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EFFECT OF POTASSIUM AND SULPHUR ON GROWTH, YIELD AND QUALITY OF ONION

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ABSTRACT

A field experiment was conducted during the rabi season of 2013-14 at research farm, College of Agriculture, Sehore (Madhya Pradesh) to study the effect of different doses of potassium and sulphur on growth, yield and quality attributes of onion. The treatments consisted of four levels of potassium (0, 40, 60 and 80 kg K_2O ha^{-1}) and five levels of sulphur (0, 20, 30, 40 and 60 kg S ha^{-1}). Results revealed that the application of potassium and sulphur had significant beneficial influence on the growth, yield and quality of onion. Maximum bulb yield (379.08 q ha^{-1}) was recorded with 60 kg K_2O ha^{-1} while application of 30 kg S ha^{-1} resulted in the highest bulb yield (399.55 q ha^{-1}) of onion. Combined effect of K and S showed significant effect on growth, yield and quality of onion. Application of 60 kg K_2O + 30 kg S ha^{-1} resulted maximum plant height (64.60 cm), polar diameter of bulb (6.17 cm), equatorial diameter of bulb (5.43 cm), fresh weight of plant (174 g), fresh weight of bulb (140.66 g) and bulb yield (490.84 q ha^{-1}). Maximum gross income (`478650 $ha^{-1}$), net income (`425235 ha^{-1}) and cost: benefit ratio (1: 8.96) were recorded with 60 kg K_2O + 30 kg S ha^{-1}.

Key words: Economics, growth, onion, potassium, quality, sulphur, yield

INTRODUCTION

Onion (*Allium cepa* L.) is one of the most important bulb crops. It is an indispensable item in every kitchen used as salad, culinary purpose for flavoring as spice in pickles, sauce and vegetable. In India, it is cultivated as annual crop for bulb production and as biennial crop for seed production. Onion is an export-oriented crop earning valuable foreign exchange for the country. India ranks first in area and second in production of onion in the world after China. It is cultivated in an area of 1203.56 thousand ha with the production of 19401.67 thousand Mt. The average yield of onion in India is about 16.1 Mt ha^{-1} which is very low as compared to the global average of 19.3 Mt ha^{-1} (Anonymous 2014). Improper nutrient management is one of the main constraints responsible for lower yield. Sulphur is essential for building up of sulphur containing amino acids (cysteine, cystine and methionine), which are essential for protein synthesis. Sulphur not only increases the bulb yield but also improves its quality especially pungency and flavour. Sulphur containing compounds are not only of importance for nutritive value or flavours but also for resistance against pests and diseases (Ullah *et al.*, 2008). Deficiency of sulphur is increasing due to continuous use of S-free fertilizers and increasing cropping intensity with high yielding cultivars and is more conspicuous in light textured soils low in organic matter (Verma and Singh, 2012, Ahirwar *et al.* 2015). Sulphur deficient plants had poor utilization of nitrogen, phosphorus and potassium and a significant reduction of catalase activities at all ages. Potassium has been reported to be involved in almost all metabolic processes in plants. It regulates many vital functions like carbon assimilation, translocation of proteins and sugars, water balance in plants, maintaining turgor pressure in the cell, root development, improving quality of the produce by maintaining desirable sugar to acid ratio etc. Severe sulphur and potassium deficiency during bulb development has detrimental effect on yield and quality of onion. Therefore, the present study was initiated to study the effect of K and S application on growth, yield and quality of onion.

MATERIALS AND METHODS

The experiment was conducted at research farm, College of Agriculture, Sehore, Madhya Pradesh during *rabi* season of 2013-14. Sehore is situated in western part of Madhya Pradesh at an altitude of 498.77 m from mean sea level in Vindhyan Plateau of Madhya Pradesh enjoying sub-tropical climate. The average rainfall is 689.3 mm concentrated mostly from the month of last July to January (crop period) and less rainfall occurs during the winter season also. The average maximum temperature is 46^0C and minimum temperature 6.8^0C. The average annual relative humidity is 74%. The physical composition of soil was medium black with 37% clay, 38% silt and 25% sand with pH of 7.2. The available N, P, K and S in soil were 152.6, 21.2, 308 and 17 kg ha^{-1}, respectively. Twenty treatment combinations comprising of four levels of potassium (0, 40, 60 and 80 kg K_2O ha^{-1}) and five levels of sulphur (0, 20, 30, 40 and 60 kg S ha^{-1}) were tested in

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randomized block design with three replications. Six weeks old seedlings of onion variety Bhima Super were transplanted at the spacing of 15 cm between rows and 10 cm between plants. The calculated quantities of N, P, K and S were applied to the respective plots as urea, diammonium phosphate, muriate of potash and elemental sulphur, respectively. Half dose of nitrogen and whole of phosphorus, potash and sulphur as per treatments were applied as basal dose prior to transplanting of onion seedlings. While the rest of nitrogen was given as top dressing in 2 equal split doses, first at 30 and second at 45 days after transplanting. Observations were recorded on five randomly selected plants in each plot in each replication on plant height, leaves per plant, number of bolting per plot, bolting percentage, days to maturity, neck thickness of bulb, polar diameter of bulb, equatorial diameter of bulb, fresh weight of whole plant, total bulb yield and total soluble solid content (with hand refractometer). Pyruvic acid content (µ moles/g fresh weight) was determined as suggested by Anthon and Barrett (2003). The data were analysed as per standard procedure suggested by Panse and Sukhatme (1967). Economics of various treatments was computed on the basis of prevailing market price of inputs and produce.

RESULTS AND DISCUSSION

Growth parameters

Plant height recorded at 90 days after transplanting was significantly affected by K levels and maximum value (61.04 cm) was recorded with 90 kg K_2O ha^{-1} which was significantly superior over other doses. There was an increase in plant height with increasing dose of sulphur from 0 to 30 kg ha^{-1}. Among the different doses, 30 kg S ha^{-1} produced the tallest plants (59.20 cm) (Table 1). Similar findings have been reported by Nasreen *et al.* (2003). Maximum plant height (64.60 cm) was recorded with combined application of 60 kg K_2O + 30 kg S ha^{-1} (Table 2). The highest plant height may be due to the positive effects of potassium and sulphur on the vegetative growth and accumulation of materials. Number of leaves showed significant increase with incremental dose of K and maximum leaves (13.02) was recorded with 60 kg K_2O ha^{-1} followed by 40 and 80 kg K_2O ha^{-1}. Higher dose of K might have stimulated the initiation of more number of leaves in the plant. Similar findings have been reported by Jawadagi *et al.* (2012) and Saud *et al.* (2013). There was significant effect of sulphur on number of leaves and maximum leaves (12.44) were recorded with application of 30 kg S ha^{-1}. Further increase in sulphur had not caused any remarkable influence. Similar findings have been reported by Suman *et al.* (2002) and Rizk *et al.* (2012). Number of bolting per plot and bolting percentage showed non-significant decrease with application of potassium and sulphur. Early maturity was found with 0 kg K_2O ha^{-1} and late maturity with 80 kg K_2O ha^{-1}. Similarly, there was an increase in days to maturity with each increasing dose of sulphur. Combined effect of K and sulphur had shown significant influence on days to maturity. Earliest maturity (107.45 days) was found with 0 kg K_2O + 0 kg S ha^{-1} while the latest maturity (113.93 days) with 80 kg K_2O + 50 kg S ha^{-1}. In general, there was an increase in maturity days with increasing dose of sulphur at all levels of potassium and vice-versa (Table 2).

Yield parameters and yield

Neck thickness of bulb revealed significant increase with incremental doses of potassium. Lowest neck thickness of bulb (1.12 cm) was recorded at control followed by 80 kg K_2O ha^{-1}. Similarly, minimum neck thickness of bulb (1.21 cm) was measured with 0 kg S ha^{-1} followed by 20 kg S ha^{-1} and 60 kg S ha^{-1} (Table 1). Though, application of 0 kg K_2O + 0 kg S ha^{-1} resulted minimum neck thickness of bulb (0.98 cm) while maximum (1.54 cm) was observed with application of 60 kg K_2O + 30 kg S ha^{-1} (Table 2). Polar diameter of bulb revealed significant effect of potassium and sulphur as well as their combinations. Among K doses, 60 kg K_2O ha^{-1} had recorded highest polar diameter of bulb (5.85 cm) which was significantly superior over control and 40 kg K_2O ha^{-1}. Similar findings have been reported by Saud *et al.* (2013). There was an increase in polar diameter of bulb with increasing doses of sulphur and maximum value (5.57 cm) was recorded with 30 kg S ha^{-1}. It was significantly superior over other lower doses (Suman *et al.*, 2002). Highest polar diameter of bulb (6.17 cm) was observed with combined application of 60 kg K + 30 kg S ha^{-1}. In general, increasing doses of sulphur enhanced polar diameter of bulb at all the levels of K and vice-versa (Table 2). Similar findings have been reported by Nagaich and Singh (2004).Highest equatorial diameter of bulb (4.88 cm) was found with application of 60 kg K_2O ha^{-1} which was significantly superior over 40 kg K_2O ha^{-1} and 80 kg K_2O ha^{-1}. These results corroborated with the findings of Dev *et al.* (2009) and Saud *et al.* (2013). Highest equatorial diameter of bulb (4.92 cm) was noticed with 30 kg S ha^{-1} which was significantly superior over 40 kg S ha^{-1}, 20 kg S ha^{-1} and 60 kg S ha^{-1}. Similar findings have been reported by Abbey *et al.* (2002) and Suman *et al.* (2002). Highest equatorial diameter of bulb (5.43 cm) was recorded with

application of 60 kg K + 30 kg S ha^{-1} (Table 2). There was significant increase in fresh weight of whole

Table 1: Individual effect of potassium and sulphur on various growth, yield and quality parameters of onion

Treatment	Plant height (cm) at 90 DAT	Leaves per plant at 90 DAT	No. of bolting per plot	Bolting percentage	Days to maturity	Neck thickness of bulb (cm)	Polar diameter of bulb (cm)	Equatorial diameter of bulb (cm)	Fresh weight of whole plant (g)	Fresh weight of bulb (g)	Bulbs yield (q ha^{-1})	TSS (%)	Pyruvic acid (µ mole g^{-1})
Potassium (kg ha^{-1})													
0	53.13	11.20	3.00	3.75	108.6	1.12	4.40	4.28	142.40	112.33	263.61	9.18	1.33
40	53.90	12.37	2.13	2.66	110.2	1.33	5.63	4.61	158.80	123.46	331.47	9.26	1.59
60	58.49	13.02	1.86	2.33	111.8	1.42	5.85	4.88	167.86	133.93	379.08	9.68	1.45
80	61.04	11.93	2.40	3.00	112.7	1.27	5.52	4.46	152.80	119.20	321.84	9.56	1.52
SEm±	0.29	0.08	0.36	0.45	0.07	0.02	0.07	0.05	0.27	0.33	7.40	0.31	0.01
C.D. (P=0.05)	0.84	0.24	N.S.	N.S.	0.22	0.07	0.20	0.14	0.79	0.97	21.29	N.S.	0.03
Sulphur (kg ha^{-1})													
0	56.45	11.80	2.66	3.33	109.7	1.21	4.69	3.95	150.83	119.91	285.56	9.49	1.18
20	57.21	11.98	2.41	3.02	110.2	1.28	5.47	4.73	153.83	122.33	337.12	9.38	1.40
30	59.20	12.44	2.16	2.70	110.8	1.34	5.57	4.92	159.16	125.66	399.55	9.51	1.52
40	57.73	12.25	2.25	2.81	111.5	1.30	5.52	4.76	157.33	122.41	313.95	8.88	1.72
60	57.30	12.18	2.25	2.81	112.0	1.28	5.49	4.42	156.16	120.83	283.82	9.84	1.48
SEm±	0.33	0.09	0.41	0.51	0.08	0.02	0.07	0.05	0.31	0.38	8.28	0.35	0.01
C.D. (P=0.05)	0.94	0.27	N.S.	N.S.	0.24	0.08	0.22	0.16	0.89	1.09	23.80	N.S.	0.04

Table 2: Interactive effect of potassium and sulphur on growth, yield, quality and economics of onion

Treatments combination	Plant height (cm) at 90 DAT	Days to maturity	Polar diameter of bulb (cm)	Equatorial diameter of bulb (cm)	Fresh weight of whole plant (g)	Fresh weight of bulb (g)	Bulbs yield q ha^{-1}	Pyruvic acid (µ mole g^{-1})	Gross income (Rs/ha)	Net income (Rs/ha)	C:B ratio
K_0S_0	53.13	107.45	4.33	3.49	135.33	109.00	226.64	1.12	213120	162805	1: 4.24
K_0S_{20}	53.53	108.00	4.36	4.55	141.33	109.33	244.84	1.29	231270	180020	1: 4.51
K_0S_{30}	55.00	108.25	4.50	4.69	146.66	116.66	326.33	1.33	313480	261765	1: 6.06
K_0S_{40}	54.26	109.35	4.43	4.63	144.66	116.00	289.48	1.59	275340	223156	1: 5.28
K_0S_{50}	53.60	110.06	4.41	4.05	144.00	110.66	230.75	1.17	220530	167884	1: 4.19
$K_{40}S_0$	56.66	109.35	4.75	4.23	151.33	118.66	296.10	1.42	283120	231666	1: 5.50
$K_{40}S_{20}$	58.33	109.85	5.77	4.76	155.33	122.00	377.31	1.52	364220	311831	1: 6.95
$K_{40}S_{30}$	58.73	110.40	5.83	4.81	158.66	123.33	381.63	1.70	370330	317476	1: 7.01
$K_{40}S_{40}$	59.06	110.75	5.91	4.81	162.66	124.66	305.56	1.26	294230	240907	1: 5.52
$K_{40}S_{50}$	59.66	111.00	5.91	4.45	166.00	128.66	296.76	1.49	285150	231365	1: 5.30
$K_{60}S_0$	60.60	110.60	5.10	4.39	168.00	135.33	345.94	1.72	333850	281835	1: 6.42
$K_{60}S_{20}$	60.93	111.10	6.11	4.90	169.33	140.00	377.88	1.88	365700	312750	1: 6.91
$K_{60}S_{30}$	64.60	111.90	6.17	5.43	174.00	140.66	490.84	1.35	478650	425235	1: 8.96
$K_{60}S_{40}$	60.26	112.65	5.99	4.87	166.66	129.00	342.96	1.45	331450	277566	1: 6.15
$K_{60}S_{50}$	58.80	113.00	5.89	4.81	161.33	124.66	337.78	1.84	326450	272104	1: 6.01
$K_{80}S_0$	55.40	111.70	4.59	3.70	148.66	116.66	273.54	1.35	260710	208117	1: 4.96
$K_{80}S_{20}$	56.06	111.86	5.67	4.72	149.33	118.00	348.44	1.50	335520	281992	1: 6.27
$K_{80}S_{30}$	58.46	112.80	5.80	4.77	157.33	122.00	399.40	1.48	386440	332447	1: 7.16
$K_{80}S_{40}$	57.33	113.50	5.77	4.73	155.33	120.00	317.80	1.56	304780	250318	1: 5.60
$K_{80}S_{50}$	57.13	113.93	5.77	4.39	153.33	119.33	270.01	1.45	284040	229116	1: 5.17
C.D. (P= 0.05)	1.89	0.49	0.45	0.32	1.78	2.18	47.60	0.06	-	-	-

plant with incremental doses of K and maximum value (167.86 g) was observed with 60 kg K_2O ha^{-1} followed by 40 kg K_2O ha^{-1} and 0 kg K_2O ha^{-1} in descending order. Similar findings have been reported by Geetha *et al.* (2000) and Shaheen *et al.* (2011). Maximum fresh weight of whole plant (159.16 g) was observed with 30 kg S ha^{-1} (Table 1). Highest fresh weight of whole plant (174.00 g) was observed with 60 kg K + 30 kg S ha^{-1} which was significantly superior over other combinations. In general, there was increase in fresh weight of whole plant with increasing dose of sulphur at all levels of potassium and vice-versa (Table 2). Potassium exerted significant increase in fresh weight of bulb. Maximum fresh weight of (133.93 g) bulb was observed with 60 kg K_2O ha^{-1}. These findings corroborated with those of Jawadagi *et al.* (2012) and Saud *et al.* (2013). Highest fresh weight of bulb (125.66 g) was observed with 30 kg S ha^{-1} which was significantly superior over rest of the doses (Table 1). Combined application of K and sulphur indicated significant effect and 60 kg K + 30 kg S ha^{-1} had recorded highest fresh weight of bulb (140.66 g).

There was a significant increase in bulb yield with increasing dose of K and maximum bulb yield (379.08 q ha^{-1}) was recorded with 60 kg K_2O ha^{-1} which was significantly superior to other levels. Sulphur application exerted positive effect on bulb yield and highest value (399.55 q ha^{-1}) was noticed with 30 kg S ha^{-1} which was significantly superior over 20 kg S ha^{-1}, 40 kg S ha^{-1} and 0 kg S ha^{-1} (Table 1). Positive effect of sulphur doses on growth parameters and yield parameters might have ultimately resulted in higher bulb yield. Similar findings have been reported by Jawadagi *et al.* (2012), Saud *et al.* (2013) and Ahir War *et al.* (2015). Highest bulb yield (490.84 q ha^{-1}) was recorded with 60 kg K_2O + 30 kg S ha^{-1} (Table 2). Nagaich and Singh (2004) and Miah *et al.* (2005) reported that interaction of K with sulphur may cause high yield of onion.

Quality parameters

Application of potassium and sulphur had non-significant influence on total soluble solids (%). Though, highest total soluble solids (TSS) were recorded with 60 kg K_2O ha^{-1}. Similarly, the highest TSS was recorded with application of 60 kg S ha^{-1} followed by 30 kg S ha^{-1}. Application of sulphur might have enhanced the availability of minerals and accumulation of soluble solids in onion bulbs which resulted in more TSS. Numerically highest value for TSS was observed with 60 kg K_2O + 50 kg S ha^{-1} (Table 2). Pyruvic acid content was significantly affected with K, sulphur as well as their combined application. There was an increase in pyruvic acid content with increasing dose of K as well as sulphur. Individually, 80 kg K_2O ha^{-1} (1.52 µ mole/g) and 40 kg S ha^{-1} (1.72 µ mole/g) resulted in maximum pyruvic acid content (Table 1). Highest pyruvic acid content (1.88 µ mole/g) was found with 60 kg K_2O + 20 kg S ha^{-1} (Table 2). Higher pyruvic acid content with increasing K and sulphur levels may be due to increased availability of sulphur which would have enhanced synthesis of volatile S compounds. Hamilton *et al.* (1997) also found increase in pyruvic acid content with increase in sulphur levels in onion.

Economics

Economic evaluation of treatments revealed that application of K as well as sulphur enhanced the gross income, net income as well as cost benefit ratio. Highest gross income (`. 4, 78,650 $ha^{-1}$), net income (`. 4, 25,235 ha^{-1}) as well as cost: benefit ratio (1: 8.96) were recorded with 60 kg K_2O + 30 kg S ha^{-1}. These results may be due to increase in economic yield with increasing dose of potassium and sulphur. More increase in economic yield as compared to increase in expenditure resulted in higher total return, net income as well as per rupee investment under 60 kg K_2O + 30 kg S ha^{-1} application (Table 2). Similar findings have been reported by Dudhat *et al.* (2010).

From the study, it could be concluded that the application of potassium and sulphur had significant influence on the growth, yield and quality attributes of onion. However, application of potassium and sulphur delayed the maturity of crop. Combined application of 60 kg K_2O + 30 kg S ha^{-1} gave the best results and recommended for higher yields and benefits in onion.

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