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Research Article

Effect of Nitrogen, Potassium and Sulphur Fertilization on Nutrient Uptake and Bulb Yield of Onion (*Allium cepa* L.) in Arid Western Rajasthan

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ABSTRACT

Present field experiment was conducted at the Instructional Farm, College of Agriculture, S.K. Rajasthan Agricultural University, Bikaner, during Rabi season in two consecutive years (2016-17 and 2017-18) to find out the effect of nitrogen, potassium and sulphur fertilization on nutrient uptake and yield of onion in arid western Rajasthan. The treatments laid out in a split plot design replicated thrice. The results of the study have clearly showed that methods and application levels of nitrogen, potassium and sulphur significantly increased N, P, K and S uptake and bulb yield. Similarly, result revolted that the nitrogen fertilization of @ 80 kg N ha^{-1} (soil application) + 20 kg N ha^{-1} (4 foliar sprays), recorded highest bulb yield (227.62 q ha^{-1}), which were closely followed by N_2 (210.45 q ha^{-1}) which was significantly higher over control.

Keywords: *Nitrogen, Potassium, Sulphur, Bulb yield, Nutrient uptake, Onion*

INTRODUCTION

Onion (*Allium cepa* L.) is the most important commercial bulbous crops cultivated extensively in India and widely used as vegetables in our country. It belongs to family Alliaceae. The chief component of pungency in onion is “allyl propyl disulphide’’. India is the second largest producer of onion in the world and occupies 1293 thousand hectare area with a production of 23610 thousand MT (Anonymous, 2018). Maharashtra is leading state in area and production whereas, productivity is highest in Gujrat. Area under onion in Rajasthan state is 65.54 thousand hectare with production of 1142.47 thousand MT and productivity is 17.39 kg ha^{-1} (Anonymous, 2016).

Nitrogen, phosphorus and potassium are often referred to as the primary macronutrients because of the probability of plants being deficient in these nutrients and because of the large quantities taken up by plants from the soil relative to other essential nutrients (Marschner, 1995 and Malvi et al., 2019).

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Nitrogen comprises 7% of total dry matter of plants and is a constituent of many fundamental cell components (Bungard, 1999). It is one of the most complexes in behavior, occurring in soil, air and water in organic and inorganic forms. For this reason, it poses the most difficult problem in making fertilizer recommendations (Archer, 2002). Plant demand for N can be satisfied from a combination of soil and fertilizer to ensure optimum growth. Potassium is a major plant nutrient, which is needed by the plants in large amount and is supplied by the fertilizer. It is available to the plants in the form of cation (K^+). Actually potassium is essential for a variety of process i.e. photosynthesis, fruit formation, winter hardiness and disease resistance. It stiffens straw and thus reduces lodging, and plays an important role in protein formation especially in grain filling (El-Tohamy et al., 2011). It was reported by many researchers that they increased the plant growth, nutrient uptake and plant yield as well as quality (Karakurt et al., 2009). Sulphur is an essential plant nutrient and plays a vital role in biosynthesis of certain amino acids (Cysteine, cystine and methionine) and also helps in the synthesis of co-enzyme-A and formation of chlorophyll and nitrogenizes enzyme. Sulphur is reported from two natural growth regulators *viz.*, thiamine and biotin. Sulphur occurs in glutathione that is important to oxidation reduction reaction. Sulphur has been recognized as an important nutrient for higher yield and quality of onion bulbs. Sulphur is essential for building up sulphur containing amino acids and also for a good vegetative growth and bulb development in onion. The largest changing trends in agricultural, yield target concept and fertilizer recommendation for maximum profit per hectare become more promising. Yield target concept has the added advantage in which target can be fixed by taking into consideration the resources available. Therefore, it is essential to find out the best and optimum level of sulphur for soil application and its effect on yield and quality of onion. (Gondane et al., 2018).

METHODS AND MATERIALS

The present investigation was carried out at Instructional Farm, College of Agriculture, S.K. Rajasthan Agricultural University, Bikaner, during *Rabi* season for consecutive two years (2016-17 and 2017-18) to find out the effect of nitrogen, potassium and sulphur fertilization on nutrient uptake and yield of onion in arid western Rajasthan. The treatments consisting of four nitrogen fertilization {N_1-control, N_2-100 kg N ha^{-1} soil application, N_3-80 kg N ha^{-1} (soil application) + 20 kg N ha^{-1} (4 foliar sprays), N_4-60 kg N ha^{-1} (soil application) + 20 kg N ha^{-1} (4 foliar sprays)}, four potassium fertilization {K_1-control, K_2-100 kg K ha^{-1} soil application, K_3-80 kg K ha^{-1} (soil application) + 20 kg K ha^{-1} (4 foliar sprays), K_4-60 kg K ha^{-1} (soil application) + 20 kg K ha^{-1} (4 foliar sprays)} and sulphur levels (S_1-control, S_2-40 kg ha^{-1} soil application). The Geographically, is climate of this zone is typically arid characterized by acridity of the atmosphere and salinity in the rhizosphere with extreme temperature both in summer and winters and their transitions are characterized with abrupt fall and rise in temperature. The annual average rainfall of this region is about 200-300 mm which is mostly received from the south-west monsoon during the period of July to September. The composite soil sample was also analyzed to determine the mechanical composition, physico-chemical properties and organic carbon contents of the soil for estimation of available N, P and K in soil samples.

RESULTS AND DISCUSSION

Plant analysis (Nutrient uptake)

Nitrogen, potassium and sulphur fertilization had a significant effect on nutrient status of onion (Table 1). Nitrogen fertilization at N_3 @ 80 kg N ha^{-1} (soil application) + 20 kg N ha^{-1} (4 foliar sprays) significantly increased nitrogen, phosphorus, potassium and sulphur uptake by bulb of onion and total uptake compared to N_1, N_2 and N_4 treatment. Significantly highest N uptake (44.85 kg ha^{-1}), P uptake (29.28 kg ha^{-1}), K uptake (50.61 kg

ha^{-1}) and S uptake (18.85 kg ha^{-1}) by bulb was recorded at N_3 {80 kg N ha^{-1} (soil application) + 20 kg N ha^{-1} (4 foliar sprays)} followed by N_2 @ 100 kg K ha^{-1} (soil application) and N_4 @ 60 kg N ha^{-1} (soil application) + 20 kg N ha^{-1} (4 foliar sprays). There was significant increase in N, P, K and S uptake by onion bulb with increasing fertilization of N along with adequate amount of P_20_5, K_20 and S irrespective of growth stages. The results confirm the findings of Singh et al. (1996) in onion. There was increase in N uptake with the sulphur application of to 40 kg ha^{-1}.

Potassium application at K_3 fertilization @ 80 kg K ha^{-1} (soil application) + 20 kg K ha^{-1} (4 foliar sprays) significantly increased nitrogen, phosphorus potassium and sulphur uptake by bulb of onion and total uptake compared to K_1, K_2 and K_4 treatment. Significantly highest N, P, K, and S uptake by bulb (40.70, 24.62, 50.58 and 17.72 kg ha^{-1}) was recorded K_3 @ 80 kg K ha^{-1} (soil application) + 20 kg K ha^{-1} (4 foliar sprays) followed by 100 kg K ha^{-1} soil application) and K_4 @ 60 kg N ha^{-1} (soil application) + 20 kg N ha^{-1} (4 foliar sprays)), while minimum was recorded under K_1 (24.18, 15.63, 23.74 and 11.31 kg ha^{-1} N,P,K,S). The significant increase in N, P, K and S uptake by the onion bulb was recorded at increasing levels of K along with adequate amount of P_20_5, K_20 and S irrespective of growth stages. This might have been possible due to synergistic effect of sulphur and potassium in augmenting uptake of all nutrients. The better crop vigour and growth due to enhanced nutrient utilization and translocation of photosynthesis from source to sink i.e. bulb yield of garlic might be possible reason for increased uptake of nutrients as reported by Verma and Singh (2012) in onion.

Sulphur @ 40 kg S ha^{-1} (soil application) was recorded an uptake of 36.74, 22.73, 44.43 and 17.81 kg ha^{-1} for nitrogen, phosphorus, potassium and sulphur, respectively and were found significantly superior to the values recorded with S_1 (control). As application of sulphur might have improved the nutritional environment in the rhizosphere as well as in plant system and consequently increased the availability of nutrients in the root zone coupled with increased metabolic activity at cellular level probably enhanced the nutrient uptake by plants and their translocation specially N, P, K and S to reproductive structures which ultimately increased the concentration of these nutrients in different plant parts. That sulphur application (45 kg ha^{-1}) recorded an uptake of 94.44, 23.89, 78.65 and 32.54 kg ha^{-1} for nitrogen, phosphorus, potassium and sulphur were found significantly superior the values recorded with rest of the levels (Chattoo, et al., 2019).

Interaction effect (N x K): Combined effect of different nitrogen and potassium fertilization significantly influenced the N uptake by bulb (Table 2). Pooled mean showed that the treatment combination N_3 {80 kg N ha^{-1} (soil application) + 20 kg N ha^{-1} (4 foliar sprays)} with K_3 {80 kg K ha^{-1} (soil application) + 20 kg K ha^{-1} (4 foliar sprays)} resulted significantly higher N uptake by bulb (65.30 kg ha^{-1}) whereas; minimum (15.72 kg ha^{-1}) was observed in control. Further, data indicated that at same application of potassium of 100 K kg ha^{-1} (soil application) along with 80 N kg ha^{-1} (soil application) + 20 kg (4 foliar sprays) recorded highest N uptake by bulb (42.16 kg ha^{-1}), which was at par with 60 N kg ha^{-1} (soil application) + 20 kg (4 foliar sprays) on pooled basis and remained significant to other treatment combination.

Yield

Onion bulb yield significantly increased with increasing nitrogen fertilization up to 80 kg N ha^{-1} (soil application) + 20 kg N ha^{-1} (4 foliar sprays) (Table 3). The maximum bulb yield were obtained using higher level of nitrogen fertilizer. These finding were completely true in both seasons (2016-17 and 2017-18) as well as pooled analysis, Application of nitrogen fertilization N_3 @ 80 kg N ha^{-1} (soil application) + 20 kg N ha^{-1} (4 foliar sprays) resulted in heavier significant bulb yield (224.77 and 230.48 q ha^{-1}, respectively) as compared to the control. This might be due to application of nitrogen fertilizer improved in turns of the vegetative growth and accelerated the photosynthesis and detected in storage organs i.e. bulbs and increased allocation to the bulbs resulting in an increased diameter and weight of the bulb. These resulted are in agreement with Yadav et al. (2003) who found that N at 150 kg ha^{-1} enhanced the formation of bulbs with larger diameters.

Application of potassium i.e. 80 kg K ha^{-1} (soil application) + 20 kg K ha^{-1} (4 foliar sprays) significantly increased the total bulb yield (218.21 q ha^{-1}) as compared to other potassium levels (K_2 and K_4) as well as control. Balanced application of macro and secondary nutrient application gave significant higher marketable yield and yield attributing characters The improvement in yield may be due to higher uptake of nitrogen, phosphorus, potassium and sulphur by the onion crop resulting higher chlorophyll, increased enzymatic and protein synthesis, proper root proliferation, and enhancing the translocation of assimilates. The above research findings are close in conformity with the earlier findings given by Yadav et al. (2015) and Uikey et al. (2015).

Application of different doses of sulphur increased the yield ha^{-1}. The application of 40 S kg ha^{-1} (soil application) enhanced yield (208.61 q ha^{-1}) significantly as compared to no application of sulphur (control). The application of sulphur in treatment helped to cure deficiency of low initial available sulphur in experimental soil. Sulphur being an integral constituent of certain amino acids of which N is also essential constituent, might have helped in increasing net assimilation rate of nitrogen and other nutrients. Thus, it might have resulted in increased yield (Yawalkar et al., 2008). These results are in agreement with findings of Sharma (2014) and Assefa et al. (2015).

Table 1: Effect of nitrogen, potassium and sulphur on N, P, K and S uptake of onion (Nasik Red)

Treatments	N uptake (kg ha^{-1})			P uptake (kg ha^{-1})			K uptake (kg ha^{-1})			S uptake (kg ha^{-1})		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
Nitrogen fertilization												
N_1	18.50	19.74	19.12	11.45	12.40	11.92	27.49	29.44	28.46	10.09	10.81	10.45
N_2	36.40	38.54	37.47	21.28	22.76	22.02	43.21	45.97	44.59	16.35	17.04	16.70
N_3	43.63	46.06	44.85	28.35	30.22	29.28	49.09	52.13	50.61	18.32	19.38	18.85
N_4	34.82	36.82	35.82	20.96	22.47	21.71	40.79	43.14	41.97	15.56	16.47	16.01
SEm±	0.54	0.58	0.39	0.36	0.37	0.26	0.78	0.78	0.55	0.27	0.30	0.20
CD at 5 %	1.85	2.00	1.21	1.26	1.27	0.80	2.68	2.71	1.70	0.92	1.03	0.62
Potassium fertilization												
K_1	23.43	24.93	24.18	15.07	16.20	15.63	22.93	24.55	23.74	10.94	11.68	11.31
K_2	35.29	37.22	36.25	22.04	23.59	22.82	45.12	47.97	46.54	16.17	16.96	16.56
K_3	39.57	41.83	40.70	23.77	25.46	24.62	49.08	52.08	50.58	17.19	18.25	17.72
K_4	35.05	37.19	36.12	21.14	22.59	21.87	43.44	46.09	44.76	16.02	16.81	16.41
SEm±	0.49	0.52	0.36	0.27	0.32	0.21	0.52	0.55	0.38	0.21	0.23	0.16
CD at 5 %	1.39	1.47	1.00	0.77	0.92	0.59	1.48	1.55	1.06	0.60	0.65	0.44
Sulphur levels												
S_1	30.92	32.87	31.89	19.02	20.47	19.74	37.22	39.55	38.39	12.76	13.64	13.20
S_2	35.76	37.72	36.74	21.99	23.46	22.73	43.07	45.79	44.43	17.40	18.22	17.81
SEm±	0.35	0.37	0.25	0.19	0.23	0.15	0.37	0.39	0.27	0.15	0.16	0.11
CD at 5 %	0.98	1.04	0.71	0.54	0.65	0.42	1.05	1.10	0.75	0.42	0.46	0.31

Table 2: Interaction effect of different nitrogen and potassium levels on N uptake by bulb

Treatments	2016-17			
Nitrogen fertilization (Kg ha^{-1})	Potassium fertilization (Kg ha^{-1})			
	K_1	K_2	K_3	K_4
N_1	16.46	28.15	15.20	33.90
N_2	23.01	36.62	41.06	40.48
N_3	18.98	44.53	63.57	31.21
N_4	15.56	36.31	54.67	33.67
SEm±	0.72			
**CD(P=0.05)	2.48			
	2017-18			
Nitrogen fertilization (Kg ha^{-1})	Potassium fertilization (Kg ha^{-1})			
	K_1	K_2	K_3	K_4
N_1	17.72	29.86	16.23	35.93
N_2	24.39	38.65	43.26	42.56
N_3	20.22	47.04	67.03	33.03
N_4	16.65	38.62	57.74	35.75
SEm±	0.74			
**CD(P=0.05)	2.55			
	Pooled			
Nitrogen fertilization (Kg ha^{-1})	Potassium fertilization (Kg ha^{-1})			
	K_1	K_2	K_3	K_4
N_1	17.09	23.70	19.60	16.11
N_2	29.01	37.63	45.78	37.46
N_3	15.72	42.16	65.30	56.20
N_4	34.92	41.52	32.12	34.71
SEm±	0.52			
**CD(P=0.05)	1.61			

Table 3: Effect of nitrogen, potassium and sulphur on bulb yield of onion (Nasik Red)

Treatments	Bulb Yield (q ha^{-1})		
	2016-17	2017-18	Pooled
Nitrogen fertilization			
N_1	135.38	138.78	137.08
N_2	209.21	211.70	210.45
N_3	224.77	230.48	227.62
N_4	205.26	207.78	206.52
SEm±	2.44	2.61	1.79
CD at 5 %	8.46	9.03	5.51
Potassium fertilization			
K_1	149.80	153.14	151.47
K_2	206.20	209.87	208.04
K_3	216.29	220.12	218.21
K_4	202.32	205.60	203.96
SEm±	2.24	2.28	1.60
CD at 5 %	6.35	6.47	4.48
Sulphur levels			
S_1	180.47	183.98	182.23
S_2	206.84	210.38	208.61
SEm±	1.58	1.62	1.13
CD at 5 %	4.49	4.58	3.17

CONCLUSIONS

On the basis of results emerging out from the present investigation, It can be concluded that application of 80 kg nitrogen ha^{-1} (soil application) + 20 kg (4 foliar sprays), 80 kg potassium ha^{-1} (soil application) + 20 kg (4 foliar sprays) and 40 kg sulphur ha^{-1} were significantly superior for higher nutrient uptake and yield of onion.

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