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Effect of potash and sulphur applications on yield and economics of onion

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Abstract
The experiment was carried out at Krishi Vigyan Kendra, Sardarkrushinagar Dantiwada Agricultural University, Khedbrahma, Sabarkantha (Gujarat) India, during *rabi* season of three consecutive years (2019–2020; 2020–2021 and 2021–2022) to study the effect of potash and sulphur application on yield and economics of onion. Potash was tested @ 40, 60 and 80 kg ha^{-1} in combination with sulphur @ 0, 20, 40 and 60 kg ha^{-1} and their combinations (12 treatment combinations) were laid out in factorial randomized block design (FRBD) with three replications. In pooled analysis, integration of potash @ 60 kg and sulphur @ 20 kg ha^{-1} with uniform application of nitrogen @ 100 kg and phosphorus @ 50 kg ha^{-1} recorded maximum bulb yield (611.21 q ha^{-1}). Maximum gross return (₹ 916815 ha^{-1}), net return (₹ 777110 ha^{-1}) and B:C ratio (5.56) were recorded with potash @ 60 kg + sulphur @ 20 kg ha^{-1} in onion.

Keywords: Onion, potash, sulphur, yield and economics

Introduction
Onion (*Allium cepa* L.) is one of the most important commercial vegetable used as raw as salad, vegetable and spice all over the world (Tripathy *et al*., 2013; Ganie *et al*., 2019) [26, 6]. Onion belongs to the family *Alliaceae* (Sable *et al*., 2013; Hirave *et al*., 2015) [22, 9] having chromosome number 2n = 16 (Meghana *et al*., 2021) [15]. It is also referred as queen of kitchen (Meghana *et al*., 2021; Ganie *et al*., 2019) [15, 6]. The pungency in onion is due to the presence of ally propyl disulphide (Mohanty and Prusti, 2001) [17]. India is second largest onion producing country in the world after China (Dhar *et al*., 2019) [4]. The area and production of onion in India is 1.62 million hectare and 26.64 million tonnes respectively (Anonymous, 2022) [2] and 16.40 t ha^{-1} productivity. The major onion growing states are Maharashtra, Karnataka, Madhya Pradesh, Gujarat, Rajasthan, Bihar etc. Onion is grown all over the country in three seasons i.e. *kharif*, late *kharif* and *rabi*. It is predominantly cultivated during *rabi* season (Tripathy *et al*., 2013) [26]. Hence, average productivity of Indian onion depends on the *rabi* onion. Intensive cropping, imbalanced fertilization, minimal usage of micro nutrients and limited application of organic manures have resulted in the depletion of soil fertility could have resulted in low productivity and quality of the crop which may be enhanced by nutrient management practices. Fertilizer management is one of the important management factors that may contribute much to the onion yield. N, P, K and S are important nutrient element that play important role on bulb formation, elongation, skin color development and pungency of onion (Kaur *et al*., 2017 and Vachhani and Patel. 1993) [11, 27]. Potash and sulphur play important role to decrease the post harvest losses in onion which ranged from 25-60 per cent in onion. Since potash is involved in many metabolic pathways that affect crop quality, it is often called as "the quality element" (Magray, 2017) [14]. It also improves quality parameters of many crops including onion like colour and dry matter accumulation besides improving keeping quality of the onion (Kaur *et al*., 2017 and Subhani *et al*., 1990) [11, 25]. Sulphur also improves the yield and quality parameters of onion. Sulphur is a constituent of secondary compounds *viz*., allin, cycloallin and thiopropanol which not only influence the taste, pungency and medicinal properties of onion and garlic but impart resistance against pests and diseases (Magray, 2017) [14]. Sulphur is the 4th important plant nutrient after nitrogen, phosphorus and potash. It is essential for the synthesis of essential amino acids like cystine (27 % S), cysteine (26 % S) and methionine (21 % S) a compound of vitamin A and activates certain enzyme systems in plants (Havlin *et al*., 2004, Randle and Bussard, 1993) [4, 21]. Recently, studies have proved that amino acids can directly or indirectly influence the physiological activities in growth and development of plant. Also, amino acid are well known as bio-stimulants which have positive effects on plant growth, yield and significantly mitigate the injuries caused by abiotic stresses

(Kowalczyk and Zielony, 2008.) [12] Sulphur is a constituent of enzyme nitrite reductase which is responsible for the reduction of NO_2 in chloroplasts and thus reduces accumulation of cancerous compound like nitrates in vegetables (Paulsen, 2001) [20]. Sulphur as a secondary nutrient has a positive effect on onion vegetable crop (Ewald, 2004) [5]. Application of sulphur in the soil has several effects; such as reducing pH, improving soil-water relation and increasing availability of nutrients like P, Fe, Mn and Zn. Non application of S in sulphur deficient soils has often resulted in low yields of bulb crops. Sulphur deficient plants also had poor utilization of macro as well as micro nutrients and lack of its optimum supply in different onion plant parts limit the growth and yield (Nasreen and Haq, 2005) [19]. It has been observed that majority of farmers are not aware about balance use of potash and sulphur along with nitrogen and phosphorus in onion. Since a meager work was conducted under North Gujarat condition in this regard, the present research was conducted to assess the beneficial effects of potash, sulphur, their interaction and economics in the onion.

2. Materials and Methods

The investigation was performed at Krishi Vigyan Kendra, Sardarkrushinagar Dantiwada Agricultural University, Khedbrahma, Sabarkantha (Gujarat) India, during *rabi* season of three consecutive years (1st year: 2019–2020, 2nd year: 2020–2021 and 3rd year: 2021–2022) to study the impact of different levels of potash and sulphur on yield and economics of onion. The experiment was laid out in factorial randomized block design (FRBD) with three replications of two factors. The two factors were potash (P) and sulphur (S) with three potash levels as P_1 (40 kg ha^{-1}), P_2 (60 kg ha^{-1}) and P_3 (80 kg ha^{-1}) whereas, four sulphur levels as S_0 (00 kg ha^{-1} or no sulphur), S_1 (20 kg ha^{-1}), S_2 (40 kg ha^{-1}) and S_3 (60 kg ha^{-1}). The experiment consisted 12 treatment combinations and symbolized *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}). The nursery of onion (cv. Agrifound Light Red) was sown on flat nursery beds using seed rate 5-7 kg ha^{-1} in last week of October of three consecutive years. The transplanting of the onion seedlings in the field was done in last week of December of three consecutive years following 15 cm x 10 cm row to row and plant to plant spacing on flat beds. Urea, diammonium phosphate and muriate of potash were used as a source of nitrogen, phosphorus and potassium. The treatment wise potash (MOP) and sulphur (90 %) were applied in the soil and transplanting was done, immediately. Well decomposed cow dung @ 25 t ha^{-1} was applied as a basal dose. The crop was uniformly fertilized with nitrogen @ 100 kg and phosphorus @ 50 kg ha^{-1}. Full dose of phosphorus and half dose of nitrogen were applied at the time of transplanting as basal dose and remaining dose of nitrogen as top dressing at 30 and 45 days after transplanting (DAT), equally. The uprooting of the bulbs was done manually in the second fortnight of April of three consecutive years. After uprooting, bulbs were cut about 2-3 cm above the neck and fresh bulb yield was recorded. Data on fresh bulb weight (g), bulb diameter (cm), fresh bulb yield (q ha^{-1}) was recorded at harvest and treatment wise economics was calculated. Bulb diameter was measured by using digital vernier caliper. The data collected on various parameters under study were statistically analyzed.

Fig 1: View of onion experimental plot

3. Results and Discussions

The outcomes of study showed that different levels of potash and sulphur caused effect on yield and economics of onion which are presented in table 1 to 3.

Yield Parameters

An examination of data indicates that yield parameters *viz*. bulb diameter (cm), bulb weight (g) and bulb yield (q ha^{-1}) differ significantly with application of potash and sulphur. It is evident from the data in table 1 that bulb diameter significantly influenced by application of the different levels of potash during 2nd year, 3rd year and in pooled analysis. The maximum bulb diameter during 2nd year (6.62 cm), 3rd year (6.75 cm) and in pooled data (6.53 cm) was recorded with application of potash @ 60 kg ha^{-1} which was at par with potash @ 80 kg ha^{-1}. Similar findings were reported by researchers like Nagaich and Singh, 2004 [18]; Dev *et al*., 2009 [3]; Saud *et al*., 2013 [23] and Jawadagi *et al*., 2012 [10]. In case of sulphur as well as interaction effect between different levels of potash and sulphur on bulb diameter was found to be non-significant during three consecutive years and pooled analysis. It is evident from the data in table 1 that the bulb weight influenced with the application of different potash levels. The significantly maximum bulb weight during 2nd year (166.10 g), during 3rd year (126.29 g) and in pooled analysis (151.93 g) was recorded with application of potash @ 60 kg ha^{-1} which was at par with potash application @ 80 kg ha^{-1} in 2nd year of the experiment. In case of sulphur levels as well as interaction effects between potash and sulphur levels on bulb weight was found to be non-significant.

Fig 2: Onion bulb size in treatment T1 (K@ 40 kg +S@ 00 kg ha-1) and T6 (K@ 60 kg +S@ 20 kg ha-1)

The data pertaining to onion bulb yield (q ha^{-1}) as influenced by different levels of potash and sulphur during 1st, 2nd, 3rd year and pooled analysis are presented (Table 2). From the data it is revealed that, significantly maximum bulb yield during 1st year (583.02 q), 2nd year (612.24 q), 3rd year (575.00 q) and pooled analysis (590.80 q) was recorded with application of potash @ 60 kg ha^{-1} which was at par with potash application @ 80 kg ha^{-1} during 1st year. In case of different levels of sulphur, the maximum bulb yield during 1st year (585.47 q) was recorded with application of sulphur @ 20 kg ha^{-1} which was at par with sulphur application @ 40 and 60 kg ha^{-1} and in 3rd year maximum bulb yield (562.93 q) was recorded with application of sulphur @ 40 kg ha^{-1} which was at par with sulphur application @ 60 and 20 kg ha^{-1}. However, in 2nd year and in pooled analysis bulb yield was found to be non-significant. Pooled data, revealed that combined application of potash @ 60 kg and sulphur @ 20 kg ha^{-1} (P_2S_1) recorded the maximum bulb yield value (611.21 q) which was at par with application of potash @ 60 kg and sulphur @ 40 kg (P_2S_2) and potash @ 60 kg and sulphur @ 60 kg ha^{-1} (P_2S_3.). This might be due to increased levels of potash and sulphur, ultimately resulting in an increased bulb fresh weight and diameter. Similar findings were reported by researchers like Garg *et al.*, 2018 [7]; Singh *et al.*, 2001 [24]; Miah *et al.*, 2005 [16] and Lal *et al.*, 2002 [13]. Application of increased levels of sulphur increases the length and girth of the cassava tuber, which corroborate the findings of the present study (Amanullah *et al.*, 2007) [14].

Table 1: Effect of different levels of potash and sulphur on bulb diameter and bulb weight of onion

Treat.	Bulb diameter (cm)				Bulb weight (g)			
	1st year	2nd year	3rd year	Pooled	1st year	2nd year	3rd year	Pooled
P Level								
P_1	5.87	6.06	6.30	6.08	155.96	139.01	110.61	135.19
P_2	6.23	6.62	6.75	6.53	163.40	166.10	126.29	151.93
P_3	6.23	6.39	6.46	6.36	160.68	156.08	108.96	141.91
SEm ±	0.20	0.11	0.12	0.09	6.87	5.81	4.75	3.39
$CD_{0.05}$	NS	0.33	0.36	0.25	NS	17.05	13.92	9.58
S Level								
S_0	5.88	6.42	6.44	6.25	157.47	156.78	112.66	142.30
S_1	6.31	6.35	6.33	6.33	165.69	155.74	110.15	143.54
S_2	6.13	6.34	6.64	6.37	157.89	153.72	123.02	144.88
S_3	6.13	6.31	6.60	6.35	159.00	149.62	115.32	141.32
SEm ±	0.23	0.13	0.14	0.10	7.94	6.71	5.48	3.91
$CD_{0.05}$	NS	NS	NS	NS	NS	NS	NS	NS
PxS								
SEm ±	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
$CD_{0.05}$								
YxP				NS				NS
YxS				NS				NS
YxPxS				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 ±	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 ±	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 ±	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: Economics of different treatments

Treatment	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
Interaction (A x B)							
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})

Economics

It is evident from the data in table 3 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).

Conclusion

Combined application of potash (P_2) @ 60 kg and sulphur (S_1) 20 kg ha^{-1} as basal dose in addition to uniform application of FYM 25 t ha^{-1}, nitrogen @ 100 kg and phosphorus 50 kg ha^{-1} were found superior in bulb yield, gross return, net return and B:C ratio of *rabi* onion under North Gujarat condition.

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