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Effect of potash and sulphur levels on growth, yield, quality parameters and economics in onion

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Abstract
The research work was conducted at Krishi Vigyan Kendra, Sardarkrushinagar Dantiwada Agricultural University, Khedbrahma (Gujarat), during *rabi* season in three consecutive years (2019–2020; 2020–2021 and 2021–2022) to study the effect of potash and sulphur levels on growth, yield and quality of onion. Potash was applied @ 40, 60 and 80 kg ha^{-1} in combination with sulphur @ 0, 20, 40 and 60 kg ha^{-1} and their twelve treatment combinations were laid out in factorial randomized block design with three replications. Uniform dose of FYM (25 t ha^{-1}) was applied to all the treatments. Data on plant height (cm), leaves plant^{-1} at 90 DAT, fresh bulb weight (g), bulb diameter (cm), fresh bulb yield (q ha^{-1}) at harvest, S content of bulb (%) after harvest and Physiological Weight Loss (PLW %) after 1, 2 and 3 months of storage were recorded. It was found that application of potash and sulphur with recommended dose of nitrogen and phosphorus gave better results in relation to yield as well as quality characters. The results revealed that application of potash and sulphur with recommended dose of nitrogen and phosphorus (P_2S_1-100:50:60:20 kg NPKS ha^{-1}) gave better results in relation to yield, quality parameters like physiological weight loss and net return in onion.

Keywords: Onion, potash, sulphur, yield, quality

Introduction
Onion (*Allium cepa* L., Family: Alliaceae) is one of the most important vegetable, salad and spice of the world, having important place in vegetable cultivation (Tripathy *et al.*, 2013; Ganie *et al*., 2019; Sable *et al*., 2013; Hirave *et al*., 2015; Meghana *et al.*, 2021 and Mohanty and Prusti, 2001) [19, 5, 16, 8, 13, 14]. India is the second leading onion producing country having an area, production, productivity of 1.62 million hectares, 26.64 million tonnes, 16.40 t ha^{-1}, respectively (Dhar *et al.*, 2019 and Anon., 2022) [3, 2]. Application of potash and sulphur in onion crop decreases post-harvest losses and enhances yield. Potash is important for many metabolic activities of crop, also responsible for quality of produce that's why it is known as quality element (Magray, 2017; Subhani *et al.*, 1990 and Vachhani and Patel, 1993) [12, 18, 20]. Sulphur is the 4th important plant nutrient after nitrogen, phosphorus and potash. It is important for synthesis of essential amino acids (cystine, cysteine and methionine); vitamin A compound and activates certain enzyme in plants (Magray, 2017; Havlin *et al*., 2004; Randle and Bussard, 1993) [12, 7, 15]. These amino acids are bio-stimulants which influence plant growth, yield and significantly mitigate the injuries caused due to abiotic stresses (Magray, 2017; Kowalczyk and Zielony, 2008) [12, 10]. Addition of sulphur in the soil has many effects i.e. pH reduction, soil-water relation improvement and increasing availability of nutrients like phosphorus, iron, manganese and zinc (Ewald, 2004) [4].
It has been observed that, low bulb yield is obtained from sulphur deficient soils and received more yield after its application. In North Gujarat, area of onion is increasing day by day, however due to lack in knowledge about adequate use of K and S as well as other nutrients affects yield and quality of onion. Looking into the importance of different nutrients like K and S application in addition with N and P to increase onion yield and quality this experiment was planned.

Materials and Methods

The research work on *rabi* onion variety Agrifound Light Red was conducted at KVK, Sardarkrushinagar Dantiwada Agricultural University, Khedbrahma (Gujarat) during three consecutive years (2019–2020, 2020–2021 and 2021–2022) entitled impact of different levels of potash and sulphur on growth, yield and quality of onion. The experiment was laid out in FRBD design with three replications of two factors. The two factors were potash (three levels) and sulphur (four levels), P_1 (40 kg ha^{-1}), P_2 (60 kg ha^{-1}) and P_3 (80 kg ha^{-1}); S_0 (00 kg ha^{-1}), S_1 (20 kg ha^{-1}), S_2 (40 kg ha^{-1}) and S_3 (60 kg ha^{-1}) respectively. There were 12 treatment combinations *viz.*T_1–P_1S_0 (P 40 kg & S 00 kg ha^{-1}), T_2 – P_1S_1 (P 40 kg & S 20 kg ha^{-1}), T_3 – P_1S_2 (P 40 kg & S 40 kg ha^{-1}), T_4 – P_1S_3 (P 40 kg & S 60 kg ha^{-1}), T_5 – P_2S_0 (P 60 kg & S 00 kg ha^{-1}), T_6 – P_2S_1 (P 60 kg & S 20 kg ha^{-1}), T_7 – P_2S_2 (P 60 kg & S 40 kg ha^{-1}), T_8 – P_2S_3 (P 60 kg & S 60 kg ha^{-1}), T_9 – P_3S_0 (P 80 kg & S 00 kg ha^{-1}), T_{10} – P_3S_1 (P 80 kg & S 20 kg ha^{-1}), T_{11} – P_3S_2 (P 80 kg & S 40 kg ha^{-1}) and T_{12} – P_3S_3 (P 80 kg & S 60 kg ha^{-1}). Around two months old seedlings were transplanted on flat beds at 15 cm x 10 cm spacing in the last week of December during, three consecutive years. As per treatments K and S were added in the soil then transplanting was done, immediately. Well decomposed FYM @ 25 t ha^{-1} was given as a basal dose. Nitrogen @ 100 kg and phosphorus @ 50 kg ha^{-1} were given as a common dose to the all treatments. Full quantity of phosphorus and half nitrogen were given at transplanting, whereas, remaining 50 percent nitrogen was top dressed at 1 month and 1.5 months after transplanting, equally. Data on plant height (cm), leaves plant^{-1} at 90 DAT, fresh bulb weight (g), bulb diameter (cm), fresh bulb yield (q ha^{-1}) at harvest, S content of bulb (%) after harvest and Physiological Weight Loss (PLW %) after 1, 2 and 3 months of storage were recorded. The data collected on various parameters under study were statistically analyzed.

Results and Discussions

Growth parameters

Application of the different levels of potash and sulphur influences the onion plant height (Table 1). Dose of potash @ 80 kg ha^{-1} showed the maximum plant height in 1st year (75.20 cm) and 2nd year (61.73 cm) of the experiments and was at par with dose of potash @ 60 kg ha^{-1}, whereas, in 3rd year of the experiment dose of potash @ 60 kg ha^{-1} showed the maximum plant height (67.03 cm) and was at par with dose of potash @ 40 kg ha^{-1} (Kaur *et al.*, 2017) [9]. While, pooled analysis of potash levels on plant height was found non-significant. Regarding effect of sulphur levels and interaction effect between different levels of potash and sulphur on plant height was found non-significant. Dose of potash @ 60 kg ha^{-1} showed the maximum number of leaves plant^{-1} (Table 1) in 1st year (9.37), 3rd year (8.63) and in pooled analysis (8.88). Such findings also proved by Kaur *et al.*, in 2017 [9]. Regarding the effect of different levels of sulphur application on number of leaves plant^{-1} was found non-significant except with sulphur application @ 20 kg ha^{-1} (9.60) in 1st year of the experiment. Interaction effect between potash and sulphur levels on number of leaves plant^{-1} was found non-significant.

Yield parameters

Table 1 showed that application of the different levels of potash during 2nd year, 3rd year and in pooled analysis significantly influences bulb diameter. Dose of potash @ 60 kg ha^{-1} was produced the maximum bulb diameter during 2nd year (6.62 cm), 3rd year (6.75 cm) and in pooled data (6.53 cm) and was at par with dose of potash @ 80 kg ha^{-1}. Regarding dose of sulphur as well as interaction effect between different levels of potash and sulphur on bulb diameter was found non-significant. Table 1 proved that the bulb weight differed with the application of different potash levels. Dose of potash @ 60 kg ha^{-1} showed significantly maximum bulb weight during 2nd year (166.10 g), during 3rd year (126.29 g) and in pooled analysis (151.93 g) and was at par with dose of potash @ 80 kg ha^{-1} in 2nd year of the experiment. Regarding dose of sulphur levels as well as interaction effects between potash and sulphur levels on bulb weight was found non-significant. Table 2 proved that onion bulb yield (q ha^{-1}) influenced by different levels of potash and sulphur during 1st, 2nd, 3rd year and in pooled analysis. Dose of potash @ 60 kg ha^{-1} gave significantly maximum bulb yield during 1st year (583.02 q), 2nd year (612.24 q), 3rd year (575.00 q) and in pooled analysis (590.80 q) and was at par with dose of potash application @ 80 kg ha^{-1} in 1st year of the experiment. Regarding different levels of sulphur, dose of sulphur @ 20 kg ha^{-1} gave the maximum bulb yield during 1st year (585.47 q) and was at par with dose of sulphur @ 40 and 60 kg ha^{-1}, whereas, in 3rd year dose of sulphur @ 40 kg ha^{-1} gave maximum bulb yield (562.93 q) and was at par with dose of sulphur application @ 60 and 20 kg ha^{-1}. During 2nd year of the experiment and in pooled analysis bulb yield was found non-significant. Pooled data, proved that dose of potash @ 60 kg and sulphur @ 20 kg ha^{-1} (P_2S_1) gave the maximum bulb yield (611.21 q) which was at par with dose of potash @ 60 kg and dose of sulphur @ 40 kg (P_2S_2) and dose of potash @ 60 kg and dose of sulphur @ 60 kg ha^{-1} (P_2S_3.). As per findings of researchers Garg *et al.*, 2018; Amanullah *et al.*, 2017; Singh *et al.*, 2001 and Lal *et al.*, 2002 [6, 1, 17, 11], yield might be increased due to increased dose of potash and sulphur, ultimately resulting in an increased bulb fresh weight and diameter.

Quality parameters

Table 3 proved that the effect of potash levels on Physiological Weight Loss (PLW %) of onion bulb after 1, 2 and 3 months of storage was found non-significant, while, effect of sulphur levels application was also found non-significant on the basis of pooled data for after 1st, 2nd and 3rd months of storage. The interaction effect between potash and sulphur levels on PLW (%) was found significant after 3 months of storage on pooled basis. The effect of potash, sulphur levels as well as the interaction effect between potash and sulphur on sulphur content in onion bulb (%) was found non-significant in three consecutive years (Kaur *et al.*, 2017) [9].

Economics

It is evident from the data in table 5 that, the treatment combination of potash application @ 60 kg and sulphur @ 20 kg ha^{-1} (P_2S_1) recorded the higher gross return (₹ 916815 ha^{-1}), net return (₹ 777110 ha^{-1}) and higher B: C ratio of 5.56. Whereas, minimum gross return, net return and B: C ratio was recorded with the treatment combination of potash @ 40 kg and sulphur @ 00 kg ha^{-1} (P_1S_0).

Table 1: Effect of different levels of potash and sulphur on plant height, leaves plant^{-1}, bulb diameter and bulb weight of onion

Treat.	Plant height (cm)				Leaves plant^{-1} (No.)				Bulb diameter (cm)				Bulb weight (g)			
	1st year	2nd year	3rd year	Pooled	1st year	2nd year	3rd year	Pooled	1st year	2nd year	3rd year	Pooled	1st year	2nd year	3rd year	Pooled
P Level																
P_1	70.05	57.97	65.85	64.62	8.45	7.55	7.98	8.13	5.87	6.06	6.30	6.08	155.96	139.01	110.61	135.19
P_2	73.03	61.42	67.03	67.83	9.37	7.90	8.63	8.88	6.23	6.62	6.75	6.53	163.40	166.10	126.29	151.93
P_3	75.20	61.73	63.23	66.72	9.18	8.03	8.03	8.42	6.23	6.39	6.46	6.36	160.68	156.08	108.96	141.91
SEm $\pm$	1.48	1.10	0.73	1.21	0.21	0.15	0.16	0.10	0.20	0.11	0.12	0.09	6.87	5.81	4.75	3.39
CD $_{0.05}$	4.35	3.23	2.14	NS	0.61	NS	0.48	0.29	NS	0.33	0.36	0.25	NS	17.05	13.92	9.58
S Level																
S_0	71.09	59.67	65.09	65.28	8.58	8.16	8.31	8.40	5.88	6.42	6.44	6.25	157.47	156.78	112.66	142.30
S_1	74.02	60.87	65.80	66.90	9.60	7.71	8.22	8.68	6.31	6.35	6.33	6.33	165.69	155.74	110.15	143.54
S_2	74.07	61.51	65.69	67.09	8.67	7.67	8.16	8.32	6.13	6.34	6.64	6.37	157.89	153.72	123.02	144.88
S_3	74.53	59.44	64.91	66.30	9.16	7.78	8.18	8.50	6.13	6.31	6.60	6.35	159.00	149.62	115.32	141.32
SEm $\pm$	1.71	1.27	0.84	0.76	0.24	0.18	0.19	0.12	0.23	0.13	0.14	0.10	7.94	6.71	5.48	3.91
CD $_{0.05}$	NS	NS	NS	NS	0.70	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
PxS																
SEm $\pm$	2.97	2.20	1.46	1.32	0.42	0.31	0.33	0.21	0.40	0.23	0.24	0.17	13.74	11.62	9.49	6.78
CD $_{0.05}$	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
YxP				NS				NS				NS				NS
YxS				NS				NS				NS				NS
YxPxS				NS				NS				NS				NS

Table 2: Effect of different levels of potash, sulphur and their interaction on onion bulb yield (q ha^{-1})

Treat.	1st year	2nd year	3rd year	Pooled
P Level				
P_1	523.22	528.77	510.95	520.98
P_2	583.02	612.24	575.00	590.80
P_3	560.92	572.33	543.00	558.74
SEm $\pm$	12.14	8.61	8.33	5.68
CD $_{0.05}$	35.60	25.24	24.44	16.06
S Level				
S_0	523.82	574.91	513.67	537.48
S_1	585.47	579.50	542.60	569.19
S_2	558.93	566.73	562.93	562.87
S_3	554.64	563.31	552.73	556.89
SEm $\pm$	14.02	9.94	9.62	9.83
CD $_{0.05}$	41.11	NS	28.22	NS
PxS				
P_1 S_0	472.13	515.07	440.20	475.80
P_1 S_1	551.07	504.53	503.00	519.53
P_1 S_2	545.73	538.13	558.60	547.49
P_1 S_3	523.93	557.33	542.00	541.89
P_2 S_0	548.00	616.27	561.20	575.16
P_2 S_1	611.47	637.16	585.00	611.21
P_2 S_2	584.53	596.67	583.20	588.13
P_2 S_3	588.07	598.87	570.60	585.84
P_3 S_0	551.33	593.40	539.60	561.44
P_3 S_1	593.87	596.80	539.80	576.82
P_3 S_2	546.53	565.40	547.00	552.98
P_3 S_3	551.93	533.73	545.60	543.75
SEm $\pm$	24.28	17.22	16.67	11.37
CD $_{0.05}$	NS	50.5	48.88	32.11
YxP				NS
YxS				NS
YxPxS				NS

Table 3: Effect of different levels of potash and sulphur on Physiological Weight Loss (PLW %) of onion after 1st, 2nd and 3rd month of storage

Treat.	PLW (%) after 1 month of storage				PLW (%) after 2 months of storage				PLW (%) after 3 months of storage			
	1st year	2nd year	3rd year	Pooled	1st year	2nd year	3rd year	Pooled	1st year	2nd year	3rd year	Pooled
P Level												
P_1	12.96 (4.56)	15.59 (6.74)	15.11 (6.31)	14.55 (5.87)	17.07 (8.17)	17.61 (8.66)	19.15 (10.30)	17.94 (9.05)	20.97 (12.40)	20.99 (10.02)	20.95 (12.35)	20.96 (12.36)
P_2	12.55 (4.27)	15.35 (6.54)	14.86 (6.08)	14.25 (5.63)	16.46 (7.60)	17.64 (8.72)	18.42 (9.50)	17.51 (8.61)	20.21 (11.55)	20.40 (10.31)	20.40 (11.68)	20.34 (11.64)
P_3	12.49 (4.29)	15.96 (7.07)	15.07 (6.29)	14.50 (5.87)	16.38 (7.58)	18.17 (9.24)	18.98 (10.10)	17.84 (8.97)	20.94 (10.49)	20.69 (10.69)	20.69 (12.01)	20.49 (11.84)
SEm ±	0.19	0.22	0.12	0.11	0.35	0.17	0.28	0.16	0.52	0.17	0.40	0.26
CD 0.05	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
S Level												
S_0	14.38 (5.67)	15.61 (6.79)	14.52 (5.81)	14.83 (6.09)	19.06 (10.18)	18.14 (9.20)	18.64 (9.77)	18.61 (9.72)	23.51 (15.44)	20.54 (10.87)	20.54 (11.39)	21.53 (13.07)
S_1	12.23 (4.02)	15.32 (6.50)	15.23 (6.41)	14.26 (5.64)	16.03 (7.18)	17.22 (8.29)	19.05 (10.17)	17.43 (8.55)	19.64 (10.89)	20.86 (9.90)	20.86 (12.21)	20.46 (11.77)
S_2	12.06 (3.89)	15.77 (6.90)	14.88 (6.10)	14.24 (5.63)	15.80 (6.59)	17.81 (8.87)	18.00 (9.69)	17.40 (8.51)	19.35 (10.53)	20.37 (10.28)	20.37 (11.65)	20.03 (11.28)
S_3	11.98 (3.84)	15.83 (6.96)	15.42 (6.59)	14.41 (5.79)	15.80 (6.83)	18.06 (9.11)	19.11 (10.24)	17.60 (8.73)	10.20 (10.39)	20.95 (10.30)	20.95 (12.32)	20.37 (11.68)
SEm ±	0.22	0.26	0.14	0.36	0.40	0.19	0.32	0.55	0.60	0.19	0.46	0.84
CD 0.05	0.66	NS	0.41	NS	1.17	0.56	NS	NS	1.75	0.56	NS	NS
PxS												
SEm ±	0.39	0.45	0.24	0.21	0.69	0.33	0.56	0.32	1.04	0.33	0.80	0.51
CD 0.05	NS	NS	0.72	NS	NS	NS	1.64	NS	NS	NS	NS	1.45
YxP				NS				NS				NS
YxS				NS				NS				NS
YxPxS				NS				NS				NS

Note: Figure in parenthesis are retransformed value and those outside are arcsine transformed value

Table 4: Effect of different levels of potash and sulphur on sulphur content of onion bulb (%)

Treat.	1st year	2nd year	3rd year	Pooled
P Level				
P_1	0.47	0.42	0.38	0.43
P_2	0.50	0.37	0.33	0.41
P_3	0.57	0.35	0.33	0.41
SEm ±	0.03	0.02	0.01	0.01
CD 0.05	NS	NS	NS	NS
S Level				
S_0	0.51	0.41	0.34	0.42
S_1	0.54	0.38	0.37	0.43
S_2	0.54	0.38	0.34	0.42
S_3	0.50	0.36	0.33	0.40
SEm ±	0.03	0.02	0.02	0.01
CD 0.05	NS	NS	NS	NS
PxS				
SEm ±	0.05	0.04	0.03	0.02
CD 0.05	NS	NS	NS	NS
YxP				NS
YxS				NS
YxPxS				NS

Table 5: Economics of different treatments

Treat.	Bulb yield (q ha^{-1})	Fixed cost (₹ha^{-1})	Variable cost (₹ha^{-1})	Total cost (₹ha^{-1})	Gross realization (₹ha^{-1})	Net Realization (₹ha^{-1})	B:C ratio
P_1 S_0	475.80	132377	2161	134538	713700	579162	4.30
P_1 S_1	519.53	132377	6800	139177	779295	640118	4.60
P_1 S_2	547.49	132377	10290	142667	821235	678568	4.76
P_1 S_3	541.89	132377	13810	146187	812835	666648	4.56
P_2 S_0	575.16	132377	2689	135066	862740	727674	5.39
P_2 S_1	611.21	132377	7328	139705	916815	777110	5.56
P_2 S_2	588.13	132377	10818	143195	882195	739000	5.16
P_2 S_3	585.84	132377	14388	146765	878760	731995	4.99
P_3 S_0	561.44	132377	3217	135594	842160	706566	5.21
P_3 S_1	576.82	132377	7856	140233	865230	724997	5.17
P_3 S_2	552.98	132377	11346	143723	829470	685747	4.77
P_3 S_3	543.75	132377	14866	147243	815625	668382	4.54

Average selling price: ₹15 kg^{-1} (Average of super size ₹20 and medium small size ₹10 kg^{-1})

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