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Influence of different sources, levels and methods of application of potash on growth, yield, nutrient uptake and bulb quality of *Rabi* onion in inceptisol

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Abstract
A field experiment on *rabi* onion (*cv*.N-2-4-1) was carried out at experimental farm of College of Agriculture, Pune during the winter season of 2016-17 with a view to study the effect of different levels and sources of potash (0, 50, 100 and 150 kg K_2O ha^{-1}) and methods of application of potash as a basal (30 % K_2O at the time of transplanting, 40% through fertigation after 30 days of transplanting till initiation of bulb formation and remaining 30% through fertigation after 60 days of transplanting till bulb formation at weekly intervals respectively). In addition to that one more additional treatment of 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 after transplanting for comparison of methods of application of potassium. 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, and higher bulb diameter, the higher nutrient uptake of nitrogen, phosphorus, potassium, sulphur, Fe, Mn, Zn and Cu uptake *rabi* onion. 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. Country produces 12.16 million tonnes of onion from 0.76 million hectares with production of 12.16 million tones and productivity of 16.1 t ha^{-1} (NHB, 2010) [9]. At present, Maharashtra is the largest producer in the country with an output of 12-15 lakh tones production from one lakh hectare area. Maharashtra leads the country accounting for more than 20 per cent of the area and 25 per cent of the production with an average yield of 12 t ha^{-1}.

The potassium nutrition to onion has important role in storage quality specifically the potassium nutrition. 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) [5]. There is vast potential for increasing the production and productivity of onion through balance and judicious use of potassium with N and P. 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 much at lower rate than potash removal resulted into heavy depletion of potassium and a negative balance in soil and plant. Potash requirement for most of crop is increasing due to modern intensive agriculture when cultivators aim at higher and quality produce of crops per unit area and per unit time. The very limited use of organic manures (due to unavailability) 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 positively affect 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 use as well as of the K applied.

Material and Methods

A field experiment was conducted at experimental Farm, College of Agriculture, 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 used in the experiment was an Inceptisol (Vertic Haplustepts) with the chemical properties: pH 8.17, electrical conductivity (EC) 0.13 dS m^{-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}). The soils are clayey in texture (Clay 56.25%).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 was 10.0 cm on raised bed. The treatments namely, T_{1-} i.e. control (only application of N and P_2O_5 but no application of K_2O) for T_2, T_3 and T_4, K_2O applied through muriate of potash (MOP) @ 50, 100 and 150 kg ha^{-1} respectively also for T_5, T_6 and T_7, K_2O 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 to soil, 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 biofertilizers was given to 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 determined plant height (cm) and neck thickness (cm) at 90 DAT and number of leaves per plant at 60 and 90 DAT. Agronomic yield were determined on plot basis and them converted into per hectare basis. Plant samples were dried to a constant weight, then ground and analyzed. Total N was determined using the micro-kjeldahl digestion method with 1:1 H_2SO_4:H_2O_2 (Parkinson and Allen, 1975) [11] followed by ammonia estimation. Total P, K and metallic micronutrients 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) [10]

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) no significant differences due to 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). The increasing bulb diameter was due to the improvement in balance nutrition to onion bulb and could be attributed the mode of action of potassium and sulphate nutrition which might have enhanced the photosynthetic activity and enzymes of carbohydrates transformation. These results are in good accordance with the findings of El-Tohamy *et al*., (2011) [3] in carrot.

Yield: The data presented in 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} (i.e.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 each 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. More or less similar trend was also noticed in dry matter yield. The higher bulb yield might be attributed to the best vigor of plant growth due to potassium element is very important in overall metabolism of plant enzymes activity and it was found to serve a vital role in photosynthesis by direct increasing in growth and total bulb yield. The similar results were also reported by Mansour (2006) [6] and Ali *et al*. (2007) [1] and Pervez *et al*. 2004 [12] who stated that as potash level increases upto optimum levels, the yield and its components increases.

Nutrient uptake

Macronutrients: The application of 100 kg K_2O ha^{-1} (i.e.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) recoded 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}) uptake by *rabi* onion. However in case of potassium and sulphur uptake by *rabi* onion, the said treatment was found significantly superior over rest of the treatment. The lowest N, P, K and S uptake by *rabi* onion was recorded in control treatment (Table 2). The increases in N, P, K and sulphur uptake may be ascribed to the role of potassium and sulphur on increasing photosynthetic activities which account much for high translocation of photo assimilates from leaves to the bulbs. (Behairy *et al*. 2015) [2]

Micronutrients: As regards to micronutrient uptake *viz*., 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 application of T_8 treatment (i.e.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 above said treatment was found significantly superior over rest of the treatments in respect of copper uptake by *rabi* onion. The lower Fe, Mn, Zn and Cu uptake was recorded in control treatment (i.e. only N and P_2O_5, no K_2O) (Table 2). The increased in micronutrients *viz*., Fe, Mn, Zn, and Cu uptake may be due to the role of potassium in plant metabolism and many important regulatory processes in the plant. Moreover potassium and sulphur could be increase mineral uptake by the plants (Marschner, 1995) [7].

Bulb quality

The bulb quality in terms of physiological loss in weight in *rabi* onion was increased significantly with increase in storage

period upto four months (Table 3). The treatment T_6 (i.e.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 (i.e.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 higher mean physiological loss in weight by control treatment (15.4%). The role of potassium in augmenting yield and improving the quality of onion bulb in term of physiological loss in weight (Kale *et al*., 1992) [5].

Economics

Data pertaining to influence of different sources, levels and methods of application of potassium on economics of potash fertilizer of *rabi* onion presented in Table 4. The results 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 highest net returns of Rs. 111100 ha^{-1} over control with higher returns per rupee invested on fertilizers. The next best treatment was 100 kg K_2O ha^{-1} (MOP applied through soil and fertigation i.e.T_3 treatment.

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.

Table 1: Influence of different sources, levels and methods of application of potassium on yield and yield contributing characters of *rabi* onion

Tr. No.	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 applied 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+	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

Table 2: Influence of different sources, levels and method of application of on total macronutrient and micronutrient uptake by *rabi* onion after harvest

Tr. No.	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+	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

Table 3: Effect of different sources, levels and method of application of potassium on periodical mean physiological loss in weight of bulb

Tr. No.	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+	0.46	1.57	0.57	0.94	
	CD at 5 %	1.39	4.75	1.75	2.87	

Table 4: Influence of different sources, levels and methods of application of potassium on economics of potash fertilizer of *rabi* onion

Tr. No.	Treatment	Yield (t ha^{-1})		Economics of potash fertilizer				
		Fresh bulb	Dry matter	Cost of fertilizer (Rs ha^{-1})	Cost of fertilizer increase over control (Rs ha^{-1})	Gross monetary retunes (Rs ha^{-1})	Gross monetary retunes 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}.

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