

Original Research Article

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Effect of Potassium and Sulphur on the Soil Properties, Growth and Yield of Onion (*Allium cepa* L.) cv. Nasik Red

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ABSTRACT

A field experiment was conducted to study the effect of different levels of doses of potassium and sulphur on the soil properties and also on the growth and yield of onion (*Allium cepa* L.) at the Research Farm of Soil Science, SHUATS, Allahabad, India, during the winter season of 2017-18. Experimental layout was done in a Randomised Block Design (RBD) with 9 treatments replicated 3 times. Treatments were assigned randomly which consisted of three levels of potassium i.e. 0, 50 and 100 kg ha⁻¹ and three levels of sulphur i.e. 0, 15, 30 kg ha⁻¹. The results indicated that the maximum average plant height (60.60cm), bulb length (6.1cm), bulb diameter (8.7cm), total bulb yield (13.55 tons ha⁻¹) showed significantly better results with the treatment T₂ (potassium at 100 kg ha⁻¹ and sulphur at 30 kg ha⁻¹). The same treatment also showed better results in the physical properties of the post-harvest quality of the soil like increase in % Pore Space, decrease in bulk and particle density of the soil and also showed a gradual decrease on the chemical properties of the soil like decrease in pH, OC % and N, P, K, S values in the soil after harvest. Hence the results revealed that the treatment combination T₂ i.e. potassium at 100 kg ha⁻¹ and sulphur at 30 kg ha⁻¹ was found to be the most beneficial and significantly improved the growth parameters and bulb yield of onion grown under Allahabad agro-climatic conditions.

Keywords

Growth parameters,
Onion, Potassium,
Soil properties,
Sulphur, Bulb yield

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Introduction

Onion (*Allium cepa* L.), belongs to family Amaryllidaceae, is the third most important vegetable crop in the world. It is a cool season but can also be grown under a wide range of climatic conditions. The onion plant has hollow leaves and shallow roots. Onion is a very important crop in India and is the 2nd largest producer of onion in the world only next to China. It is grown all over the country across various states like Maharashtra,

Gujarat, Uttar Pradesh, Orissa, Karnataka, Andhra Pradesh, Madhya Pradesh and Bihar which are the major onion growing states in the country. It is cultivated over an area of 1064 thousand hectares with an annual production of 15118 thousand tons but the productivity in India is very low i.e. 14.21 tons ha⁻¹.

Potassium plays an important role on onion production. Generally, a heavy dose of potassium is recommended for onion

cultivation. Like other tuber and root crops, onion is very responsive to potash. Among all the different types of nutrients which are required to produce a high yield of onion, potassium is considered to be one of the most important element due to its role in the translocation of photosynthates, storage quality, bulb size, and yield per plant. Potassium deficiency in onion is expressed by the appearance of brown tips in older leaves and poor bulb formation. The application of an appropriate quantity and source of K to onion at critical growth stages is thus essential for maintenance of growth and quality (Subba Rao and Brar, 2002).

The application of sulphur has been found to found not only to increase the bulb yield of onion but also improve its quality, especially pungency and flavors (Jaggi and Dixit, 1999). Bell (1981) also reported sulphur containing secondary compounds was not only of importance for nutritive value and flavors, but also for resistance against pests and diseases. The yield potential of onion has not been exploited fully as the sulphur fertilizer is used in very low quantity instead of its very high requirement. In recent years, sulphur is receiving more attention throughout the world. The deficiency of sulphur in the soil, as a nutrient is increasing in India. Surveys have found that 240 districts to be generally deficient in S and the problem is spreading (Sakal *et al.*, 1981). A recent effort by the Fertilizer Association of India, The Sulphur Institute and the International Fertilizer Industry Association (FAI-TSI-IFA) studied 27,000 samples distributed over 12 states and found that over 40% of samples were deficient in available S and another 35% potentially deficient. More than 70% soil samples taken from Uttar Pradesh, Madhya Pradesh, Maharashtra, Orissa, Jharkhand, West Bengal, Andhra Pradesh and Karnataka were low to medium in available S (Biswas *et al.*, 2004). The main reason behind such widespread

deficiency are over dependence on “S-free” fertilizers, depletion of S without continuous cropping, sizable areas (around 27% of the country’s gross cropped area) under pulses and oilseeds that have higher requirement for S, loss of S due to leaching, soil erosion, lack of organic manure addition and low awareness of farmers towards use of importance of S in agriculture. Therefore, with these facts in consideration, the present study was carried out to find the effect of potassium and sulphur on the soil properties, response of onion to the bulb yield and plant growth properties and also the economic benefits and profit.

Materials and Methods

The field experiment to study the effect of potassium and sulphur on onion (*Allium cepa* L.) was conducted at Research Farm of Soil Science, SHUATS, Allahabad, India. Improved variety of onion, Nasik red, was selected for the study. The soil before the start of the experiment was sandy loam with pH 7.4, available NPK was 205:23.5:283.4 kg ha⁻¹ and available S was 16.8 kg ha⁻¹, organic carbon 0.50%, electric conductivity 0.41 dSm⁻¹, bulk density at 1.30 gm cm⁻³, particle density at 2.7 gm cm⁻³ and pore space 51.3%. Two different factors were considered of treatments were considered: (A) Potassium levels (0, 50, 100) kg ha⁻¹, (B) Sulphur levels (0, 15, 30) kg ha⁻¹. The experiment consisted of 9 treatments and the field was laid out in a Randomized Block Design (RBD) with three replications and treatments were assigned accordingly. Size of each plot was 1m x 1m. The seedlings were transplanted into the plots at a spacing of 20x15cm. Standard recommended doses of Nitrogen as urea and Phosphorus as DAP (Diammonium Phosphate) were applied across all plots at 100 kg ha⁻¹ and 50 kg ha⁻¹ respectively. Potassium was applied as MOP (Muriate of Potash) and Sulphur was applied in the form of elemental sulphur according to the treatment

combinations which were then applied as a basal dose before transplanting of onion seedlings while Nitrogen was applied at split doses, first after transplanting and the second dose after 30 days of transplanting. Various intercultural operations such as irrigation, weeding, pest control etc. were done uniformly as required. Data from the plants were recorded and observed by selecting and tagging 3 plants at random for each treatment and plant height was observed at 30, 60 and 90 days after transplanting (DAT). Bulb height, width and total yield per plot were recorded after harvest. Soil parameters, both physical and chemical, were observed and recorded from each individual plot both before transplanting operations and also after harvest by taking soil at depth of 0-15 cm. The various parameters analysed were pH, organic carbon %, pore space %, bulk and particle density, EC, Nitrogen, Phosphorus, Potassium and Sulphur. The data was then analysed by subjecting it to two way statistical analysis of variance (ANOVA) at 5% level of probability.

Results and Discussion

The data in (Table 1) shows the pre-transplant soil data and (Table 2 and 3) shows the analysed statistical data of the various effects of potassium and sulphur doses on the soil properties, growth and yield parameters of onion of which the results are discussed below.

Plant Height

At all stages of growth of the plant, the treatment combination T₂ (K at 100kg ha⁻¹ and S at 30kg ha⁻¹), recorded the maximum plant height at 26 cm, 45.1 cm and 60 cm at 30, 60 and 90 DAT respectively, while control treatment recorded the lowest plant height at 8.5 cm, 24 cm and 35 cm at 30, 60 and 90 DAT respectively. The application of potassium plays an important role in the

metabolism and many processes to sustain and promote plant vegetative growth and development and also plays a major role in cell division and elongation and metabolism and synthesis of carbohydrates and protein compounds. The increase in plant height due to increasing levels of potassium were also observed and recorded by Abou El-Nasr and Ibrahim (2011), Shafeek *et al.*, (2013) and Awatef G. Behairy *et al.*, (2015). Higher dosage of sulphur also showed significant increase in plant height across all stages of crop growth. The increase in plant height might be due to the role of sulphur in the synthesis of chloroplast. M. H. A. Rashid (2010), R. Meher *et al.*, (2016) and P. Tripathy *et al.*, (2013) also reported similar results of increase in plant height of onion with increasing levels of sulphur.

Bulb length and diameter

The bulb length and diameter of the bulbs showed significant increase with higher levels of potassium and sulphur. The treatment combination T₂ (K at 100 kg ha⁻¹ and S at 30 kg ha⁻¹) gave the highest results at 6.1 cm and 8.7 cm for bulb length and diameter respectively. It is due to the fact that potassium is very important for the overall metabolism of plant enzyme activity and it was found to serve a vital role in photosynthesis by directly increasing the growth of the bulb. Also, potassium has a beneficial effect on water consumption (Mansour, 2006). Similar results were also observed by Awatef G. Behairy *et al.*, (2015) and M.K. Ali *et al.*, (2007).

Sulphur application also play an important role in determining the shape and size of onion bulb. More efficient S utilization resulted in greater increases in bulb length (Abbey *et al.*, 2002). These results are in accordance with Nagaich *et al.*, (1999) and Tripathy *et al.*, (2013) who also reported similar findings.

Total yield of onion bulbs

Potassium application at higher doses showed significant increase in total yield of onion. This could be due to the fact that potassium plays a very important role in photosynthesis by increasing the overall metabolism of plant enzyme activity which shows the direct increase in growth and bulb yield. Similar results were observed by Shah Saud *et al.*, (2013).

Sulphur increases the uptake of N, P, K and S by the plant which might lead to enhanced synthesis and translocation of photosynthates to the bulbs and hence increase the overall total yield. Similar results on the total yield of onion due to increasing levels of sulphur were also observed by R. Meher *et al.*, (2016) and R. F. Channagoudar and A. D. Janawade (2006). The treatment combination T₂ (K at 100 kg ha⁻¹ and S at 30 kg ha⁻¹) had the highest yield total bulb at 13.55 tons ha⁻¹.

Bulk and particle density and pore space of soil

The bulk density and particle density of the soil after crop harvest decreased as a result of increased dosage of potassium and sulphur which might be due to the fact that that onion is a bulb crop and it loosens the soil when it grows in the soil thereby improving soil structure and increasing the availability of certain plant nutrients in soil, which in turn showed an increase in the pore space percentage in the soil compared to the soil data before transplanting, This results were also reported by R. Pradhan *et al.*, (2014).

Soil organic carbon

The organic carbon content in the soil showed a significantly slight decrease with increasing dosage of potassium and sulphur which might be attributed to the fact that plants used the

organic carbon present for their growth and development and also because more inorganic materials were added rather than organic fertilizers and due to lack of the addition of FYM. This was also reported by P. K. Basavaraja *et al.*, (2007).

Soil pH

The soil pH showed a significant drop after crop harvest with increasing dosage of potassium and sulphur. The initial pH value of the soil before transplanting operations was done was observed to be at 7.4 and the application of K at 100 kg ha⁻¹ and S at 30 kg ha⁻¹ showed pH value of 7.07 after harvest. The decrease in pH can be due to the fact that with higher application of potassium and sulphur, it increases the overall metabolism of the plant and photosynthesis and respiration. Respiration in plants changes the carbon dioxide and reacts with water with water to form carbonic acid in the soil. This was also reported by R. Pradhan *et al.*, (2014).

Electric conductivity of soil

The EC value of the soil did show a slight decrease after harvest but the results were found to be non-significant and the addition of different levels of potassium and sulphur showed no particular effects.

Available NPK and Sulphur in soil

The available values of NPK along with sulphur in the soil after harvesting showed a gradual decrease significantly with increasing dosage on potassium and sulphur. Nitrogen levels were lowest in the treatment combination T₂ (K at 100 kg ha⁻¹ and S at 30 kg ha⁻¹) at 95.50 kg ha⁻¹ and highest in control at 107.25 kg ha⁻¹. Compared to the soil sample data before transplanting at 205 kg ha⁻¹, the amount of nitrogen had decreased significantly.

Table.1 Initial status of the soil before transplanting and growth of onion

Parameters	Results
Texture of the soil	Sandy Loam
Bulk density (gm/cm ³)	1.30
Particle density (gm/cm ³)	2.7
Pore space (%)	51.3
Soil pH	7.4
EC (dSm ⁻¹)	0.41
OC (%)	0.50
Available N (Kg ha ⁻¹)	205
Available P (Kg ha ⁻¹)	23.5
Available K (Kg ha ⁻¹)	283.4
Available S (Kg ha ⁻¹)	16.8

Table.2 Effect of different levels of Potassium and Sulphur on growth parameters and yield of Onion

Treatment dosage	Plant height (cm)	Bulb width (cm)	Bulb length (cm)	Bulb yield (tons ha ⁻¹)
T ₁ (K at 50 kg ha ⁻¹ S at 15 kg ha ⁻¹)	58.07	5.2	4.5	8.15
T ₂ (K at 100 kg ha ⁻¹ S at 30 kg ha ⁻¹)	60.60	8.7	6.1	13.55
T ₃ (K at 50 kg ha ⁻¹ S at 30 kg ha ⁻¹)	58.50	6.8	5.5	10.1
T ₄ (K at 50 kg ha ⁻¹ S at 0 kg ha ⁻¹)	53	5.8	4.5	8.55
T ₅ (K at 100 kg ha ⁻¹ S at 15 kg ha ⁻¹)	55.47	7.5	4.7	9.05
T ₆ (K at 100 kg ha ⁻¹ S at 0 kg ha ⁻¹)	54.40	6.2	5.4	8.92
T ₇ (K at 0 kg ha ⁻¹ S at 30 kg ha ⁻¹)	55.50	5.2	4.8	7.64
T ₈ (K at 0 kg ha ⁻¹ S at 15 kg ha ⁻¹)	56.60	5.0	4.3	7.82
T ₀ (Control)	43	4.5	3.9	6.38
F-Test	S	S	S	S
SE. d(±)	4.08	0.21	0.19	1.18
C.D. at 5%	8.66	0.44	0.41	2.51

Table.3 Effect of different levels of Potassium and Sulphur on soil properties (physical and chemical) after harvest of onion

Treatment dosage	Bulk Density (gm/cm ³)	Particle Density (gm/cm ³)	Pore Space (%)	OC (%)	pH	EC (dSm ⁻¹)	N (kg ha ⁻¹)	P (kg ha ⁻¹)	K (kg ha ⁻¹)	S (kg ha ⁻¹)
T ₁ (K at 50 kg ha ⁻¹ S at 15 kg ha ⁻¹)	1.14	2.58	53.31	0.47	7.23	0.36	102	17.3	256.30	13.92
T ₂ (K at 100 kg ha ⁻¹ S at 30 kg ha ⁻¹)	1.13	2.67	56.95	0.45	7.07	0.35	95.50	15.07	241.80	13.20
T ₃ (K at 50 kg ha ⁻¹ S at 30 kg ha ⁻¹)	1.15	2.59	54.59	0.44	7.17	0.38	99.75	17.43	261.60	14.98
T ₄ (K at 50 kg ha ⁻¹ S at 0 kg ha ⁻¹)	1.15	2.62	53.59	0.46	7.15	0.37	102.75	17.93	267.10	15.19
T ₅ (K at 100 kg ha ⁻¹ S at 15 kg ha ⁻¹)	1.15	2.61	53.98	0.45	7.30	0.36	100.50	18.57	270.40	14.93
T ₆ (K at 100 kg ha ⁻¹ S at 0 kg ha ⁻¹)	1.18	2.65	54.32	0.45	7.27	0.37	101.25	20.27	266.80	13.80
T ₇ (K at 0 kg ha ⁻¹ S at 30 kg ha ⁻¹)	1.17	2.59	52.66	0.47	7.30	0.36	105.75	17.30	249.53	14.34
T ₈ (K at 0 kg ha ⁻¹ S at 15 kg ha ⁻¹)	1.17	2.62	52.51	0.46	7.27	0.36	102.75	21.27	265.20	14.91
T ₀ (Control)	1.22	2.54	51.68	0.46	7.33	0.38	107.25	22.60	276.00	15.62
F-Test	S	S	S	S	S	NS	S	S	S	S
SE. d(±)	0.01	0.07	1.92	0.02	0.09	0.005	5.11	1.26	4.35	0.58
C.D. at 5%	0.03	0.14	4.08	0.04	0.19	0.03	10.83	2.67	9.21	1.26

The increased uptake of nitrogen can be attributed to the increased dry matter production and usage by the plant for its development. Higher levels of sulphur also influenced nitrogen uptake by the plant which may have influenced the synthesis and translocation of the stored materials. Increased uptake of nitrogen due to higher doses of potassium application was also reported by Girigowda *et al.*, (2005) and Shafeek *et al.*, (2013). Effect of sulphur on

nitrogen uptake by onion plant was reported by R. Pradhan *et al.*, (2014).

Similar trends were observed in phosphorus, potassium and sulphur values in the soil after harvest along with increasing dosage of potassium and sulphur. Available phosphorus values went down from 23.5 kg ha⁻¹ before transplanting to 15.07 kg ha⁻¹ at the treatment combination of T₂ (K at 100 kg ha⁻¹ and S at 30 kg ha⁻¹). The decrease in

phosphorus may be attributed due to plant uptake of phosphorus as immobilization as a result of increased microbial activity which was reported by Emmanuel Kwada Kwaghe *et al.*, (2017).

The application of increasing levels of sulphur shows the increased intake of potassium by the onion plant significantly which indicates the synergistic effect of sulphur on potassium nutrition in onion. The treatment combination of T₂ (K at 100 kg ha⁻¹ and S at 30 kg ha⁻¹) showed available potassium values at 241.80 kg ha⁻¹ compared to pre-transplant soil data at 283.4 kg ha⁻¹. This is due to the greater vegetative growth, translocation of stored material and bulb production. This was observed and reported by R. Pradhan *et al.*, (2014) and Jaggi (2005).

The decrease of sulphur content in the soil was also observed due to the increased uptake of sulphur by the plant. Again the treatment combination of T₂ (K at 100 kg ha⁻¹ and S at 30 kg ha⁻¹) showed the lowest amount of available sulphur in the soil after harvest at 13.20 kg ha⁻¹ comparing to the amount of 16.8 kg ha⁻¹ before transplanting operations. This is because increasing dosage of both potassium and sulphur increases the metabolism and nutrient uptake of the plants which leads to increased uptake of sulphur from the soil by the plants. These results are in accordance with the findings of R. Pradhan *et al.*, (2014), Dabhi *et al.*, (2004) and Jaggi (2005).

Based on the above results and data collected and observed, it is concluded that the application of potassium and sulphur at 100 kg ha⁻¹ and 30 kg ha⁻¹ showed the most beneficial and significant increase in growth parameters and total bulb yield of Onion grown under Allahabad agro-climatic conditions while also providing the maximum gross return, net profit and Cost: Benefit ratio.

It also significantly improved the soil physical soil structure properties but showed a significant decrease in amount of available nutrients in the soil after harvest. Although this may be due to the fact that the increasing amount of dosage of potassium and sulphur aids the plant to grow healthier, which leads to the increased uptake of nutrients, the residual nutrient amount in the soil is very important for sustainability. As such, properties of the soil like soil organic carbon content could be increased with addition of organic fertilizers like FYM or also using bio-fertilizers along with ideal dosage of fertilizers. Nitrogen can also be replenished with the rotation of crops after onion harvest with the planting of leguminous crops which will cycle nitrogen back into the soil. As such, these findings are based on one year research trial, to sustain more work to be needed for the same.

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