

Original Research Article

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Potassium Levels, Sources and Time of Application on Nutrient Uptake and Nutrient Use Efficiency of Onion (*Allium cepa* L.)

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ABSTRACT

The present study on potassium levels, sources and time of application on nutrient uptake and nutrient use efficiency of onion var. ArkaKalyan was carried out at the College of Horticulture, Bagalkot, Karnataka during *Kharif* season of 2015 and 2016. The uptake of nitrogen, phosphorus, potassium and zinc recorded significantly in 200 per cent RDK (203.62, 47.33, 236.36 kg ha⁻¹ and 347.19 g ha⁻¹, respectively) over 100 per cent RDK. Among the potassium sources, SOP recorded higher nitrogen and phosphorus, potassium and zinc uptake (171.02 and 40.29, 197.73 kg ha⁻¹ and 264.02 g ha⁻¹ respectively) over MOP. The higher nitrogen, phosphorus, potassium and zinc uptake was recorded significantly in application of 50 per cent potassium at transplanting and 50 per cent at 30 DAT (168.52, 39.74, 195.69 kg ha⁻¹ and 289.76 g ha⁻¹) over 100 per cent potassium at transplanting (157.90, 37.03, 187.23 kg ha⁻¹ and 277.73 g ha⁻¹). Significantly higher nitrogen and phosphorus use efficiency was recorded in 200 per cent RDK (162.90 and 63.10%, respectively) over 100 per cent RDK. The higher potassium use efficiency on the contrary was recorded in 100 per cent RDK (121.18%) over 125, 150, 175 and 200 per cent RDK. Among the potassium sources, SOP recorded higher nitrogen, phosphorus and potassium use efficiency of onion plant (136.82, 53.72 and 107.89%, respectively) over MOP. The higher nitrogen, phosphorus and potassium use efficiency was recorded significantly in application of 50 per cent potassium at transplanting and 50 per cent at 30 DAT (134.82, 52.99 and 106.68%) over 100 per cent potassium at transplanting (126.31, 49.37 and 102.0%).

Keywords

Onion, Nitrogen, Phosphorus, Potassium, Zinc, Uptake and use efficiency

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Introduction

Onion (*Allium cepa* L.) is one of the important commercial bulbous crops cultivated extensively in India and it belongs to the family Alliaceae. It is a most widely grown and popular crop among the *Alliums*. The

primary centre of origin of onion lies in Central Asia (Vavilov, 1951) and the near East and the Mediterranean regions are the secondary centres of origin. It is an ancient crop utilized in medicine, rituals and as a food in Egypt and in India since 600 BC. Onion is mainly used for its flavour and pungency. The

component which is responsible for pungency in onion is an alkaloid "Allyl propyl disulphide".

The onion is a shallow rooted and potash loving crop, hence it requires fairly higher amount of nutrients including potassium must be maintained in the upper layer of the soil. Generally a heavy dose of fertilizer is recommended for onion cultivation (McGillivray, 1961). Like other tuber and root crops, onion is very responsive to potash. Potassium is helpful in many metabolic processes namely production and transport of carbohydrates and sugars, protein synthesis, imparting resistance to pests and diseases, activation of many enzymes, stalk and stem breakage and stress conditions, storage quality, increased bulb size and bulb yield (Pachauri *et al.*, 2005).

Potassium deficiency can bring reduction in production, quality and shelf life of onion. Soils with poor available potassium content usually fail to support satisfactory crop yield (Engels *et al.*, 2012 and Hawkesford *et al.*, 2012). Applying sufficient plant nutrients is needed to sustain the higher production in the face of depleting soil fertility status, continuous cropping and reduced arable land area. Compared with most crops, onion is usually quite susceptible to nutrient deficiency because of their shallow and unbranched root system.

Thus, it requires optimum nutrition which is very well reflected through positive response to the added fertilizers. In addition onions have relatively high demand for soil nutrients, especially N, P and K. This has necessitated the application of inorganic fertilizers for maximum growth and yield. However, inappropriate application of inorganic fertilizers may lead to soil acidity or alkalinity. Best quality onion can be produced through the application of balanced nutrition.

Hence, the present investigation is alarmed with the objectives. To study the effect of different methods of application, sources, potassium levels on nutrient uptake and nutrient use efficiency of onion crop.

Materials and Methods

The present investigation on "Effect of potassium levels, sources and time of application on nutrient uptake and use efficiency of onion var. ArkaKalyan" was carried out at the College of Horticulture, Bagalkot, Karnataka during *Kharif* season of 2015 and 2016. The details of the materials used and the techniques adopted during the investigation are outlined in this chapter. Bagalkot is situated in the Northern Dry Zone (Zone-3) of Karnataka. The centre is located at 75° 42' East longitude and 16° 10' North latitude with an altitude of 542.00 m above Mean Sea Level (MSL). The district is grouped under arid and semi-arid region with mean annual rainfall of 517.3 mm and mean temperature of 32.6°C. The soil of the experimental site was red sandy soil.

Experimental details

Treatments: 20 (5 × 2 × 2)

Design: Factorial R.B.D

Replications: Three

Season: *Kharif*

Variety: ArkaKalyan

Spacing: 15 cm × 10 cm

Plot size: 2.1 m × 2.0 m

Fertilizer dose: 125: 75: 125 kg NPK ha⁻¹

Location: Haveli farm, COH, Bagalkot

Storage period: Three months under ambient condition

$$\text{Nutrient (Zn) uptake (g ha}^{-1}\text{)} = \frac{\text{Nutrient content in plant (ppm)} \times \text{Yield of dry matter (kg)}}{1000}$$

Treatment details

Factor I: Levels of potassium

- 100% RDK + RDNP&FYM (K₁)
- 125% RDK + RDNP&FYM (K₂)
- 150% RDK + RDNP&FYM (K₃)
- 175% RDK + RDNP&FYM (K₄)
- 200% RDK + RDNP&FYM (K₅)

Factor II: Sources of potassium: 1. MOP (S₁), 2. SOP (S₂)

Factor III: Time of application; 1. 100% K at transplanting (T₁), 2. 50% K at transplanting and 50% K at 30 DAT (T₂) Note: Recommended dose of NP @ 125:75 kg and FYM @ 30 t ha⁻¹ was applied commonly to all the treatments and nitrogen was applied 50 % at transplanting and 50 % at 30 days after transplanting.

Total nutrient uptake (kg ha⁻¹)

The plant nutrient (NPK &ZN) uptake was calculated by multiplying dry weight of leaf and bulb (oven dried at 65⁰C for 48 hours) with nutrient content in plant (leaf and bulb). Further total nutrient uptake was calculated by adding nutrient content of leaf and bulb and was expressed in kg ha⁻¹.

$$\text{Nutrient uptake by leaf (kg ha}^{-1}\text{)} = \frac{\text{Dry weight of leaf} \times \text{Nutrient content in leaf}}{100}$$

$$\text{Nutrient uptake by bulb (kg ha}^{-1}\text{)} = \frac{\text{Dry weight of bulb} \times \text{Nutrient content in bulb}}{100}$$

$$\text{Total nutrient uptake by plant (kg ha}^{-1}\text{)} = \text{Nutrient uptake by leaf} + \text{Nutrient uptake by bulb}$$

Nutrient use efficiency (%)

Nutrient (NPK) use efficiency was calculated by using following formula and was expressed in per cent.

$$\text{Nutrient use efficiency (\%)} = \frac{\text{Total nutrient uptake}}{\text{Nutrient applied}} \times 100$$

Results and Discussion

Nitrogen uptake (kg ha⁻¹)

The data obtained on nutrient uptake and nutrient use efficiency by onion plant in 2015, 2016 and pooled data are presented.

Nitrogen uptake by plant differed significantly due to potassium levels during both the years and in pooled (Table 1). In pooled data the higher nitrogen uptake was recorded significantly in 200% RDK (203.62 kg ha⁻¹) over 100%, 125%, 150% and 175% RDK (131.70, 143.30, 159.66 and 177.77 kg ha⁻¹, respectively) and lowest nitrogen uptake was recorded in 100% RDK. Nitrogen uptake varied significantly by potassium sources during both the years as well as in pooled data. Among the potassium sources, SOP recorded higher nitrogen uptake (171.02 kg ha⁻¹) over MOP (155.40 kg ha⁻¹).

Time of potassium application significantly influenced on nitrogen uptake during 2015 and in pooled data except 2016. In pooled data, higher nitrogen uptake was recorded in application of 50% potassium at transplanting and 50% at 30 DAT (168.52 kg ha⁻¹) over 100% potassium at transplanting (157.90 kg ha⁻¹).

The interaction effect of potassium levels, sources and time of potassium application on nitrogen uptake by plant did not differ significantly during both the years and in pooled data.

Phosphorus uptake (kg ha⁻¹)

Phosphorus uptake significantly influenced due to potassium levels during both the years and in pooled (Table 1). In pooled data, higher phosphorus uptake was recorded significantly in 200% RDK (47.33 kg ha⁻¹) over 100%, 125%, 150% and 175% RDK (30.97, 34.13, 38.37 and 41.16 kg ha⁻¹, respectively) and lowest phosphorus uptake was recorded in 100% RDK.

Phosphorus uptake significantly influenced by potassium sources during both the years as well as in pooled data. Among the potassium sources, SOP recorded higher phosphorus uptake (40.29 kg ha⁻¹) over MOP (36.49 kg ha⁻¹).

Time of potassium application significantly influenced on phosphorus uptake during 2015 and in pooled data except 2016.

In pooled data, higher phosphorus uptake was recorded in application of 50% potassium at transplanting and 50% at 30 DAT (39.74 kg ha⁻¹) over 100% potassium at transplanting (37.03 kg ha⁻¹).

The interaction effect of potassium levels, sources and time of potassium application on phosphorus uptake did not differ significantly during 2016 and in pooled data except 2015. The treatment combination of K₅S₂T₂ (200% RDK, SOP with application of 50% potassium at transplanting and 50% at 30 DAT) was recorded significantly higher phosphorus uptake (71.74 kg ha⁻¹) and lowest phosphorus uptake was recorded in K₁S₁T₂ (28.90 kg ha⁻¹) in 2015.

Potassium uptake (kg ha⁻¹)

Potassium uptake by onion plant significantly influenced due to potassium levels during both the years and in pooled (Table 2). In pooled data, higher potassium uptake was recorded significantly in 200% RDK (236.36 kg ha⁻¹) over 100%, 125%, 150% and 175% RDK (151.48, 171.53, 189.17 and 208.77 kg ha⁻¹, respectively) and lowest potassium uptake was recorded in 100% RDK. Potassium uptake varied significantly by potassium sources during both the years as well as in pooled data. Among the potassium sources, SOP recorded higher potassium uptake (197.73 kg ha⁻¹) over MOP (185.20 kg ha⁻¹).

Time of potassium application significantly influenced in potassium uptake during 2015 and in pooled data except 2016. In pooled data, the higher potassium uptake was recorded in application of 50% potassium at transplanting and 50% at 30 DAT (195.69 kg ha⁻¹) over 100% potassium at transplanting (187.23 kg ha⁻¹). The interaction effect of potassium levels, sources and time of potassium application on potassium uptake did not differ significantly during both the years as well as in pooled.

Zinc uptake (g ha⁻¹)

Zinc uptake significantly influenced due to potassium levels during both the years and in pooled (Table 2). In pooled data, the higher zinc uptake was recorded significantly in 200% RDK (347.19 g ha⁻¹) over 100%, 125%, 150% and 175% RDK (230.72, 251.03, 285.56 and 304.23 g ha⁻¹, respectively) and lowest zinc uptake was recorded in 100% RDK. Zinc uptake varied significantly influenced by potassium sources during both the years as well as in pooled data. Among the potassium sources, SOP recorded higher zinc uptake (303.47 g ha⁻¹) over MOP (264.02 g ha⁻¹).

Table.1 Nitrogen and phosphorus uptake (kg ha^{-1}) by onion var. ArkaKalyan as influenced by the soil application of potassium levels, sources and time of application during *kharif* season

Treatment	Nutrient uptake (kg ha^{-1})					
	Nitrogen (kg ha^{-1})			Phosphorus (kg ha^{-1})		
	2015	2016	Pooled	2015	2016	Pooled
Potassium levels (k)						
K ₁ -100 % RDK	118.51	144.89	131.70	37.88	24.06	30.97
K ₂ -125 % RDK	122.24	164.37	143.30	40.10	28.17	34.13
K ₃ -150 % RDK	131.71	187.61	159.66	46.80	29.93	38.37
K ₄ -175 % RDK	142.14	213.41	177.77	46.84	35.47	41.16
K ₅ -200 % RDK	172.07	235.17	203.62	56.08	38.58	47.33
S.Em±	3.99	7.12	4.54	1.90	1.25	1.18
C.D. (p= 0.05)	11.44	20.39	13.00	5.45	3.57	3.39
Potassium sources (S)						
S ₁ - Muriate of potash (MOP)	132.81	177.99	155.40	43.00	29.99	36.49
S ₂ - Sulphate of potash (SOP)	141.85	200.19	171.02	48.08	32.49	40.29
S.Em±	2.53	4.50	2.87	1.20	0.79	0.75
C.D. (p= 0.05)	7.23	12.90	8.22	3.45	2.26	2.14
Time of application (T)						
T ₁ - 100 % K at transplanting	131.30	184.49	157.90	43.27	30.79	37.03
T ₂ - 50 % K at transplanting & 50 % K at 30 DAT	143.36	193.68	168.52	47.81	31.68	39.74
S.Em±	2.53	4.50	2.87	1.20	0.79	0.75
C.D. (p= 0.05)	7.23	NS	8.22	3.45	NS	2.14
Interactions						
K ₁ S ₁ T ₁	100.30	126.72	113.51	31.46	20.23	25.85
K ₁ S ₁ T ₂	95.88	131.94	113.91	28.90	20.93	24.92
K ₁ S ₂ T ₁	113.93	158.63	136.28	34.78	27.88	31.33
K ₁ S ₂ T ₂	163.92	162.25	163.09	56.36	27.18	41.77
K ₂ S ₁ T ₁	129.15	153.74	141.45	41.57	27.85	34.71
K ₂ S ₁ T ₂	125.73	158.45	142.09	40.98	31.76	36.37
K ₂ S ₂ T ₁	103.97	171.78	137.88	35.06	26.64	30.85
K ₂ S ₂ T ₂	130.13	173.49	151.81	42.80	26.42	34.61
K ₃ S ₁ T ₁	141.22	166.75	153.99	51.38	31.64	41.51
K ₃ S ₁ T ₂	135.32	204.99	170.16	43.27	27.87	35.57
K ₃ S ₂ T ₁	128.68	190.90	159.79	49.31	31.14	40.23
K ₃ S ₂ T ₂	121.60	187.81	154.71	43.24	29.08	36.16
K ₄ S ₁ T ₁	124.10	188.63	156.37	41.20	30.78	35.99
K ₄ S ₁ T ₂	144.37	203.52	173.95	47.65	35.32	41.48
K ₄ S ₂ T ₁	141.88	228.09	184.99	50.12	34.77	42.44
K ₄ S ₂ T ₂	158.22	233.38	195.80	48.39	41.02	44.71
K ₅ S ₁ T ₁	163.19	219.49	191.34	48.81	36.98	42.89
K ₅ S ₁ T ₂	168.87	225.64	197.26	54.75	36.52	45.63
K ₅ S ₂ T ₁	166.62	240.18	203.40	49.03	40.06	44.55
K ₅ S ₂ T ₂	189.60	255.36	222.48	71.74	40.74	56.24
S.Em±	7.99	14.24	9.08	3.81	2.49	2.37
C.D. (p= 0.05)	NS	NS	NS	10.91	NS	NS

DAT – Days after transplanting, NS-Non significant.

Note: Recommended dose of N: P at 125:75 kg and farmyard manure 30 t ha⁻¹ was applied commonly to all the treatments and nitrogen was applied 50 % at transplanting and 50 % at 30 DAT.

Table.2 Potassium and zinc uptake (kg ha^{-1}) by onion var. ArkaKalyan as influenced by the soil application of potassium levels, sources and time of application during *kharif* season

Treatment	Nutrient uptake (kg ha^{-1})					
	Potassium (kg ha^{-1})			Zinc (g ha^{-1})		
	2015	2016	Pooled	2015	2016	Pooled
Potassium levels (k)						
K ₁ -100 % RDK	148.78	154.18	151.48	301.67	159.76	230.72
K ₂ -125 % RDK	162.55	180.52	171.53	307.81	194.25	251.03
K ₃ -150 % RDK	185.77	192.58	189.17	345.93	225.18	285.56
K ₄ -175 % RDK	189.12	228.41	208.77	348.23	260.23	304.23
K ₅ -200 % RDK	224.25	248.47	236.36	403.11	291.27	347.19
S.Em±	4.82	5.87	4.43	13.90	10.76	9.26
C.D. (p= 0.05)	13.81	16.80	12.69	39.79	30.80	26.51
Potassium sources (S)						
S ₁ - Muriate of potash (MOP)	176.38	194.02	185.20	317.45	210.59	264.02
S ₂ - Sulphate of potash (SOP)	187.81	207.64	197.73	365.25	241.70	303.47
S.Em±	3.05	3.71	2.80	8.79	6.80	5.86
C.D. (p= 0.05)	8.73	10.62	8.03	25.16	19.48	16.77
Time of application (T)						
T ₁ - 100 % K at transplanting	176.33	198.13	187.23	331.76	223.70	277.73
T ₂ - 50 % K at transplanting & 50 % K at 30 DAT	187.85	203.53	195.69	350.93	228.57	289.76
S.Em±	3.05	3.71	2.80	8.79	6.80	5.86
C.D. (p= 0.05)	8.73	NS	8.03	NS	NS	NS
Interactions						
K ₁ S ₁ T ₁	127.89	141.23	134.56	235.96	136.27	186.12
K ₁ S ₁ T ₂	139.31	156.45	147.88	257.02	141.01	199.01
K ₁ S ₂ T ₁	146.76	162.73	154.74	296.46	193.87	245.16
K ₁ S ₂ T ₂	181.17	156.32	168.75	417.23	167.91	292.57
K ₂ S ₁ T ₁	167.47	172.20	169.84	340.80	183.72	262.26
K ₂ S ₁ T ₂	164.60	172.35	168.48	322.12	182.86	252.49
K ₂ S ₂ T ₁	153.24	188.10	170.67	264.33	202.25	233.29
K ₂ S ₂ T ₂	164.88	189.42	177.15	303.98	208.18	256.08
K ₃ S ₁ T ₁	201.61	204.50	203.06	340.29	204.25	272.27
K ₃ S ₁ T ₂	172.74	182.54	177.64	330.54	244.73	287.63
K ₃ S ₂ T ₁	183.15	187.95	185.55	413.86	242.60	328.23
K ₃ S ₂ T ₂	185.57	195.34	190.45	299.05	209.16	254.10
K ₄ S ₁ T ₁	159.25	196.92	178.09	307.34	236.22	271.78
K ₄ S ₁ T ₂	194.25	245.15	219.70	322.91	219.63	271.27
K ₄ S ₂ T ₁	200.88	225.34	213.11	400.59	283.96	342.27
K ₄ S ₂ T ₂	202.11	246.23	224.17	362.10	301.13	331.61
K ₅ S ₁ T ₁	216.53	239.86	228.20	339.46	261.46	300.46
K ₅ S ₁ T ₂	220.13	229.00	224.57	378.04	295.73	336.88
K ₅ S ₂ T ₁	206.54	262.50	234.52	378.52	292.48	335.50
K ₅ S ₂ T ₂	253.79	262.52	258.15	516.40	315.42	415.91
S.Em±	9.65	11.73	8.87	27.79	21.52	18.52
C.D. (p= 0.05)	NS	NS	NS	79.57	NS	NS

DAT – Days after transplanting, NS-Non significant.

Note: Recommended dose of N: P at 125:75 kg and farmyard manure 30 t ha⁻¹ was applied commonly to all the treatments and nitrogen was applied 50 % at transplanting and 50 % at 30 DAT.

Table.3 Nitrogen, phosphorus and potassium use efficiency (%) of onion var. ArkaKalyan as influenced by the soil application of potassium levels, sources and time of application during *khariif* season

Treatment	Nutrient use efficiency (%)								
	Nitrogen (%)			Phosphorus (%)			Potassium (%)		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Potassium levels (k)									
K ₁ -100 % RDK	94.81	115.91	105.36	50.50	32.08	41.29	119.02	123.35	121.18
K ₂ -125 % RDK	97.79	131.49	114.64	53.47	37.55	45.51	104.03	115.53	109.78
K ₃ -150 % RDK	105.36	150.09	127.73	62.40	39.91	51.15	99.08	102.71	100.89
K ₄ -175 % RDK	113.71	170.73	142.22	62.45	47.30	54.87	86.46	104.42	95.44
K ₅ -200 % RDK	137.66	188.14	162.90	74.77	51.43	63.10	89.70	99.39	94.54
S.Em±	3.20	5.70	3.63	2.54	1.66	1.58	2.55	2.90	2.18
C.D. (p= 0.05)	9.15	16.31	10.40	7.27	4.76	4.52	7.30	8.29	6.25
Potassium sources (S)									
S ₁ - Muriate of potash (MOP)	106.25	142.39	124.32	57.33	39.98	48.66	96.22	105.47	100.85
S ₂ - Sulphate of potash (SOP)	113.48	160.15	136.82	64.11	43.32	53.72	103.09	112.69	107.89
S.Em±	2.02	3.60	2.30	1.61	1.05	1.00	1.61	1.83	1.38
C.D. (p= 0.05)	5.79	10.32	6.58	4.60	3.01	2.86	4.62	5.24	3.95
Time of application (T)									
T ₁ - 100 % K at transplanting	105.04	147.59	126.31	57.69	41.06	49.37	96.40	107.70	102.05
T ₂ - 50 % K at transplanting & 50 % K at 30 DAT	114.69	154.95	134.82	63.74	42.24	52.99	102.91	110.45	106.68
S.Em±	2.02	3.60	2.30	1.61	1.05	1.00	1.61	1.83	1.38
C.D. (p= 0.05)	5.79	NS	6.58	4.60	NS	2.86	4.62	NS	3.95
Interactions									
K ₁ S ₁ T ₁	80.24	101.38	90.81	41.95	26.97	34.46	102.31	112.98	107.65
K ₁ S ₁ T ₂	76.71	105.55	91.13	38.54	27.91	33.22	111.45	125.16	118.30
K ₁ S ₂ T ₁	91.15	126.91	109.03	46.37	37.18	41.77	117.41	130.18	123.79
K ₁ S ₂ T ₂	131.14	129.80	130.47	75.15	36.25	55.70	144.93	125.06	135.00
K ₂ S ₁ T ₁	103.32	123.00	113.16	55.43	37.13	46.28	107.18	110.21	108.70
K ₂ S ₁ T ₂	100.58	126.76	113.67	54.64	42.35	48.50	105.34	110.31	107.82
K ₂ S ₂ T ₁	83.18	137.42	110.30	46.75	35.51	41.13	98.07	120.38	109.23
K ₂ S ₂ T ₂	104.10	138.79	121.45	57.07	35.22	46.14	105.52	121.23	113.38
K ₃ S ₁ T ₁	112.98	133.40	123.19	68.50	42.18	55.34	107.53	109.07	108.30
K ₃ S ₁ T ₂	108.26	163.99	136.13	57.70	37.16	47.43	92.13	97.35	94.74
K ₃ S ₂ T ₁	102.94	152.72	127.83	65.75	41.52	53.63	97.68	100.24	98.96
K ₃ S ₂ T ₂	97.28	150.25	123.76	57.65	38.77	48.21	98.97	104.18	101.57
K ₄ S ₁ T ₁	99.28	150.90	125.09	54.94	41.04	47.99	72.80	90.02	81.41
K ₄ S ₁ T ₂	115.50	162.82	139.16	63.53	47.10	55.31	88.80	112.07	100.43
K ₄ S ₂ T ₁	113.51	182.48	147.99	66.82	46.36	56.59	91.83	103.01	97.42
K ₄ S ₂ T ₂	126.57	186.70	156.64	64.52	54.70	59.61	92.39	112.56	102.48
K ₅ S ₁ T ₁	130.55	175.59	153.07	65.07	49.31	57.19	86.61	95.94	91.28
K ₅ S ₁ T ₂	135.10	180.52	157.81	73.00	48.69	60.84	88.05	91.60	89.83
K ₅ S ₂ T ₁	133.29	192.14	162.72	65.37	53.42	59.39	82.62	105.00	93.81
K ₅ S ₂ T ₂	151.68	204.29	177.98	95.66	54.32	74.99	101.52	105.01	103.26
S.Em±	6.39	11.40	7.27	5.08	3.32	3.16	5.10	5.79	4.37
C.D. (p= 0.05)	NS	NS	NS	14.54	NS	NS	NS	NS	NS

DAT – Days after transplanting, NS-Non significant.

Note: Recommended dose of N: P at 125:75 kg and farmyard manure 30 t ha⁻¹ was applied commonly to all the treatments and nitrogen was applied 50 % at transplanting and 50 % at 30 DAT.

Time of potassium application did not differ significantly in zinc uptake during both the years and in pooled data. In pooled data, higher zinc uptake was recorded in application of 50% potassium at transplanting and 50% at 30 DAT (289.76 g ha⁻¹) over 100% potassium at transplanting (277.73 g ha⁻¹).

The interaction effect of potassium levels, sources and time of potassium application on zinc uptake did not differ significantly during 2016 and in pooled except 2015. The treatment combination of K₅S₂T₂ (200% RDK, SOP with application of 50% potassium at transplanting and 50% at 30 DAT) was recorded significantly higher zinc uptake (516.40 g ha⁻¹) and lowest zinc uptake by onion plant was recorded in K₁S₁T₁ (235.96 g ha⁻¹).

Nitrogen use efficiency (%)

Nitrogen use efficiency of onion plant significantly influenced due to potassium levels during both the years as well as in pooled (Table 3). In pooled data, the higher nitrogen use efficiency was recorded significantly in 200% RDK (162.90%) over 100%, 125%, 150% and 175% RDK (105.36, 114.64, 127.73 and 142.22%, respectively) and minimum nitrogen use efficiency was recorded in 100% RDK.

Nitrogen use efficiency significantly influenced by potassium sources during both the years as well as in pooled data. Among the potassium sources, SOP recorded higher nitrogen use efficiency (136.82%) over MOP (124.32%).

Time of potassium application differ significantly in nitrogen use efficiency during 2015 and in pooled data except 2016. In pooled data, the higher nitrogen use efficiency was recorded significantly in application of

50% potassium at transplanting and 50% at 30 DAT (134.82%) over 100% potassium at transplanting (126.31%).

The interaction effect of potassium levels, sources and time of potassium application on nitrogen use efficiency of onion plant did not differ significantly during both the years and in pooled.

Phosphorus use efficiency (%)

Phosphorus use efficiency significantly influenced due to potassium levels during both the years as well as in pooled (Table 3). In pooled data, the higher phosphorus use efficiency was recorded significantly in 200% RDK (63.10%) over 100%, 125%, 150% and 175% RDK (41.29, 45.51, 51.15 and 54.87%, respectively) and minimum phosphorus use efficiency was recorded in 100% RDK.

Phosphorus use efficiency varied significantly by potassium sources during both the years as well as in pooled data. Among the potassium sources, SOP recorded higher phosphorus use efficiency (53.72%) over MOP (48.66%).

Time of potassium application differ significantly in phosphorus use efficiency during 2015 and in pooled data except 2016. In pooled data, the higher phosphorus use efficiency was recorded significantly in application of 50% potassium at transplanting and 50% at 30 DAT (52.99%) over 100% potassium at transplanting (49.37%).

The interaction effect of potassium levels, sources and time of potassium application on phosphorus use efficiency did not differ significantly during 2016 and in pooled except 2015. The treatment combination of K₅S₂T₂ (200% RDK, SOP with application of 50% potassium at transplanting and 50% at 30 DAT) was recorded significantly higher phosphorus use efficiency of onion plant

(95.66%) and minimum was recorded in $K_1S_1T_2$ (38.54%).

Potassium use efficiency (%)

Potassium use efficiency significantly influenced due to potassium levels during both the years as well as in pooled (Table 3). In pooled data, the higher potassium use efficiency was recorded significantly in 100% RDK (121.18%) over 125%, 150% 175% and 200% RDK (109.78, 100.89, 95.44 and 94.54%, respectively) and minimum potassium use efficiency was recorded in 200% RDK.

Potassium use efficiency significantly influenced by potassium sources during both the years as well as in pooled data. Among the potassium sources, SOP recorded higher phosphorus use efficiency (107.89%) over MOP (100.85%).

Time of potassium application differed significantly in potassium use efficiency during 2015 and in pooled data except 2016. In pooled data, the higher potassium use efficiency was recorded significantly in application of 50% potassium at transplanting and 50% at 30 DAT (106.68%) over 100% potassium at transplanting (102.05 %).

The interaction effect of potassium levels, sources and time of potassium application on potassium use efficiency did not differ significantly during both the years as well as in pooled.

The uptake of NPK and Zn increased with levels of potassium. In general, the increased uptake of nitrogen, phosphorus, potassium and zinc recorded in 200 per cent RDK (203.62, 47.33, 236.36 kg ha⁻¹ and 347.19 g ha⁻¹, respectively) over 100 per cent RDK. This increased uptake of nutrients could be attributed to increased dry matter production

under increased potassium levels. Watson (1963) has attributed such a higher nutritional uptake mainly by greater expansion of root system caused by increased supply of photosynthates. The higher uptake of nutrients with addition of potassium might be attributed to increased vigour of crop growth with enhanced nutrient utilization and translocation into the plant resulting in the enhancement of bulb yield. These results are in conformity with the earlier findings of Hariyappa *et al.*, (2011), Shafeek *et al.*, (2013), Deshpande *et al.*, (2013) and Poornima *et al.*, (2015).

Nitrogen, phosphorus and potassium use efficiency was significantly influenced due to potassium levels. Significantly higher nitrogen and phosphorus use efficiency was recorded in 200 per cent RDK (162.90 and 63.10%, respectively) over 100 per cent RDK. Similarly potassium use efficiency influenced due to potassium levels. The higher potassium use efficiency on the contrary was recorded in 100 per cent RDK (121.18%) over 125, 150, 175 and 200 per cent RDK (109.78, 100.89, 95.44 and 94.54 %, respectively). The nutrient use efficiency of nitrogen and phosphorus increased with increased levels of potassium. However, inverse relationship was observed between potassium use efficiency and its application rate. Increasing levels of potassium there is a imbalance of nutrients mainly inturns nitrogen and phosphorus which resulted in the low use efficiency of potassium applied. In the present study the higher residual potash in the soil with the lower level of available soil phosphorus at 200 per cent RDK clearly indicates the need of balanced nutrient application to enhance the potassium use efficiency. The potassium use efficiency was found decreasing in the 100 per cent-200 per cent of potassium application. The variation in nutrient use efficiency of applied nutrient could be attributed to the combined effect of all the

nutrients on the whole plant system (Assefa *et al.*, 2015). There are many reports of higher nutrient use efficiencies through balanced fertilizer application (Nasreen *et al.*, 2007a). Similar results on nutrient use efficiency of onion are being reported by Anwar *et al.*, (2001) and Majumdar *et al.*, (2003).

Nitrogen, phosphorus, potassium and zinc uptake by plant differed significantly by potassium sources. Among the potassium sources, SOP recorded higher nitrogen and phosphorus, potassium and zinc uptake (171.02 and 40.29, 197.73 kg ha⁻¹ and 264.02 g ha⁻¹ respectively) over MOP. This increased uptake of nutrients due to application of sulphate of potash could be attributed to increased uptake by different plant parts and increased dry matter production under supply of nutrients especially potassium and sulphur. Watson (1963) has attributed such a higher nutritional uptake mainly to greater expansion of root system caused by increased supply of photosynthetic production. The higher uptake of nutrients with addition of potassium might be attributed to increased vigour of crop growth with enhanced nutrient utilization and translocation into the plant resulting in the enhancement of bulb yield as reported by Desuki *et al.*, (2006). These results are in conformity with the earlier findings of Girigowda *et al.*, (2005), Verma and Singh (2012), shafeek *et al.*, (2013) and Deshpande *et al.*, (2013),

Nitrogen, phosphorus and potassium use efficiency was significantly influenced by potassium sources. Among the potassium sources, SOP recorded higher nitrogen, phosphorus and potassium use efficiency of onion plant (136.82, 53.72 and 107.89%, respectively) over MOP (124.32, 48.66 and 100.85%, respectively). In the present investigation among the potassium sources, SOP recorded the higher nutrient use efficiency with respect to nitrogen,

phosphorus and potassium due to application of sulphate of potash as compared to muriate of potash. This may be because of application potassium sources along with nitrogen and phosphorus which are responsible for increasing nutrient uptake by the crop. Uptake of nutrients increased with increasing availability of nutrient and also with nutrient use efficiency. The variation in nutrient use efficiency of applied nutrient could be attributed to the combined effect of all the nutrients on the whole plant system (Assefa *et al.*, 2015). Similar results on nutrient use efficiency of onion are reported by Anwar *et al.*, (2001), Majumdar *et al.*, (2003) and Desuki *et al.*, (2006).

The higher nitrogen, phosphorus, potassium and zinc uptake was recorded in application of 50 per cent potassium at transplanting and 50 per cent at 30 DAT (168.52, 39.74, 195.69 kg ha⁻¹ and 289.76 g ha⁻¹) over 100 per cent potassium at transplanting (157.90, 37.03, 187.23 kg ha⁻¹ and 277.73 g ha⁻¹). Time of potassium application differ significantly in nutrient use efficiency of onion plant. The higher nitrogen, phosphorus and potassium use efficiency was recorded significantly in application of 50 per cent potassium at transplanting and 50 per cent at 30 DAT (134.82, 52.99 and 106.68%) over 100 per cent potassium at transplanting (126.31, 49.37 and 102.0%).

The result indicated that the nutrient uptake and nutrient use efficiency increased with application 50 per cent potassium at transplanting and 50 per cent K at 30 DAT with recommended dose of nitrogen and phosphorus. The higher amount of nutrient in plant leaves and bulb may be due to higher nutrient uptake by onion plant which resulted in vigorous plant growth. If the plants shows more growth then it is inevitable that plant takes more nutrients from the soil. This might be attributed to increased dry matter

production. It is known that potash helps in root development and increases the efficiency of leaf in manufacturing sugars and starch. Though split application, potash is likely to be utilized by the crop more efficiently. Significantly improvement in nutrient uptake and use efficiency by onion plant due to split application of potash. These findings are in agreement with the results of Singh and Verma (2001) and Islam *et al.*, (2008).

The interaction effect of potassium levels, sources and time of potassium application on nitrogen, phosphorus, potassium and zinc uptake. The treatment combination of K₅S₂T₂ (200% RDK, SOP with application of 50 per cent potassium at transplanting and 50 per cent at 30 DAT) was recorded higher nitrogen, phosphorus, potassium and zinc uptake by onion plant (222.48, 71.74, 258.15 kg ha⁻¹ and 516.40 g ha⁻¹). The interaction effect of potassium levels, sources and time of potassium application on nitrogen and phosphorus use efficiency. The treatment combination of K₅S₂T₂ (200% RDK, SOP with application of 50 per cent potassium at transplanting and 50 per cent at 30 DAT) was recorded maximum nitrogen use efficiency (177.98, 95.66%). The treatment combination of K₁S₂T₂ (100 per cent RDK, SOP with application of 50 per cent potassium at transplanting and 50 per cent at 30 DAT) was recorded higher potassium use efficiency (135.00%). Increased nutrient uptake was also observed due to the interaction effects of potassium levels, sources and time of application. The increased nutrient uptake could be attributed to increased dry matter production under supply of potassium levels, sources especially potassium and sulphur present in sulphate of potash and split application of potash with nitrogen during the crop growth period. The higher nutrient uptake might be attributed to increased vigour of crop growth with enhanced nutrient utilization and translocation into the plant

resulting in the higher yield ultimately increased the nutrient use efficiency by the crop. These results are in conformity with the finding of Desuki *et al.*, (2006) and El-Bassiony (2006).

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