes 77.00'E while above mean sea level is 218 m and which lies in western Uttar Pradesh, there are semiarid and subtropical climate zones.

**Experimental Design and Treatments details:** The experiment consists of 11 treatment combinations which were laid out in Randomized Block Design (RBD) with 3 replications. The treatments were allocated randomly in each replication as per the standard procedure and the cultivar grown was Agrifound Light Red. Recommended dose of NPKS for onion in this zone is 100:50:50:40 kg $ha^{-1}$. Nitrogen, phosphorus and sulphur were applied commonly through urea, (half as basal dose and remaining half in two equal splits at 30 and 50 DAT), DAP and bentonite. Potassium was applied as per treatments through MOP and polyhalite. T1-Control (N100 P50 S40 K0), T2-NPS + K50 (K 100% at basal), T3-NPS + K50 (K50% basal + 50% at bulb formation stage), T4-NPS + K50 (K25% basal + 37.5%at vegetative + 37.5% at bulb formation stage), T5-NPS + K62.5 (K 100% at basal), T6-NPS + K62.5 (K 50% basal + 50% at bulb formation stage), T7-NPS + K62.5 (K 25% basal + 37.5% at vegetative + 37.5% at bulb formation stage), T8-NPS + K75 (K 100% at basal), T9-NPS + K75 (K 50% basal + 50% at bulb formation stage), T10-NPS + K75 (K 25% basal + 37.5% at vegetative + 37.5% at bulb formation stage) and T11-NP + K50 (100% basal through Polyhalite)

**Initial Soil Properties:** Soil Samples were randomly taken from six locations in field from 0 to 15-cm soil depth for physico-chemical analysis. A part of the representative soil samples was air dried, ground, and passed through 2mm sieve for determination of nitrogen, phosphorous, potash, sulphur, bulk density, pH and EC by standard procedures and presented in Table 1.

**Table 1:** Physical and chemical properties of soil of 0 to 15cm depth of the experimental field at the beginning of the study

| Soil Properties | Value |
|---|---|
| Sand (%) | 49.92 |
| Silt (%) | 27.85 |
| Clay (%) | 17.96 |
| Textural class | Sandy loam |
| BD (gm./cc) | 1.54 |
| pH | 7.22 |
| EC (dms$^{-1}$) | .12 |
| OC (g/kg) | 4.30 |
| Available (N kg/h) | 122.96 |
| Olsen-P (kg/h) | 31.83 |
| Available-K (kg/h) | 144.48 |
| S (kg/h) | 13.3 |

**Observations recorded:** To assess the effect of applied treatments on onion crop some observations related to growth and yield attributes were taken at different time intervals from five randomly selected plants from the net plot area for each treatment and were labelled. Throughout the crop growth period, tagged plants were used to record plant height (cm) and leaf count at intervals of 30, 60, and 90 days, and an average was calculated. The height of the plant was measured from the soils surface to the tip of each leaf. Neck, equatorial and polar diameter was recorded using digital vernier calliper and expressed in millimetres(mm), and the same bulbs were used for measuring their polar diameter, equatorial diameter, during 30, 60, 90 DAT, and at harvest. The bulb yield per plot was recorded by weighing the weight of bulbs from net plot area and expressed in kg per plot and converted into yield quintal per hectare (qha$^{-1}$). The average bulb weight was then calculated and expressed in grams. With the aid of a digital vernier calliper, the distance between the bulb's two polar ends was measured, and the mean diameter of the five bulbs used in each treatment was calculated. All the data obtained from experiment was statistically analyzed by using the procedure given by Gomez and Gomez (1984).

## Results and Discussion

**Growth attributes:** Pooled data regarding the effect of various doses of potassic fertilizers on the different growth attributes like plant height (cm), no. of leaves per plant, fresh weight of leaves (g) and dry weight of leaves were measured at different growth stages of onion i.e. 30, 60, and 90 DAT (day after transplant) are presented in Table 2.

**Table 2:** Effect of different potassium doses on growth attributes of onion at different growth intervals

| Treatments | Plant height (cm) | | | No. of leaves/plant | | | Fresh weight of leaves (g) | | | Dry weight of leaves (g) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 30 | 60 | 90 | 30 | 60 | 90 | 30 | 60 | 90 | 30 | 60 | 90 |
| $T_1$ | 16.97 | 33.98 | 49.63 | 2.83 | 4.65 | 5.82 | 2.25 | 24.35 | 84.56 | 0.22 | 2.45 | 9.68 |
| $T_2$ | 17.10 | 36.37 | 59.07 | 3.23 | 5.10 | 6.52 | 3.20 | 27.27 | 111.15 | 0.32 | 2.89 | 10.79 |
| $T_3$ | 17.60 | 36.83 | 60.82 | 3.42 | 5.24 | 6.56 | 3.26 | 27.49 | 115.02 | 0.33 | 3.24 | 11.01 |
| $T_4$ | 17.97 | 37.64 | 61.73 | 3.43 | 5.33 | 6.63 | 3.31 | 29.33 | 119.38 | 0.33 | 3.25 | 11.42 |
| $T_5$ | 18.20 | 37.71 | 64.27 | 3.43 | 5.41 | 6.68 | 3.45 | 29.87 | 124.55 | 0.34 | 3.37 | 11.53 |
| $T_6$ | 18.77 | 38.44 | 64.85 | 3.58 | 5.59 | 6.77 | 3.59 | 33.89 | 130.44 | 0.36 | 3.73 | 12.21 |
| $T_7$ | 18.63 | 38.50 | 64.77 | 3.51 | 5.52 | 6.71 | 3.50 | 30.77 | 126.82 | 0.35 | 3.54 | 11.95 |
| $T_8$ | 19.10 | 39.42 | 65.23 | 3.60 | 5.63 | 6.88 | 3.70 | 34.52 | 144.06 | 0.37 | 3.78 | 12.63 |
| $T_9$ | 20.25 | 40.60 | 66.13 | 3.74 | 5.82 | 7.22 | 3.93 | 43.77 | 154.77 | 0.39 | 3.88 | 13.73 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $T_{10}$ | 19.53 | 40.20 | 65.33 | 3.63 | 5.75 | 7.02 | 3.74 | 37.92 | 150.31 | 0.37 | 3.83 | 12.97 |
| $T_{11}$ | 21.52 | 42.95 | 68.53 | 4.00 | 6.05 | 7.55 | 4.07 | 47.93 | 158.77 | 0.41 | 4.05 | 14.57 |
| SEm | 0.66 | 1.47 | 2.32 | 0.14 | 0.22 | 0.27 | 0.14 | 1.45 | 5.32 | 0.01 | 0.19 | 0.48 |
| CD 5% | 1.94 | 4.32 | 6.84 | 0.41 | 0.66 | 0.79 | 0.42 | 4.27 | 15.68 | 0.04 | 0.57 | 1.41 |

$T_1$: Control (N100 P50 S40 K0); $T_2$: NPS + K50 (K 100% at basal); $T_3$: NP S + K50 (K 50% basal + 50% at bulb formation stage); $T_4$: NPS + K50 (K 25% basal + 37.5% at vegetative + 37.5% at bulb formation stage); $T_5$: NP S + K63 (K 100% at basal); $T_6$-NPS + K63 (K 50% basal + 50% at bulb formation stage); $T_7$: NPS + K63 (K 25% basal + 37.5% at vegetative + 37.5% at bulb formation stage); $T_8$: NPS + K75 (K 100% at basal); $T_9$: PS + K75 (K 50% basal + 50% at bulb formation stage); $T_{10}$: NPS + K75 (K 25% basal + 37.5% at vegetative + 37.5% at bulb formation stage); $T_{11}$: NP + K50 (100% basal through Polyhalite)

The plant heights of onion differ significantly during various growths periods under different treatments. The maximum plant height 21.52, 42.95 and 68.53cm at 30, 60 and 90 DAT, respectively under T11 (NP + K50, 100% basal through polyhalite) followed by T9 (NPS + K75-50% basal + 50% at bulb formation stage) and T10 (NPS + K75-25% basal + 37.5% at vegetative + 37.5% at bulb formation stage). The plant height of onion followed an increasing like T1 < T2 < T3 < T4 < T5 < T7 < T6 < T8 < T10 < T9 < T11 at 30, 60 and 90 DAT. The plant height of onion at 90 DAT under T11 was increased by 16.01, 6.62 and 5.05% over T2 (NPS + K50- 100% at basal), T5 (NPS + K63- 100% at basal) and T8 (NPS + K75-100% at basal), respectively while maximum increase of 38.08% over control (T1). The response of 100% recommended potassium dose was lower than 125% and 150% of potassium dose of potassium fertilizer than basal and though split doses.

No. of leaves per plant increased as the potassium doses increased and differ significantly under various treatments. The number of leaves par plant increased about two times as the growth period increased from 30 to 90 DAT. The number of leaves par plant increased under split application of potassium doses over basal application but it was not at significant level. The application of potassium through poly halite recorded maximum leaves 4.00, 6.05 and 7.55 at 30,60and 90 DAT, respectively which significantly higher over T1,T2,T3 and T4 at all growth stages while T5, T6 and T7 at 30 DAT. The minimum leaves par plant was found under T1 at 30, 60 and 90 DAT i.e. 2.83, 4.65 and 5.82 respectively which was 41.34, 30.10 and 29.72% lower than T11(NP + K50-100% basal through Polyhalite). The average fresh weight of 5 selected plant leaves was measured at 30, 60 and 90 DAT and it was found that it differs significantly under various treatments. The maximum fresh weight of leaves was found under T11 (NPS + K50-100% basal through Polyhalite) i.e. 4.07, 47.93 and 158.77 g at 30, 60 and 90 DAT, respectively followed by T9 (NPS + K75-50% basal + 50% at bulb formation stage) and T10(NPS + K75-25% basal + 37.5% at vegetative + 37.5% at bulb formation stage) while minimum under T1 i.e. 2.25, 24.35 and 84.56 g at respective growth periods. The basal application off 125% K though MOP as in T5 and 100% K through MOP of recommended dose either basal or in two and three splits were achieved significantly lower weight of fresh leaves as compared to 150% of K in two splits application as in T9(NPS + K75-50% basal + 50% at bulb formation stage).

The dry weight of leaves (g) is presented in Table 2 which differs significantly under different treatments. The reflection of better nutrients management in respect to potassium dose and time of application is reflecting from data and maximum dry weight i.e.0.41, 4.05 and 14.57 g at 30, 60 and 90 DAT, respectively was found under T11(N P S + K50-100% basal through Polyhalite) followed by T9 (NPS + K75-50% basal + 50% at bulb formation stage) and T10(NPS + K75-25% basal + 37.5% at vegetative + 37.5% at bulb formation stage).The increment in dry weight of leaves was about 86.36, 65.30 and 50.51% over T1, 28.12, 40.13 and 35.03% over T2 20.58, 20.17 and 26.36% over T5 10.81, 7.14 and 15.36% over T8 was found at 30, 60 and 90 DAT, respectively under T11.The application of potassium in two splits was found better than three splits of 100, 125 and 150% K of recommended dose. The findings of this experiment in respect to growth attributes of onion showed the importance of potassium and in many researches of other scientists revealed that the increased dose of potassium from recommended application improved the plant heigh, number of leaves and many other growth attributes (Behairy et al. 2015, Díaz-Pérez et al. 2016). The vigorous growth due to the higher dose of potassium application might be due to higher uptake under balanced fertilization and this result also showed conformity with the findings of Kumara et al. 2018 and Deshpande et al. 2013.

Yield attributes: All the yield attributes of onion crop is presented in Table 3 which significantly different under various treatments and clearly reflect the effect of various potassium doses. The neck thickness under various treatments was increased as the growth duration increased from 30 DAT to at harvest. The neck thickness of onion at 30 DAT was found maximum (2.79mm) under T11 (NPS + K50-100% basal through Polyhalite) which was significantly higher only over T1 (control) and at par to all other treatments. But in advanced growth stages i.e. 60, 90 and at harvest the maximum neck thickness under T11(NPS + K50-100% basal through Polyhalite) i.e. 11.24, 14.22 and 14.32mm, respectively was significantly higher over T1, T2, T3, T4, T5, and T7 which at par to T6, T8, T9 and T10. The increment in neck thickness under T11 (NPS + K50-100% basal through Polyhalite) at harvest was about 44.06, 35.46, 19.43 and 8.56% over T1, T2, T5 and T8, respectively.

**Table 3:** Effect of different potassium doses on growth attributes of onion at different growth intervals.

| Treatments | Neck Thickness (mm) | | | | Equatorial Bulb Diameter (mm) | | | | Polar Diameter (mm) | | | | No. of Scales/bulb | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 30 | 60 | 90 | At harvest | 30 | 60 | 90 | At harvest | 30 | 60 | 90 | At harvest | 30 | 60 | 90 | At harvest |
| $T_1$ | 1.48 | 7.34 | 10.74 | 9.94 | 2.83 | 8.73 | 24.16 | 47.64 | 9.47 | 22.34 | 32.49 | 47.71 | 3.33 | 5.91 | 7.17 | 7.90 |
| $T_2$ | 2.44 | 8.69 | 11.76 | 10.57 | 3.77 | 13.36 | 31.82 | 58.35 | 12.84 | 26.72 | 40.82 | 54.04 | 3.70 | 6.80 | 8.10 | 8.70 |
| $T_3$ | 2.47 | 9.00 | 11.96 | 11.41 | 3.92 | 13.93 | 33.06 | 59.15 | 13.53 | 27.35 | 42.32 | 55.62 | 3.70 | 7.10 | 8.27 | 8.90 |
| $T_4$ | 2.48 | 9.45 | 12.44 | 11.75 | 4.02 | 13.99 | 33.59 | 58.83 | 13.62 | 27.59 | 43.69 | 56.76 | 3.80 | 7.25 | 8.30 | 9.70 |
| $T_5$ | 2.51 | 9.66 | 12.85 | 11.99 | 4.06 | 14.26 | 33.99 | 58.50 | 14.03 | 28.81 | 44.16 | 57.67 | 3.95 | 7.30 | 8.41 | 9.70 |
| $T_6$ | 2.62 | 9.92 | 13.13 | 13.08 | 4.19 | 15.11 | 35.03 | 63.85 | 14.81 | 29.47 | 44.85 | 58.48 | 4.10 | 7.65 | 8.50 | 9.90 |
| $T_7$ | 2.57 | 9.79 | 12.90 | 12.31 | 4.09 | 14.77 | 34.23 | 60.96 | 14.05 | 28.96 | 44.70 | 57.83 | 4.10 | 7.45 | 8.45 | 9.70 |
| $T_8$ | 2.68 | 10.18 | 13.01 | 13.19 | 4.26 | 15.37 | 35.42 | 64.69 | 15.01 | 30.72 | 44.84 | 58.56 | 4.10 | 7.85 | 8.50 | 10.30 |
| $T_9$ | 2.74 | 10.65 | 13.92 | 14.18 | 4.53 | 16.53 | 36.77 | 67.92 | 16.40 | 31.45 | 47.54 | 61.71 | 4.30 | 8.05 | 8.70 | 10.70 |
| $T_{10}$ | 2.71 | 10.26 | 13.28 | 13.98 | 4.47 | 15.47 | 35.61 | 65.32 | 15.94 | 30.62 | 46.90 | 58.87 | 4.10 | 7.80 | 8.58 | 10.70 |
| $T_{11}$ | 2.79 | 11.24 | 14.22 | 14.32 | 4.68 | 17.55 | 37.44 | 70.33 | 16.94 | 33.21 | 49.15 | 64.73 | 4.47 | 8.25 | 8.90 | 11.30 |
| SEm | 0.12 | 0.39 | 0.45 | 0.52 | 0.18 | 0.64 | 1.18 | 2.19 | 0.52 | 1.05 | 1.89 | 2.00 | 0.15 | 0.26 | 0.29 | 0.38 |
| CD 5% | 0.35 | 1.14 | 1.32 | 1.53 | 0.52 | 1.90 | 3.48 | 6.47 | 1.54 | 3.11 | 5.58 | 5.90 | 0.43 | 0.77 | 0.85 | 1.11 |

$T_1$: Control (N100 P50 S40 K0); $T_2$: NPS + K50 (K 100% at basal); $T_3$: NP S + K50 (K 50% basal + 50% at bulb formation stage); $T_4$: NPS + K50 (K 25% basal + 37.5% at vegetative + 37.5% at bulb formation stage); $T_5$: NP S + K63 (K 100% at basal); $T_6$-NPS + K63 (K 50% basal + 50% at bulb formation stage); $T_7$: NPS + K63 (K 25% basal + 37.5% at vegetative + 37.5% at bulb formation stage); $T_8$: NPS + K75 (K 100% at basal); $T_9$: PS + K75 (K 50% basal + 50% at bulb formation stage); $T_{10}$: NPS + K75 (K 25% basal + 37.5% at vegetative + 37.5% at bulb formation stage); $T_{11}$: NP + K50 (100% basal through Polyhalite)

The equatorial bulb diameter (mm) presented in Table 3 showed an improvement as potassium doses increase and applied in two split doses except basal and three splits. The equatorial bulb diameter (mm) at harvest was found maximum (70.33mm) under T11(NPS + K50-100% basal through Polyhalite) was increased by 20.53, 20.22 and 8.71% over T2, T5, and T8 while over control (T1) increment of 47.62% was observed. The equatorial bulb diameter (mm) was better under two split application of MOP rather than basal and three splits while 150% recommended dose of potassium was better than 100 and 125% of recommended dose. Moreover, polar bulb diameter also fallowed the same trend as like equatorial bulb diameter. The maximum increment in polar bulb diameter was found under T11 (NPS + K50-100% basal through Polyhalite) i.e. 78.88, 48.65, 51.27 and 35.67% at 30, 60, and 90 and at harvest respectively over T1. In comparison to basal and splits application the polar diameter was found maximum under T9 NPS + K75 (K 50% basal + 50% at bulb formation stage) i.e. 61.71 mm at harvest over all other treatments except T11.

The no. of scales per bulb varied significantly under various treatments at different growth stages. The increasing dose of potassic fertilizers were responsive in respect to no. of scales per bulb but three split application was not so responsive than two splits and basal application. The maximum no. of scales per bulb was found under T11 i.e. 4.47, 8.25, 8.90 and 11.30 at 30, 60, 90 and at harvest while minimum under T1. No. of scales under T11 at harvest was found significantly higher over T1, T2, T3, T4, T5, T6 and T7 while at par to T8, T9, T10 and T11. The 100% recommended dose of potassium through polyhalite was found better than 100%, 125 and 150% recommended dose of K though MOP. The maximum length was recorded T11 (2.26) followed by T9 (2.11) and T10 (2.07) while minimum was recorded T1 (1.49). The application of MOP for potassium supplement was found better for improving the neck length when applied 150% of recommended dose in two splits as in T9 as compared to 100 and 125% of recommended dose while no significant difference was observed between two and three split of potassium application. The neck length under all treatments was significantly higher over control (N100 P50 S40 K0) except T2 (NPS + K50 - 100% at basal).

The fresh weight of bulb increased as the growth period increased and clear reflection of increasing potassium dose was shown at harvest where maximum fresh weight (67.06g) bulb was observed under T11 (NPS + K50-100% basal through Polyhalite) at par to T9 (64.85g) and significantly higher over all other treatment with increased of 50.56, 30.67, 25.51and13.14 % over T1, T2,T5 and T8, respectively. The application of potassium doses in their splits was not significantly responsive as compared to two splits application in respect to both fresh & dry weight of bulb. Maximum dry weight (11.23g) of onion bulb was observed at harvest under T11(NPS + K50-100% basal through Polyhalite) followed by T9 (10.84g) and T10 (10.13g) while minimum (4.19g) under T1 (control) both fresh and dry weight increased under T11 due to application of polyhalite because it supplied potassium as well as sulphur. Dry weight of bulb under T9 was increased by 158.71, 102.23, 80.06, 24.16, 23.74 and 22.48 over T1, T2, T3, T5, T6 and T7, respectively at harvest and this reflect that increasing dose improve the yield parameters of onion crop. Since potassium is crucial for the movement of photosynthates from leaves to bulbs, the addition of potassium may have increased the production of photosynthates, which were then used to build new cells, resulting in improved height, vigour, and a greater number of leaves per plant, as well as larger leaves with greater length and breadth and thicker necks, which in turn increased the amount of leaf area per plant (El-Bassiouny 2006). Higher potassium levels resulted in greater leaf area, which helped to boost the generation and distribution of dry matter. With increasing potassium administration, there was a rise in the accumulation of dry matter in both the leaf and the bulb. The improvement in yield attributes of onion might be due to low physiological loss in weight and rotting bulbs due to application of potassium (Poornima et al. 2015).

The onion bulb yield varied significantly among the treatments depending on the levels of potassium (Table 4).

**Table 4:** Effect of different potassium doses on yield and yield attributes of onion at different growth intervals.

| Treatments | Neck length at harvest (cm) | Fresh weight of bulb (g) | | | | Dry weight of bulb (g) | | | | Yield (q/ha) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 30 | 60 | 90 | At harvest | 30 | 60 | 90 | At harvest | |
| $T_1$ | 1.49 | 0.42 | 5.38 | 20.56 | 44.55 | 0.27 | 0.42 | 2.00 | 4.19 | 200.97 |
| $T_2$ | 1.66 | 0.53 | 5.99 | 23.22 | 51.32 | 0.33 | 0.51 | 2.12 | 5.36 | 229.01 |
| $T_3$ | 1.85 | 0.55 | 6.20 | 23.45 | 54.40 | 0.36 | 0.53 | 2.19 | 6.02 | 241.37 |
| $T_4$ | 1.87 | 0.56 | 6.27 | 25.52 | 52.07 | 0.37 | 0.56 | 2.40 | 8.00 | 247.04 |
| $T_5$ | 1.95 | 0.58 | 6.33 | 26.13 | 53.44 | 0.37 | 0.57 | 2.48 | 8.73 | 254.06 |
| $T_6$ | 1.97 | 0.59 | 6.93 | 27.06 | 56.63 | 0.40 | 0.58 | 2.73 | 8.76 | 264.55 |
| $T_7$ | 1.95 | 0.59 | 6.42 | 26.10 | 55.60 | 0.38 | 0.57 | 2.60 | 8.85 | 257.93 |
| $T_8$ | 2.02 | 0.60 | 7.08 | 28.49 | 59.27 | 0.40 | 0.65 | 2.84 | 9.74 | 272.83 |
| $T_9$ | 2.11 | 0.65 | 8.66 | 30.74 | 64.85 | 0.41 | 0.64 | 3.36 | 10.84 | 290.73 |
| $T_{10}$ | 2.07 | 0.61 | 7.54 | 29.30 | 61.09 | 0.41 | 0.71 | 3.02 | 10.13 | 280.55 |
| $T_{11}$ | 2.26 | 0.67 | 9.86 | 31.14 | 67.06 | 0.42 | 0.37 | 3.89 | 11.23 | 309.92 |
| SEm | 0.07 | 0.02 | 0.24 | 1.26 | 1.67 | 0.02 | 0.03 | 0.10 | 0.38 | 7.99 |
| CD 5% | 0.21 | 0.06 | 0.72 | 3.71 | 4.94 | 0.06 | 0.08 | 0.29 | 1.13 | 23.58 |

$T_1$: Control (N100 P50 S40 K0); $T_2$: NPS + K50 (K 100% at basal); $T_3$: NP S + K50 (K 50% basal + 50% at bulb formation stage); $T_4$: NPS + K50 (K 25% basal + 37.5% at vegetative + 37.5% at bulb formation stage); $T_5$: NP S + K63 (K 100% at basal); $T_6$-NPS + K63 (K 50% basal + 50% at bulb formation stage); $T_7$: NPS + K63 (K 25% basal + 37.5% at vegetative + 37.5% at bulb formation stage); $T_8$: NPS + K75 (K 100% at basal); $T_9$: PS + K75 (K 50% basal + 50% at bulb formation stage); $T_{10}$: NPS + K75 (K 25% basal + 37.5% at vegetative + 37.5% at bulb formation stage); $T_{11}$: NP + K50 (100% basal through Polyhalite)

The maximum bulb yield 309.92 q$ha^{-1}$was observed in T11 (NPS + K50-100% basal through Polyhalite) followed by T9 (290.73 q $ha^{-1}$) and T10 (280.55 q $ha^{-1}$) while minimum yield (200.97q $ha^{-1}$) was recorded in control treatment. The yield under T11 was increased by 54.21, 35.33, 21.98 and 13.59 % over T1, T2, T5 and T8, respectively. The application of 150% recommended dose of potassium in two split doses as in T9 was recorded and yield increment of 26.95, 17.68, 14.43, 12.71 and 3.62% over T2, T4, T5, T7 and T10, respectively. At a specified level of potassium, onion bulb yield differ between two source of K i.e. Polyhalite and MOP (muriate of potash). The application of potassic fertilizer either in two split or three split in same dose was not so responsive. The yield of onion showed the importance of potassium for their growth and development. The reasons behind the higher yield of onion under T11 because the polyhalite is not only source of potassium but it also supplied sulphur that was essential for better crop growth and development. The above result was found in close correlation with the findings of Bekele 2018 who also reported that increasing the potassium level from 0 to 80 and 120 kg $ha^{-1}$ potassium increased the yield by 47% over control. Similar result was also reported by Pachauri et al. 2005 and Priyanka et al. 2017.

## Conclusion

The results clearly reflect the importance of potassium in improving the growth and increasing the yield about 54.21% (under best treatment) over control. The recommended dose was not quit enough to increase the yield but when 150% of recommended potassium was applied in two splits (30 and 50 DAT) yield, growth yield attributes increased at a significant level. Another important and interesting conclusion is that application of multi-nutrient carrier source polyhalite was found very effective in improving growth and ultimately yield of onion as in T11 (NP + K50-100% basal through Polyhalite). So, polyhalite can be used with nitrogen and phosphorous basal application because it works like slow release nutrient fertilizer.

## सारांश

प्याज एक नकदी फसल है, जो उत्तर भारत में सर्दियों में उगाई जाती है लेकिन महाराष्ट्र जैसे राज्यों में यह साल में दो बार उगाई जाती है। इसमें विटामिन सी, फास्फोरस आदि पोषक तत्व पाए जाते हैं। इसका उपयोग सलाद, सब्जी, मसाले के रूप में किया जाता है तथा कंद के साथ–साथ इसकी पत्तियों का भी उपयोग किया जाता है। प्याज के उत्पादन के लिए पोषक तत्वों का उचित प्रबंध आवश्यक है और पोटैशियम तथा सल्फर का विशेष महत्व है। वर्तमान अध्ययन में पोटैशियम की विभिन्न मात्रा का उपयोग कर उसके फसल के वृद्धि एवं उत्पादन पर पड़ने वाले प्रभाव के बारे में जानने की कोशिश की गई है। नाइट्रोजन, फास्फोरस एवं सल्फर के साथ पोटैशियम की 100, 125 तथा 150 प्रतिशत मात्रा को दो से तीन बार में दिया गया है और यह पाया गया कि 50 किग्रा. संस्तुत पोटैशियम के स्थान पर 75 किग्रा. पोटैशियम को दो बार (30 और 50 दिन पर) देने से फसल की अच्छी वृद्धि के साथ–साथ उत्पादन में भी वृद्धि होती है। पोलीहैलाइट एक प्राकृतिक खनिज है जो एम.ओ.पी. का विकल्प हो सकता है इसमें पोटैशियम के अतिरिक्त सल्फर, कैल्शियम व मैग्निशियम भी पाया जाता है जिसके प्रयोग से प्याज के उत्पादन में अत्यधिक वृद्धि दर्ज की गई साथ ही अतिरिक्त खर्च से भी बचा जा सकता है। अतः निष्कर्ष रूप में यह कहा जा सकता है कि नाइट्रोजनः फास्फोरसः पोटैशियम–100:50:50 किग्रा. प्रति हेक्टेयर, क्रमशः यूरिया, डीएपी तथा पोलीहैलाइट से देने पर प्याज का अच्छा उत्पादन किया जा सकता है तथा सल्फर भी अलग से देने की आवश्यकता नहीं होगी।

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