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Effect of Sources, Levels and Methods of Potash Fertilization on Yield, Nutrient Uptake, Soil Chemical Properties and Quality of *Rabi* Onion in an Inceptisol

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Abstract: A field experiment on *rabi* onion (*cv*. N-2-4-1) was carried out experimental farm of College of Agriculture, Pune during the winter season of 2016-17, to study the effect of different levels and sources of potash (0, 50, 100 and 150 kg K_2O ha^{-1}) and methods of its application as a basal (30% K_2O at the time of transplanting, 40 per cent through fertigation after 30 days of transplanting till initiation of bulb formation and remaining 30 per cent through fertigation after 60 days of transplanting till bulb formation at weekly intervals, respectively). In addition to that one additional treatment of 100 kg K_2O ha^{-1} was applied in the proportion of 90 kg K_2O through MOP (Muriate of Potash) as a basal application + 10 kg K_2O through SOP (Sulphate of Potash) as a foliar spray @ 1% after 60 and 75 days after transplanting for comparing the methods of K application. The results revealed that the application of 100 kg K_2O ha^{-1} (90 kg K_2O ha^{-1} as basal at the time of transplanting through MOP and 10 kg K_2O through two foliar sprays of SOP at 60 and 75 days after transplanting) recorded maximum fresh bulb weight, dry matter yield; higher bulb diameter and uptake of nitrogen, phosphorus, potassium, sulphur, Fe, Mn, Zn and Cu by *rabi* onion. There was improvement in available N,P,K , S and Mn content of soil due to application of 150 kg K_2O ha^{-1} through SOP applied through soil and fertigation over control. The application of 100 kg K_2O ha^{-1} (SOP) through soil and fertigation or 100 kg K_2O ha^{-1} was applied in the proportion of 90 kg K_2O through MOP as a basal application + 10 kg K_2O through SOP as a foliar spray @ 1% after 60 and 75 days of transplanting recorded magnitudely lower mean physiological loss in weight.

Keywords: *Potash, rabi onion, yield and quality*

Introduction

Onion (*Allium cepa* L.) is one of the most important vegetable grown all over the world. India is second largest producer of onion next to China. At present, Maharashtra is the largest producer in the country with an output of 12-15 lakh tones production from one lakh hectare area.

The potassium nutrition to onion has important role in storage quality. The application of appropriate quantity and source of nutrients to onion at critical growth stage is essential for better growth and quality (Kale *et al*. 1992). Potash nutrition has great role to play for regulating respiration, improving the quality parameters, prolonging the shelf life, developing the healthy root system *etc*. It is observed that the doses of K fertilizers added to vegetable crops are at much lower rate than its removal resulting in a negative balance in soil. Potash requirement for most of the crop is increasing due to intensive agriculture *vis-à-vis* cultivator's aim at higher yield and quality produce of

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crops per unit area and per unit time. The limited use of organic manures and relatively minimum use of fertilizer potassium lead to widespread deficiency of K in cultivated soils.

Moreover, different sources like MOP and SOP may also have bearing on yield and quality of onion as S applied through SOP is thought to have positively affect on onion yield and quality. Scarcity of water has lead to use of micro irrigation methods and also K fertilizer application through fertigation and foliar application is also supposed to enhance the efficiency of both water uses as well as of the K applied. The present experiment aims to evaluate the sources levels and methods of K application productivity and quality *rabi* onion.

Material and Methods

A field experiment was conducted at experimental Farm, College of Agriculture, and Pune (M.S.) in 2016-17 to study the influence of different sources, levels and methods of application of potash on yield and nutrient uptake of *rabi* onion (*cv.* N-2-4-1). The soil (Vertic Haplustepts) had 56.25% clay with pH 8.17, electrical conductivity (EC) 0.13 dSm^{-1}, organic carbon (6.8 g kg^{-1}), calcium carbonate (27.50 g kg^{-1}), low in available nitrogen (147 kg ha^{-1}), medium in available phosphorus (19.8 kg ha^{-1}) and very high in available potassium (304 kg ha^{-1}). There were 8 treatments replicated thrice in a randomized block design with plot size 15 sq.m. (5.0 x 3.0 m^2) with row to row spacing 15x10 cm and plant to plant distance 10.0 cm on raised bed. The treatments namely, T_1-. control (only application of N and P_2O_5 but no application of K_2O);for T_2, T_3 and T_4 had K_2O through muriate of potash (MOP) @ 50, 100 and 150 kg ha^{-1} respectively; for T_5, T_6 and T_7, K_2O was applied through sulphate of potash (SOP) @ 50, 100 and 150 kg ha^{-1} respectively through soil and fertigation (The K_2O through MOP and SOP applied @ 30% K_2O at the time of transplanting, 40% K_2O through fertigation from first leaf fall (after 30 DAT) till initiation of bulb formation at weekly intervals and remaining 30% K_2O through fertigation at initiation of bulb formation (after 60 DAT) till bulb formation at weekly intervals for T_2 to T_4 and T_5 to T_7 treatments respectively) and T_8 -100 kg K_2O applied through both MOP as a basal and SOP (90% K_2O *i.e.* 90 kg K_2O ha^{-1} as a basal at the time of transplanting through MOP and 10% K_2O *i.e.* 10 kg K_2O ha^{-1} was applied in two foliar sprays through SOP at 60 and 75 days DAT @ 1% K_2O *i.e.* 10 kg K_2O ha^{-1} through SOP at 60 and 75 days after transplanting). The recommended dose of 100 kg N (50 % N at transplanting and remaining 50% N after 30 days of transplanting) and entire 50 kg P_2O_5 ha^{-1} through DAP along with 20 t ha^{-1} FYM and bio-fertilizers was applied in all the treatments as a basal application. All recommended package of practices were adopted while raising the crop.

At harvest, random sample of five plants were selected from each plot and plant height (cm) and neck thickness (cm) at 90 DAT, number of leaves per plant at 60 and 90 DAT were recorded. Agronomic yield was computed on plot basis and then converted into per hectare basis. Plant samples were dried to a constant weight, processed and analyzed. Total N was determined using the micro-kjeldhal digestion method with 1:1 H_2SO_4:H_2O_2 (Parkinson and Allen 1975) followed by ammonia estimation. Total P, K and micronutrient cations were determined following wet digestion of the dried plant material with 4:10 HNO_3: $HClO_4$ (Johnson and Ulrich 1959). The data on various parameters recorded during the period of investigation were tabulated and statistically analyzed (Panse and Sukhatme 1967).

Results and Discussion

Yield contributing characters

The results revealed that number of leaves at 60 and 90 DAT, plant height at 90 DAT and neck thickness at 90 DAT did not have significant differences for different treatments (Table 1). However, the application of 100 kg K_2O ha^{-1} (90 kg K_2O ha^{-1} as basal at the time of transplanting through MOP and 10 kg K_2O through two foliar sprays of SOP at 60 and 75 days after transplanting) recorded significantly higher bulb diameter (6.89 cm) owing to diameter may be attributed potassium and sulphate nutrition which might have enhanced the photosynthetic activity and enzymes of carbohydrates transformation. Similar results were also reported by El-Tohamy *et al*. (2011) in carrot crop.

Table 1. Effect of sources, levels and methods of potash fertilization on yield and yield contributing characters of *rabi* onion

	Treatment	Yield (t ha^{-1})			Yield contributing characters			
		Fresh bulb	Dry matter	No. of leaves at 60 DAT	No. of leaves at 90 DAT	Plant height at 90 DAT (cm)	Neck thickness at 90 DAT (cm)	Bulb Diameter (cm)
T_1	Control (Only N and P_2O_5, no K_2O).	67.23	2.92	9.20	11.67	62.03	1.455	5.53
T_2	50 kg K_2O ha^{-1} (MOP applied through soil and fertigation)	72.14	3.26	9.27	13.60	63.67	1.503	6.76
T_3	100 kg K_2O ha^{-1} (MOP applied through soil and fertigation)	77.71	3.943	9.27	13.67	63.67	1.553	6.84
T_4	150 kg K_2O ha^{-1} (MOP applied through soil and fertigation)	75.40	4.38	9.73	14.40	63.81	1.773	6.75
T_5	50 kg K_2O ha^{-1} (SOP applied through soil and fertigation)	72.21	3.32	9.20	13.13	62.47	1.593	6.77
T_6	100 kg K_2O ha^{-1} (SOP applied through soil and fertigation)	77.67	4.34	9.60	13.87	64.03	1.620	6.85
T_7	150 kg K_2O ha^{-1} (SOP applied through soil and fertigation)	74.97	3.72	9.47	15.13	65.00	1.715	6.82
T_8	100 kg K_2O ha^{-1} (MOP app lied as basal through soil plus SOP applied through foliar sprays)	78.34	4.89	9.33	13.80	65.27	1.693	6.89
	SE$\pm$	1.14	0.32	0.39	1.15	1.30	0.068	0.072
	CD at 5 %	3.46	0.97	NS	NS	NS	NS	0.217

Yield

The data (Table 1) showed that potassium application through soil, fertigation and foliar through different sources had a significant effect on bulb yield. The application of 100 kg K_2O ha^{-1} (T_8 - 90 kg K_2O ha^{-1} as basal at the time of transplanting through MOP and 10 kg K_2O through two foliar sprays of SOP at 60 and 75 days after transplanting) recorded maximum fresh bulb weight (78.34 t ha^{-1}) and dry matter yield (4.89 t ha^{-1}) and closely followed by 100 kg K_2O through MOP and SOP applied through soil and fertigation. However, these treatments were on par with 150 kg K_2O ha^{-1} application either through MOP or SOP. Similar trend was also noticed for dry matter yield. The higher bulb yield might be attributed to the vigour of plant growth due to potassium *via* its influence on metabolism of plant enzymes and photosynthesis. Similar results was also reported by Ali *et al*. (2007). As the K level increases up to optimum level, the yield and its related parameters also increased (Pervez *et al*. 2004).

Nutrient uptake

Macronutrients

The application of 100 kg K_2O ha^{-1} (T_6 - 90 kg K_2O ha^{-1} as basal at the time of transplanting through MOP and 10 kg K_2O through two foliar sprays of SOP at 60 and 75 days after transplanting) recorded significantly higher nitrogen (180.27 kg ha^{-1}), phosphorus (103.4 kg ha^{-1}), potassium (259.40 kg ha^{-1}) and sulphur (97.68 kg ha^{-1}) uptakes. However in case of potassium and sulphur uptake, treatment T_6 was significantly superior over rest of the treatment. The lowest N, P, K and S uptake was recorded in control treatment (Table 2). The increase in N, P, K and sulphur uptakes may be ascribed to the role of potassium photosynthetic activities resulting high translocation of assimilates in from leaves to the bulbs (Behairy *et al*. 2015).

Micronutrients

The uptake of Fe (3404 g ha^{-1}), Mn (873 g ha^{-1}), Zn (1084 g ha^{-1}) and Cu (386 g ha^{-1}) by *rabi* onion was significantly higher due to T_8 treatment (90 kg K_2O ha^{-1} as basal at the time of transplanting through MOP and 10 kg K_2O through two foliar sprays of SOP at 60 and 75 days after transplanting). The lower Fe, Mn, Zn and Cu uptake was recorded in control (Table 2). The increased uptake of Fe, Mn, Zn, and Cu may be due to the role of potassium in plant metabolism and many important regulatory processes in the plant. Potassium and sulphur could increase mineral uptake by the plants (Marschner 1995).

Table 2. Effect of sources, levels and methods of potash fertilization on total macronutrient and micronutrient uptake by *rabi* onion at harvest

	Treatment	Macronutrient uptake ($kg\ ha^{-1}$)				Micronutrient uptake ($g\ ha^{-1}$)			
		N	P	K	S	Fe	Mn	Zn	Cu
T_1	Control (Only N and P_2O_5, no K_2O).	127.72	64.63	155.52	60.09	2397	548	717	211
T_2	50 kg K_2O ha^{-1} (MOP applied through soil and fertigation)	140.72	75.87	176.78	70.81	2660	647	823	250
T_3	100 kg K_2O ha^{-1} (MOP applied through soil and fertigation)	166.53	89.97	222.91	83.79	3054	749	956	312
T_4	150 kg K_2O ha^{-1} (MOP applied through soil and fertigation)	166.41	92.70	234.60	87.39	3228	804	1012	339
T_5	50 kg K_2O ha^{-1} (SOP applied through soil and fertigation)	142.41	78.86	183.50	73.86	2713	618	849	272
T_6	100 kg K_2O ha^{-1} (SOP applied through soil and fertigation)	172.07	93.28	235.65	87.64	3179	786	1013	333
T_7	150 kg K_2O ha^{-1} (SOP applied through soil and fertigation)	161.98	92.50	227.82	87.25	3029	756	973	333
T_8	100 kg K_2O ha^{-1} (MOP applied as basal through soil plus SOP applied through foliar sprays)	180.27	103.40	259.40	97.68	3404	873	1084	386
	SE$\pm$	5.94	3.59	5.14	2.86	110.0	27.2	38.5	14.5
	CD at 5 %	18.03	10.89	15.60	8.68	333.8	82.5	116.7	44.0

Soil chemical properties

The results indicate that soil pH, EC, organic carbon and calcium carbonate content of soil were not significantly influenced due to different levels and sources of potash application at harvest. The soil available N,P,K,S content of soil increased significantly with increase in levels and sources of potassium. The application of 150 kg K_2O ha^{-1} SOP applied through soil and fertigation had maximum available N, P, K and S (Table 3). The results of present investigation are in conformity with the findings of Kumar *et al.* (2006) and Singh and Pandey (2006). The DTPA - Fe, Zn and Cu were not significantly increased due to different

Table 3. Effect of sources, levels and methods of application of potassium on soil properties at harvest of *rabi* onion

	Treatment	Soil chemical properties				Available nutrient (kg ha^{-1})		
		pH	EC (dS m^{-1})	Organic Carbon (%)	$CaCO_3$ (%)	N	P	K
T_1	Control (Only N and P_2O_5, no K_2O).	7.46	0.34	0.63	2.33	151	21.1	353
T_2	50 kg K_2O ha^{-1} (MOP applied through soil and fertigation)	7.48	0.45	0.73	2.50	158	23.6	396
T_3	100 kg K_2O ha^{-1} (MOP applied through soil and fertigation)	7.48	0.40	0.67	1.67	163	25.2	458
T_4	150 kg K_2O ha^{-1} (MOP applied through soil and fertigation)	7.45	0.44	0.74	2.17	169	27.6	470
T_5	50 kg K_2O ha^{-1} (SOP applied through soil and fertigation)	7.46	0.37	0.67	1.33	162	23.8	384
T_6	100 kg K_2O ha^{-1} (SOP applied through soil and fertigation)	7.47	0.40	0.72	1.75	165	24.7	462
T_7	150 kg K_2O ha^{-1} (SOP applied through soil and fertigation)	7.47	0.44	0.75	1.83	170	26.9	476
T_8	100 kg K_2O ha^{-1} (MOP applied as basal through soil plus SOP applied through foliar sprays)	7.52	0.35	0.71	2.33	166	24.8	460
	SE±	0.04	0.06	0.03	0.42	1.53	0.52	11.1
	CD at 5 %	NS	NS	NS	NS	4.65	1.58	33.6
	Initial value	8.1	0.13	0.68	2.75	147	19.8	304

Table 4. Effect of source, land and methods of potash application on available S, Fe, Mn, Zn and Cu at harvest.

	Treatment	Suphur and DTPA - micronutrients (mg kg^{-1})				
		S	Fe	Mn	Zn	Cu
T_1	Control (Only N and P_2O_5, no K_2O).	9.80	3.88	8.53	3.56	5.58
T_2	50 kg K_2O ha^{-1} (MOP applied through soil and fertigation)	10.34	4.04	9.01	3.66	5.88
T_3	100 kg K_2O ha^{-1} (MOP applied through soil and fertigation)	9.90	4.36	10.23	3.84	5.60
T_4	150 kg K_2O ha^{-1} (MOP applied through soil and fertigation)	10.10	4.37	10.22	3.70	5.87
T_5	50 kg K_2O ha^{-1} (SOP applied through soil and fertigation)	10.40	4.05	9.80	3.68	5.69
T_6	100 kg K_2O ha^{-1} (SOP applied through soil and fertigation)	11.50	4.44	10.18	3.70	5.88
T_7	150 kg K_2O ha^{-1} (SOP applied through soil and fertigation)	12.40	4.13	10.28	3.91	5.94
T_8	100 kg K_2O ha^{-1} (MOP applied as basal through soil plus SOP applied through foliar sprays)	10.20	4.39	9.35	3.75	5.74
	SE±	0.30	0.21	0.31	0.12	0.18
	CD at 5 %	0.92	NS	0.93	NS	NS
	Initial value	9.5	4.6	9.8	4.2	5.9

treatments (Table 4). The application of 150 kg K_2O ha^{-1} through SOP applied through soil and fertigation recorded significantly higher in DTPA - Mn over control.

Bulb quality

The bulb quality in terms of physiological loss in weight of *rabi* onion was increased significantly with increase in storage period up to four months (Table 5). The treatment T_6 (100 kg K_2O ha^{-1} SOP applied through soil and fertigation) recorded lower mean physiological loss in weight (8.9%) which was closely followed by T_8 (90 kg K_2O ha^{-1} as basal at the time of transplanting through MOP and 10 kg K_2O through two foliar sprays of SOP at 60 and 75 days after transplanting). However, the highest physiological loss in mean weight (15.4%) was recorded in control treatment. The role of potassium in augmenting yield and improving the quality of onion bulb in term of physiological loss in weight is also reported by Kale *et al*. (1992).

Table 5. Effect of sources, levels and methods of potash fertilization on periodical mean physiological loss in weight of bulb

	Treatment	Monthly physiological loss in weight (%)				Mean
		I	II	III	IV	
T_1	Control (Only N and P_2O_5, no K_2O).	6.16	13.53	17.08	24.71	15.4
T_2	50 kg K_2O ha^{-1} (MOP applied through soil and fertigation)	5.23	12.51	15.61	22.92	14.1
T_3	100 kg K_2O ha^{-1} (MOP applied through soil and fertigation)	4.22	8.14	13.27	18.17	11.0
T_4	150 kg K_2O ha^{-1} (MOP applied through soil and fertigation)	4.08	11.13	15.07	19.77	12.5
T_5	50 kg K_2O ha^{-1} (SOP applied through soil and fertigation)	4.13	8.08	12.26	21.47	11.5
T_6	100 kg K_2O ha^{-1} (SOP applied through soil and fertigation)	3.12	6.21	9.64	16.62	8.9
T_7	150 kg K_2O ha^{-1} (SOP applied through soil and fertigation)	3.81	8.47	11.69	18.03	10.5
T_8	100 kg K_2O ha^{-1} (MOP applied as basal through soil plus SOP applied through foliar sprays)	3.57	6.07	10.51	16.14	9.1
	SE$\pm$	0.46	1.57	0.57	0.94	
	CD at 5 %	1.39	4.75	1.75	2.87	

Economics

The results (Table 6) showed that the application of 100 kg K_2O ha^{-1} (90 kg K_2O ha^{-1} as basal at the time of transplanting through MOP and 10 kg K_2O through two foliar sprays of SOP at 60 and 75 days after transplanting) recorded the highest net returns of Rs. 1,11,100 ha^{-1} over control. The next best treatment was T_3 where 100 kg K_2O ha^{-1} was applied as MOP through soil and fertigation.

Table 6. Effect of sources, levels and methods of potash fertilization on economics of potash fertilizer of *rabi* onion

Treatment	Fresh bulb Yield (t ha^{-1})	Dry matter Yield (t ha^{-1})	Economics of potash fertilizer				
			Cost of fertilizer (Rs ha^{-1})	Cost of fertilizer increase over control (Rs ha^{-1})	Gross monetary returns (Rs ha^{-1})	Gross monetary returnes increase over control (Rs ha^{-1})	Returns/Rupees invested on potash fertilizers
T_1 Control (Only N and P_2O_5, no K_2O).	67.23	2.92	33842	--	672300	--	--
T_2 50 kg K_2O ha^{-1} (MOP applied through soil and fertigation)	72.14	3.26	35245	1403	721400	49100	34.99
T_3 100 kg K_2O ha^{-1} (MOP applied through soil and fertigation)	77.71	3.943	36648	2806	777100	104800	37.34
T_4 150 kg K_2O ha^{-1} (MOP applied through soil and fertigation)	75.40	4.38	38050	4208	754000	81700	19.41
T_5 50 kg K_2O ha^{-1} (SOP applied through soil and fertigation)	72.21	3.32	37842	4000	722100	49800	12.45
T_6 100 kg K_2O ha^{-1} (SOP applied through soil and fertigation)	77.67	4.34	41842	8000	776700	104400	13.05
T_7 150 kg K_2O ha^{-1} (SOP applied through soil and fertigation)	74.97	3.72	45842	12000	749700	77400	6.45
T_8 100 kg K_2O ha^{-1} (MOP applied as basal through soil plus SOP applied through foliar sprays)	78.34	4.89	37167	3325	783400	111100	33.41

Rates:
Urea: 6.4 Rs.kg^{-1}, DAP: 25 Rs. kg^{-1}, MOP: 16.8 Rs. kg^{-1}, SOP: 40 Rs. kg^{-1} and FYM: 1.5 Rs. kg^{-1} and onion bulb Rs. 10 kg^{-1}.

Conclusion

From the present experimental data, it is concluded that, the application 90 kg K_2O ha^{-1} as basal at the time of transplanting through MOP and 10 kg K_2O through two foliar sprays of SOP @ 1% at 60 and 75 days after transplanting was found beneficial for increasing fresh bulb yield, bulb diameter and nutrient uptake.

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