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Effect of potassium and sulphur on soil properties and growth and yield of onion (*Allium cepa* L.) cv. Nasik red

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Abstract
The experimental layout was done in a randomised block design (RBD) with nine treatments replicated three times. Treatments were assigned randomly which consisted of three levels of potassium i.e. 0, 25 and 50 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 (76 cm), bulb length (5.8 cm), bulb diameter (7.8 cm), total bulb yield *(13.55 t ha^{-1}) showed significantly better results with the treatment T_8 (potassium at 100 kg ha^{-1} and sulphur at 100 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 T_8 *i.e.* potassium at 100 kg ha^{-1} and sulphur at 100 kg ha^{-1} with a cost benefit ratio of 1:4.88 was found to be the most beneficial and significantly improved the growth parameters and bulb yield of onion grown under Prayagraj Agro climatic conditions.

Keywords: bulb yield, growth parameters, onion, potassium, soil properties, sulphur, etc

Introduction
Onion *(Allium cepa L.)* "Queen of the Kitchen" belongs to family Alliaceas, one of the most commercially valuable vegetables grown in India. It considered as a rich source of carbohydrates, proteins, vitamin C besides minerals like phosphorus and calcium. India is the second largest producer of onion in the world, next to China with an area of 1.05 million hectares with production of 16.81 million tonnes (Anonymous 2014) [2] but the productivity is low 14.85 t ha^{-1} as compared to other countries. Fertilizer management is one of the important management factors that may contribute much to the onion yield. Nitrogen, potassium and sulphur are important nutrient element that play important role on bulb formation, elongation, skin colour development and pungency of onion (Vachhani and Patel. 1993) [22]. Similarly, storage life of onion is also important factor to sell the onion in off season for better profit market. Potash and sulphur play important role to decrease the post-harvest losses in onion which ranged from 25-60% in onion.

Potassium plays a vital role in plant metabolism such as photosynthesis, translocation of photosynthesis, regulation of plant pores, activation of plant catalysts and resistance against pests and diseases. It also improves quality parameters of many crops including onion like colour, glossiness and dry matter accumulation besides improving keeping quality of the onion (Subhani *et al.*, 1990) [19].

Sulphur is also known to improve the yield and quality parameters of important vegetable crops. Sulphur requirement of vegetable crops is almost similar to that of phosphorus. Sulphur is a constituent of secondary compounds viz. allin, cycloallin and thiopropanol which not only influence the taste, pungency, medicinal properties of onion and garlic besides inducing resistance against pests and diseases. Sulphur is also required for the synthesis of three important essential amino acids such as cystine (27% S), cysteine (26% S) and methionine (21% S) besides increasing allyl propyl disulphide alkaloid (43% S) and the capsaicin, the principle alkaloids responsible for pungency in onion and chilli, respectively (Randle and Bussard, 1993) [16]. The present experiment was therefore, designed with an emphasis on application of different combination of fertilizers since vegetative growth, bulb production and storability is important for economic valve of this crop. However, this study was undertaken to find out the effect of potash and sulphur application along with recommended doses of nitrogen and phosphorus for higher yield and storability of onion under different planting methods in onion.

Materials and Method
The field experiment was to study the effect of potassium and sulphur on onion (*Allium cepa* L.) was conducted at research farm of soil science, SHUATS, Prayagraj, India. Improved variety of onion, Nasik red, was selected for the study. The was sandy loam with pH 7.6; available NPK was 220.15:34.65:200 kg ha^{-1} and available Sulphur was 18.8 kg ha^{-1}, organic carbon 1.32 %, electric conductivity 0.61 dSm^{-1}, bulk density at 1.25 Mg m^{-3}, particle density at 2.25 Mg m^{-3} and pore space 43.75 %. The transplanting of the onion seedlings in the field was done on 6th December 2018, where the size of each plot was 1m x 1m. The seedlings were transplanted to the plot with a spacing of 20x15cm row to row and plant to plant under flat planting. 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 nine treatments and the field was laid out in a randomized block design (RBD) with three

replications and treatments were assigned accordingly. Standard recommended doses of Nitrogen as Urea and Phosphorus as DAP (Diammonium Phosphate) were applied across all plots at 50 kg ha^{-1} and 25 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. The remaining dose of nitrogen was top dressed after one month of transplanting. Full dose of phosphorus, potash, sulphur and half nitrogen was applied before 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 three plants at random for each treatment and plant height was observed at 30, 60 and 90 days after transplanting (DAT).

The uprooting of the bulbs was done manually in the last week of March. After harvesting, the bulbs were cured and then leaves were cut 1-2 cm above the neck and bulb yield was recorded. 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 %, and 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

The plant height as influenced by different levels of potassium and sulphur gave significant results according to the different treatments provided. The plant heights were measured at 30, 60 and 90 DAT. The maximum plant height recorded were 18.83 cm at 30 DAT, 49.7 cm at 60 DAT and 73.43 cm at 90 DAT which were observed under the treatment T_8 (potassium @ 100% + sulphur @ 100%) while the minimum plant height observed were 12.47 cm at 30 DAT, 26.60 cm at 60 DAT and 59.93 cm at 90 DAT which were under the treatment T_0 (control).

Potassium plays a pivotal role in plant growth and development. Like other vegetable crops, onion is very responsive to potassium fertilization. Also potassium plays a key role of crop quality. It improves size of fruit and stimulates root growth. The increase in potassium application significantly increased the dry weight of tops and bulbs, bulb diameter, 100 bulb weight and bulb yield up to 40 kg K_2O ha^{-1}.

Application of sulphur also showed increase in plant height across all stages of crop growth. The increase in plant height of onion might be due to the role of sulphur in the synthesis of chloroplast. Therefore the increase of plant height of the plant might be due to increase of intake of sulphur by the plants. Rashid (2010) [17], Meher *et al*, (2016) [10] and Tripathy *et al.,* (2013) [20] were also reported similar results of increase in plant height of onion with increasing level 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 T_8 (potassium @ 100% + sulphur @100%) gave the highest results at 6.27 cm and 8.41 cm for bulb length and diameter respectively. It is due to the fact that potassium element is very important in overall metabolism of plant enzymes activity, it was found to serve a vital role in photosynthesis by direct increasing in growth and total bulb yield. Also, potassium has a beneficial effect on water consumption (Mansour, 2006) [9]. The same result was also concluded by Ghafoor *et al*., (2003), Pervez *et al*., (2004) [14], Ali *et al*., (2007) who stated that as potash level increases up to optimum levels the yield and its components increases. Also, potassium and sulphur fertilizers increased the cell division, cell elongation synthesis of the different components of protein, increased production of carbohydrate, constituent of the cell nucleus and translocation of photosynthesis. These result are may be close agreement with the finding of Singh *et al.*, (2000) [18], Bassiony (2006) [4] and Nasreen *et al*., (2007) [13].

Total yield of onion bulbs

The highest bulb yield recorded was observed with the treatment T_8 (potassium @ 100% + sulphur @100%) with 18.98 t $ha^{-1}$and the minimum bulb yield was observed in the treatment T_0 (control) obtaining the length of 8.26 t ha^{-1} (Fig 1). Also, potassium element is very important in overall metabolism of plant enzymes activity, it was found to serve a vital role in photosynthesis by direct increasing in growth and total bulb yield. Sulphur increases the uptake of N, P, K and S by the plant which might lead to enhanced synthesis and translocation of photosynthesis to the bulbs and hence increase the overall yield. Sulphur fertilizer might have promoted the availability of native soil sulphur as reflected by their uptake. Similar opinion was reported by Nasreen *et al*., (2007) [13].

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 is 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. The findings are similar and results were also reported by Pradhan *et al.,* (2014) [15].

Soil organic carbon

The organic carbon of the soil after harvest was affected by different treatment combination of potassium and sulphur. The initial available organic carbon content was 1.32% before transplanting after which it significantly decreased after harvesting. This might be attributed to the fact that plants used it for 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 Basavaraja *et al*., (2017) [3].

Soil pH

The pH of the soil after post- harvest was affected by different treatment combination of potassium and sulphur. The initial pH value of the soil before transplanting operations was done was observed to be 7.6. The mean pH values after harvest was observed and recorded to be maximum in the treatment T_0 (control) at 7.70 and the minimum was observed in the treatment T_8 (potassium @ 100% + sulphur @ 100%) at 7.40. Comparing the pH values of pre-transplanting soil sample and the post-harvest soil samples, there is a slight decrease in the value of pH. The initial soil was poor in sulphur; that explains why the sulphur rates applied stimulated the crop yields and had no stronger influence on the physicochemical properties of the soil. Similar results were obtained by Motowicka-Terelak and Terelak (1998) [12].

Electric conductivity of soil

The soil electrical conductivity of the post-harvest soil of onion showed a very slight decrease in EC values compared to the pre-transplanting data.

Available NPK and Sulphur in soil

The available values of NPK along with sulphur in the soil after harvesting showed a gradual increase significantly with increasing dosage on potassium and sulphur. Nitrogen levels were highest in the treatment combination T_8 (potassium @ 100 kg ha^{-1} and sulphur @ 100 kg ha^{-1}) at 234.80 kg ha^{-1} and highest in control at 214.57 kg ha^{-1}. Compared to the soil sample data before transplanting at 220.15 kg ha^{-1}, the amount of nitrogen had increased significantly.

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

Parameters	Results
Texture of the soil	Sandy Loam
Bulk density (Mg m^{-3})	1.25
Particle density (Mg m^{-3})	2.25
Pore space (%)	43.75
Soil pH	7.6
EC (dS m^{-1})	0.61
OC (%)	0.60
Available N (Kg ha^{-1})	220.15
Available P (Kg ha^{-1})	34.65
Available K (Kg ha^{-1})	200
Available S (Kg ha^{-1})	18.8

Table 2: Effect of different levels of Potassium and Sulphur on growth parameters and yield of Onion and cost benefit ratio.

Treatment dosage	Plant height (cm)	Bulb width (cm)	Bulb length (cm)	Bulb yield (t ha^{-1})	C:B
T_0 Control	59.93	4.87	3.97	8.26	1:3.38
T_1 (Potassium @ 0 % + Sulphur @ 50%)	60.10	6.10	4.57	10.88	1:4.09
T_2 (Potassium @ 0% potassium + Sulphur @100%)	70.23	6.17	4.83	12.31	1:4.58
T_3 (Potassium @ 50% + Sulphur @ 0%)	66.93	5.43	4.33	9.55	1:3.61
T_4 (Potassium@ 50% + Sulphur @ 50%)	73.13	7.10	4.77	11.30	1:4.23
T_5 (Potassium @ 50% + Sulphur @ 100%)	72.63	7.87	5.50	12.25	1:4.52
T_6 (Potassium @ 100% + Sulphur 0%)	67.17	6.60	4.53	8.31	1:3.12
T_7 (Potassium @ 100% + Sulphur @ 50%)	73.30	7.87	5.60	12.80	1:4.74
T_8 (Potassium @ 100% + Sulphur @ 100%)	73.43	8.41	6.27	13.33	1:4.88
F-Test	S	S	S	S	
SE. d(±)	2.64	0.67	0.33	1.50	
C.D. at 5%	5.61	1.42	0.69	13.33	

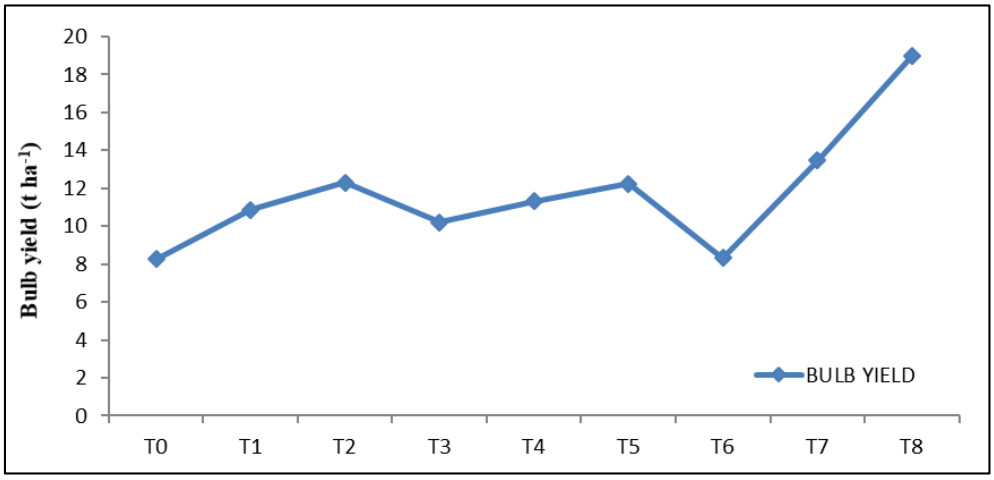

Fig 1: Effect of Potassium and Sulphur on bulb yield (t ha^{-1}) of Onion (*Allium cepa* L.)3

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

Treatment dosage	Bulk density ($Mg\ m^{-3}$)	Particle density ($Mg\ m^{-3}$)	Pore space (%)	OC (%)	pH (1:2)	EC (dSm^{-1})	N ($kg\ ha^{-1}$)	P ($kg\ ha^{-1}$)	K ($kg\ ha^{-1}$)	S ($kg\ ha^{-1}$)
T_0 Control	1.25	2.41	51.65	0.53	7.70	0.43	214.57	31.03	195.50	17.13
T_1 (Potassium @ 0 % + Sulphur @ 50%)	1.23	2.56	52.66	0.51	7.60	0.37	226.20	37.07	204.97	22.13
T_2 (Potassium @ 0% potassium + Sulphur @100%)	1.20	2.568	52.42	0.52	7.40	0.41	229.07	40.00	207.40	25.53
T_3 (Potassium @ 50% + Sulphur @ 0%)	1.19	2.62	53.26	0.56	7.50	0.37	221.10	35.67	201.00	19.60
T_4 (Potassium@ 50% + Sulphur @ 50%)	1.18	2.51	53.73	0.58	7.60	0.38	227.03	38.77	205.37	23.40
T_5 (Potassium @ 50% + Sulphur @ 100%)	1.16	2.63	52.01	0.61	7.40	0.39	231.40	41.27	208.97	26.97
T_6 (Potassium @ 100% + Sulphur 0%)	1.15	2.62	53.67	0.58	7.60	0.41	222.30	36.07	202.50	21.17
T_7 (Potassium @ 100% + Sulphur @ 50%)	1.13	2.65	54.55	0.62	7.40	0.38	232.43	42.97	210.33	28.50
T_8 (Potassium @ 100% + Sulphur @ 100%)	1.12	2.68	56.93	0.64	7.40	0.36	234.80	44.97	212.33	29.43
F-Test	S	S	S	S	S	S	S	S	S	S
SE. d(±)	0.56	0.78	7.34	0.03	0.45	0.10	1.35	0.90	1.24	0.52
C.D. at 5%	1.20	1.65	15.56	0.06	0.95	0.20	2.85	1.90	2.63	1.10

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. Potassium plays a pivotal role in plant growth and development. Like other vegetable crops, onion is very responsive to potassium fertilization. It has a crucial role in the energy status of the plant, translocation and storage of assimilates and maintenance of tissue water relation. Also potassium plays a key role of crop quality. It improves size of fruit and stimulates root growth. It is necessary for the translocation of sugars and formation of carbohydrates. According to report by Madan and Sandhu (1983) [8]. Statistically significant difference in the sulphur content of soil after harvest was obtained when different combinations of nitrogen were applied. Several soil factors influence the availability of sulphur and hence the status of different forms of sulphur in soils varies widely with soil type (Trivedi *et al*., 2000) [21]. The available sulphur content showed positive correlation with both pH and organic carbon in the experimental soils which are in agreement with Ghosh and Sarkar (1994) [7], Ghosh *et al*., (1991) [6] and Mishra *et al*., (1990) [11].

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 Prayagraj agro-climatic conditions while also providing the maximum gross return, net profit and Cost: Benefit ratio. Application of potassium and sulphur increased uptake of nutrients e.g viz N, P, K and S by crop and resulted in good built of soil sulphur and potassium which is beneficial for bulb crops. The increase in growth parameters with the application of sulphur might be due to higher production of metabolites and increase in meristematic activity. The increase in growth parameters of onion with progressive increase in the application of potassium might be due to higher uptake of potassium at higher levels. Since potassium is mainly involved in the activation of enzymes and better translocation of photosynthesis from source to sink, which were further utilized in building up of new cells leading to better height and vigour of crop.

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