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Response of Okra (*Abelmoschus esculentus* L.) to Various Levels of Nitrogen and Potassium at Different Crop Growth Stages

B. Naveen Kumar*, G. Padmaja and P. Chandrasekhar Rao

Department of Soil Science and Agricultural Chemistry, College of Agriculture,
Professor Jayashankar Telangana State Agricultural University, Hyderabad

*Corresponding Author E-mail: naveenb.agri999@gmail.com

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ABSTRACT

A field experiment was conducted during kharif season of 2011 on a sandy loam soil (Alfisol) at Student's Farm, College of Agriculture, Rajendranagar, Hyderabad with a view to study the effect of levels of nitrogen (0, 60, 120 and 180 kg N ha^{-1}) and potassium (0, 30, 60 and 90 kg K_2O ha^{-1}) on dry matter accumulation and uptake of nutrients by okra at different stages of crop growth. Randomized Block Design (RBD) with factorial concept was followed. The results of the experiment revealed that with increase in successive levels of nitrogen upto 180 kg ha^{-1} and potassium upto 90 kg ha^{-1} there was significant increase in dry matter production of okra at all the stages of crop growth viz., 30, 60 and 90 DAS. However, the dry matter production was higher with combined application of 180 kg N ha^{-1} along with 90 kg K_2O ha^{-1} at 30 (1243.9 kg ha^{-1}), 60 (2274.4 kg ha^{-1}) and 90 DAS (3467.4 kg ha^{-1}) than with nitrogen and potassium alone. Similar results were obtained with regard to per cent nutrient content viz., N, P and K and nutrient uptake by okra. The nutrient content and uptake of N, P and K by okra plants at all the growth stages viz., 30, 60 and 90 DAS were highest with N_3K_3 combination and the total (plant + pod) N and K uptake values at harvest was found to be 83.83 and 75.19 kg ha^{-1}, respectively and it was also observed that dry matter production and nutrient uptake increased with increase in age of the crop. From the results it was evident that higher levels of N and K had met the requirement of okra crop at different growth stages.

Key words: *Nitrogen, Potassium, Dry matter, Nutrient content, Nutrient uptake, Okra.*

INTRODUCTION

Okra is one of the most important vegetable crops grown throughout the year which is having rich diet value, medicinal and industrial importance. In India, *Okra* is cultivated in 0.50 million hectares producing 5.70 million tonnes with a productivity of 11.3 t ha^{-1} [4]. In general crop responds well to N and K application. Okra production depends on many factors, among them judicious application of N and K plays a vital role.

Nitrogen is the first limiting nutrient in okra production that greatly influences crop growth and pod yield.

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The Indian soils are generally deficient in organic matter thus unable to release N at a rate required to maintain adequate N supply to the growing plant. Nitrogen is an essential constituent of various metabolically active compounds like amino acids, proteins, nucleic acids, pyrimidines, flavines, purines, nucleoproteins, enzymes, alkaloids etc[6]. Therefore, application of nitrogen in the form of fertilizers becomes indispensable to meet the N needs of the crop. Potassium is another important plant nutrient that plays a vital role in enzyme activation, water regulations, translocaton of assimilates, photosynthesis and protein synthesis. It counteracts harmful effects of excess nitrogen in plants. The response of crop to potassium increases significantly in the presence of nitrogen[11].

Hence, keeping in view the significance of N and K on productivity of okra, an experiment was conducted to study the effect of levels of nitrogen and potassium on dry matter production and nutrient uptake at different growth stages of okra grown on an Alfisol.

MATERIALS AND METHODS

A field experiment was conducted on a sandy loam soil (*Alfisol*) at Student's Farm, College of Agriculture, Rajendranagar, Hyderabad during *kharif* season 2011. The experiment was laid out in Randomized Block Design (RBD) with factorial concept consisting of sixteen treatment combinations with four levels each of nitrogen (N_0-0, N_1-60, N_2-120 and N_3-180 kg ha^{-1}) and potassium (K_0-0, K_1-30, K_2-60 and K_3-90 kg ha^{-1}). Nitrogen and potassium were applied in the form of urea and muriate of potash in 3 splits as per treatment combinations. A basal dose of 60 kg P_2O_5 ha^{-1} was applied in the form of single super phosphate to all the treatment plots. The experimental soil is sandy loam in texture, slightly alkaline (pH 7.8) in reaction, non saline (0.23 dS m^{-1}), low in organic carbon (0.48 per cent) and available nitrogen (226.8 kg N ha^{-1}), medium in available phosphorus (38.63 kg P_2O_5 ha^{-1}) and potassium (278.5 kg K_2O ha^{-1}). Plant samples collected at 30, 60 and 90 DAS and pod samples collected at harvest (90 DAS) were oven dried at 65^0 C and the dried samples were powdered and analyzed for per cent N, P and K contents by adopting the standard procedures[8]. Dry matter production (kg ha^{-1}) was also recorded to compute nutrient uptake and at different growth stages by using formula:

$$\text{Nutrient uptake (kg ha}^{-1}) = \frac{\text{Nutrient content (\%) x Dry matter production (kg ha}^{-1})}{100}$$

RESULTS AND DISCUSSION

The effects of different treatments were evaluated in terms of dry matter production, per cent nutrient content and uptake at 30, 60 and 90 days after sowing.

Dry Matter Production

The effect of different levels of nitrogen, potassium and their interactions found to have significant effect on dry matter production of okra plants at all the growth stages (Table 1). In general, dry matter production increased with increase in age of the crop. Among the nitrogen levels, N_3 (180 kg ha^{-1}) has recorded significantly highest plant dry matter production viz., 1125.7, 2086.1 and 3281.9 kg ha^{-1} at 30, 60 and 90 DAS, respectively and the lowest value was recorded at N_0 level. The per cent increase being 114.95, 136.89 and 95.95 over N_0 at 30, 60 and 90 DAS, respectively. Similarly, application of potassium @ 90 kg ha^{-1} (K_3) has recorded highest plant dry matter production at 30 (966.0 kg ha^{-1}), 60 (1660.0 kg ha^{-1}) and at 90 DAS (2716.3 kg ha^{-1}) and the extent of increase was 41.13, 33.77 and 24.97

per cent over control at 30, 60 and 90 DAS, respectively. With regard to interaction effects, N_3K_3 has recorded significantly highest plant dry matter production at 30 DAS (1243.9 kg ha^{-1}), 60 DAS (2274.4 kg ha^{-1}) and at 90 DAS (3467.4 kg ha^{-1}) while the lowest value was recorded at N_0K_0 at all the stages of crop growth period. However at 30 DAS, N_3K_3 (1243.9 kg ha^{-1}) was on par with N_3K_2 (1232.9 kg ha^{-1}) and significantly superior over other interaction effects. Dry matter production of pod was also significantly influenced by different levels of nitrogen, potassium and their interactions (Table 1). The results revealed that with increase in levels of N application, significantly highest pod dry matter production of 1600.5 kg ha^{-1} was recorded at 180 kg N ha^{-1} (N_3) at harvest (90 DAS) and the extent of increase was 49.08 per cent over control (N_0). Among the potassium levels, K_3 (90 kg K_2O ha^{-1}) has recorded significantly highest pod dry matter yield of 1518.0 kg ha^{-1} at 90 DAS followed by K_2, K_1 and K_0, the per cent increase being 27.34 over control (K_0). The interaction effects of N x K also influenced the pod dry matter production significantly, recording the highest dry matter production of 1685.5 kg ha^{-1} at N_3K_3, while the lowest was recorded with control (N_0K_0). Nitrogen being a constituent of chlorophyll resulted in increased photosynthesis which ultimately accelerated the growth[2]. Similar increase in dry matter production of okra with increasing levels of nitrogen and potassium were reported by Paramasivan *et al.*[7] and Rani and Jose[9]. Also split application of N and K in light textured soils improves the use efficiency through minimizing the leaching losses and efficient utilization by the crop[13].

Nutrient Content

The nitrogen and potassium content in plant decreased as the age of the plant increased. Nitrogen and potassium contents were significantly influenced by levels of nitrogen, potassium and their interactions at all the stages of crop growth. Among the different nitrogen levels, the highest N content was recorded at N_3, which was significantly superior over lower levels at 30, 60 and at 90 DAS (table 2). The values ranged from 2.00 to 2.81, 1.61 to 2.23 and 1.05 to 1.47 per cent at 30, 60 and at 90 DAS, respectively. Similarly, N_3 (180 kg N ha^{-1}) recorded highest K content (2.09, 1.59 and 1.37 per cent) at 30, 60 and at 90 DAS which was significantly superior over other levels of N (Table 3). With regard to levels of potassium, application of 90 kg K_2O ha^{-1} (K_3) recorded highest plant N content at 90 DAS (1.31 per cent) but was on par with K_2 and significantly superior over K_1 and K_0 (table 2). However, at 30 and 60 DAS it was found to be non significant. With respect to potassium content, K_3 recorded significantly highest K content followed by K_2, K_1 and K_0 at 60 and 90 DAS. The contents ranged from 1.70 to 2.07, 1.36 to 1.56 and 1.18 to 1.37 per cent at 30, 60 and 90 DAS, respectively (Table 3). Interaction effects revealed that the treatment N_3K_3 recorded significantly highest plant K content of 2.33 %, 1.67% and 1.41 per cent at 30, 60 and 90 DAS respectively. However, at 90 DAS, N_3K_3 (1.41 per cent) was on par with N_3K_2 (1.40 per cent). But the nutrient interaction did not show any significant effect on N content of okra plants at 30, 60 and at 90 DAS.

The nitrogen and potassium content in okra pods increased significantly with increase in levels of nitrogen from N_0 to N_3 and potassium from K_0 to K_3 (table 2 and 3). Among the interaction effects, N_3K_3 recorded higher N and K content of 1.88 % and 1.56 %, respectively and were significantly higher over rest of the treatments. However, N_2K_3 and N_2K_2 were on par with each other for nitrogen content and N_3K_3 and N_3K_2 were on par with each other for potassium content. Higher dose of basal nitrogen applied, efficient root absorption and vigorous vegetative growth during initial stages especially during the first month, might be responsible for greater nitrogen content at 30 DAS. As the plant entered reproductive phase in the subsequent months (pod formation), there was translocation of nitrogen and potassium from plants to pods there by decreasing the nitrogen content in plants[10]. Potassium concentration at 60 and 90 DAS also followed the similar trend as that of N due to active vegetative growth and consequent dilution effect[3]. Similar results were also reported by Padmaja and Sreenivasa Raju[5] in brinjal crop. Combined application of nitrogen and potassium had synergistic effect on nutrient content.

Nutrient uptake

In general, with increase in age of the crop there was an increase in nitrogen and potassium uptake by okra plants (Table 4 and 5). Among the nitrogen levels, application of nitrogen @ 180 kg ha^{-1} (N_3) recorded highest N uptake (viz., 31.73, 46.61 and 48.19 kg ha^{-1} at 30, 60, and 90 DAS, respectively) and the highest K uptake (viz., 15.44 kg ha^{-1}, 33.26 kg ha^{-1} 44.95 kg ha^{-1} at 30, 60, and 90 DAS, respectively). These values were significantly superior over other levels of N application. Among the potassium levels, application of potassium @ 90 kg ha^{-1} (K_3) has recorded highest N uptake at 30 (23.86 kg ha^{-1}), 60 (32.59 kg ha^{-1}) and 90 DAS (36.54 kg ha^{-1}) (Table 4). Similarly, highest K uptake of 13.27, 26.29 and 37.31 kg ha^{-1} was recorded at 30, 60 and 90 DAS, respectively with K_3 (Table 5) and these values were found to be significantly superior over K_2, K_1 and K_0. The interaction effects revealed that the K uptake at N_3K_3 was significantly superior over other treatment combinations at 60 and 90 DAS, however at 30 DAS N_3K_3 and N_3K_2 were on par with each other and lowest values being recorded under control (N_0K_0). But the Interaction of nitrogen and potassium did not show any significant effect on N uptake.

The okra pods were also analyzed for their N and K uptake at harvest (90 DAS) and presented in table 4 & 5, respectively. Among the nitrogen levels, application of nitrogen @ 180 kg ha^{-1} (N_3) recorded significantly highest N uptake (28.61 kg ha^{-1}) and K uptake (24.10 kg ha^{-1}) by pods followed by N_2, N_1 and N_0. Among the potassium levels, K_3 recorded highest N and K uptake of 25.13 kg ha^{-1} and 22.81 kg ha^{-1}, respectively and were significantly superior over all other K levels. The N and K uptake by pods of okra were also influenced by interaction effect of N_3K_3 and recorded significantly highest values of 31.69 kg ha^{-1} and 26.29 kg ha^{-1}, respectively and the lowest values were recorded under control (N_0K_0). Okra is also heavy feeder of nutrients and requires nitrogen and potassium for vegetative growth, flowering and pod formation. With increase in the levels of nitrogen and potassium there was significant increase in total N and K uptake. Similar results were also reported by Balle Gowda *et al*.[1] and Sharma *et al*.[12]. The indeterminate growth of the plants also increased fresh weight and in turn the dry matter production leading to increase in total nutrient uptake to meet the metabolic activities of the plant.

It can be concluded that combined application of nitrogen @ 180 kg ha^{-1} + potassium @ 90 kg ha^{-1} (N_3K_3) contributed to higher drymatter production, nutrient content and further uptake at different growth stages of okra crop grown on light textured red sandy loam soils (alfisols) of Telangana state.

Table 1: Effect of levels of nitrogen, potassium and their interactions on dry matter production (kg ha^{-1}) of okra at 30, 60 and 90 DAS

Levels	30 DAS					60 DAS					Plant (90 DAS)					Pod (90 DAS)				
	K_0	K_1	K_2	K_3	**Mean**	K_0	K_1	K_2	K_3	**Mean**	K_0	K_1	K_2	K_3	**Mean**	K_0	K_1	K_2	K_3	**Mean**
N_0	404.1	487.7	521.2	681.8	**523.7**	706.9	808.3	904.7	1102.5	**880.6**	1438.1	1572.3	1711.5	1977.7	**1674.9**	884.2	972.4	1174.1	1263.6	**1073.6**
N_1	631.2	648.3	796.8	896.3	**743.1**	1000.8	1195.8	1299.6	1463.5	**1239.9**	1846.8	2106.4	2235.4	2502.9	**2172.8**	1108.5	1347.3	1406.9	1508.8	**1342.8**
N_2	798.0	805.6	975.5	1042.1	**905.3**	1358.3	1579.9	1706.2	1799.5	**1611.0**	2356.8	2629.6	2771.7	2917.2	**2668.8**	1313.3	1446.2	1534.5	1614.3	**1477.1**
N_3	904.6	1121.3	1232.9	1243.9	**1125.7**	1897.8	2022.7	2149.7	2274.4	**2086.1**	3052.4	3256.6	3351.4	3467.4	**3281.9**	1462.5	1584.1	1670.2	1685.5	**1600.5**
Mean	**684.5**	**765.7**	**881.6**	**966.0**		**1240.9**	**1401.7**	**1515.0**	**1660.0**		**2173.5**	**2391.2**	**2517.5**	**2716.3**		**1192.1**	**1337.5**	**1446.4**	**1518.0**	

	30 DAS S.Ed±	30 DAS CD (0.05)	60 DAS S.Ed±	60 DAS CD (0.05)	Plant (90 DAS) S.Ed±	Plant (90 DAS) CD (0.05)	Pod (90 DAS) S.Ed±	Pod (90 DAS) CD (0.05)
N	23.64	48.28	14.94	30.52	21.30	43.49	13.04	26.63
K	23.64	48.28	14.94	30.52	21.30	43.49	13.04	26.63
N×K	47.27	96.57	29.88	61.04	42.60	86.99	26.07	53.26

Table 2: Effect of levels of nitrogen, potassium and their interactions on nitrogen content (%) of okra at 30, 60 and 90 DAS

Levels	**30 DAS**					**60 DAS**					**Plant (90 DAS)**					**Pod (90 DAS)**				
	K_0	K_1	K_2	K_3	**Mean**	K_0	K_1	K_2	K_3	**Mean**	K_0	K_1	K_2	K_3	**Mean**	K_0	K_1	K_2	K_3	**Mean**
N_0	1.95	1.98	2.02	2.04	**2.00**	1.58	1.61	1.62	1.64	**1.61**	0.98	1.02	1.14	1.07	**1.05**	1.26	1.32	1.38	1.42	**1.35**
N_1	2.15	2.17	2.20	2.23	**2.19**	1.69	1.71	1.74	1.78	**1.73**	1.15	1.20	1.25	1.29	**1.22**	1.45	1.48	1.52	1.54	**1.50**
N_2	2.45	2.53	2.45	2.48	**2.48**	1.87	1.90	1.92	1.94	**1.91**	1.28	1.34	1.37	1.39	**1.35**	1.64	1.68	1.71	1.71	**1.69**
N_3	2.76	2.79	2.83	2.87	**2.81**	2.20	2.22	2.25	2.26	**2.23**	1.43	1.45	1.48	1.50	**1.47**	1.72	1.75	1.79	1.88	**1.79**
Mean	**2.33**	**2.37**	**2.38**	**2.40**		**1.84**	**1.86**	**1.88**	**1.90**		**1.21**	**1.25**	**1.31**	**1.31**		**1.52**	**1.56**	**1.60**	**1.64**	
	S.Ed±			CD (0.05)		S.Ed±			CD (0.05)		S.Ed±			CD (0.05)		S.Ed±			CD (0.05)	
N	0.03			0.05		0.02			0.05		0.02			0.04		0.007			0.015	
K	0.03			N.S.		0.02			N.S.		0.02			0.04		0.007			0.015	
N×K	0.05			N.S.		0.05			N.S.		0.04			N.S.		0.014			0.029	

Table 3: Effect of levels of nitrogen, potassium and their interactions on potassium content (%) of okra at 30, 60 and 90 DAS

Levels	**30 DAS**					**60 DAS**					**Plant (90 DAS)**					**Pod (90 DAS)**				
	K_0	K_1	K_2	K_3	**Mean**	K_0	K_1	K_2	K_3	**Mean**	K_0	K_1	K_2	K_3	**Mean**	K_0	K_1	K_2	K_3	**Mean**
N_0	1.64	1.75	1.77	1.80	**1.74**	1.21	1.31	1.41	1.43	**1.34**	1.02	1.12	1.19	1.29	**1.16**	1.13	1.24	1.32	1.42	**1.28**
N_1	1.71	1.81	1.88	1.97	**1.84**	1.35	1.40	1.45	1.51	**1.43**	1.16	1.17	1.26	1.37	**1.24**	1.29	1.30	1.38	1.49	**1.37**
N_2	1.67	1.86	2.15	2.18	**1.96**	1.39	1.45	1.53	1.63	**1.50**	1.24	1.29	1.32	1.39	**1.31**	1.37	1.41	1.44	1.52	**1.44**
N_3	1.76	1.97	2.31	2.33	**2.09**	1.50	1.57	1.62	1.67	**1.59**	1.31	1.35	1.40	1.41	**1.37**	1.42	1.49	1.54	1.56	**1.50**
Mean	**1.70**	**1.85**	**2.03**	**2.07**		**1.36**	**1.43**	**1.50**	**1.56**		**1.18**	**1.23**	**1.29**	**1.37**		**1.30**	**1.36**	**1.42**	**1.50**	

	30 DAS S.Ed±	30 DAS CD (0.05)	60 DAS S.Ed±	60 DAS CD (0.05)	Plant S.Ed±	Plant CD (0.05)	Pod S.Ed±	Pod CD (0.05)
N	0.02	0.04	0.01	0.02	0.01	0.03	0.008	0.018
K	0.02	0.04	0.01	0.02	0.01	0.03	0.008	0.018
N×K	0.04	0.08	0.02	0.04	0.02	0.05	0.017	0.035

Table 4: Effect of levels of nitrogen, potassium and their interactions on nitrogen uptake (kg ha^{-1}) by okra at 30, 60 and 90 DAS

Levels	30 DAS					60 DAS					Plant (90 DAS)					Pod (90 DAS)				
	K_0	K_1	K_2	K_3	**Mean**	K_0	K_1	K_2	K_3	**Mean**	K_0	K_1	K_2	K_3	**Mean**	K_0	K_1	K_2	K_3	**Mean**
N_0	7.90	9.64	10.55	13.94	**10.51**	11.20	13.00	14.65	18.08	**14.23**	14.08	16.04	19.51	21.17	**17.70**	11.14	12.84	16.20	17.94	**14.53**
N_1	13.60	14.07	17.54	19.97	**16.30**	16.91	20.45	22.61	25.99	**21.49**	21.24	25.26	27.93	32.28	**26.68**	16.07	19.94	21.38	23.24	**20.16**
N_2	19.58	20.41	23.90	25.83	**22.43**	25.39	30.01	32.77	34.89	**30.77**	30.17	35.24	37.98	40.55	**35.99**	21.54	24.30	26.24	27.65	**24.93**
N_3	24.96	31.30	34.97	35.70	**31.73**	41.76	44.92	48.36	51.39	**46.61**	43.64	47.22	49.74	52.14	**48.19**	25.16	27.72	29.89	31.69	**28.61**
Mean	**16.51**	**18.86**	**21.74**	**23.86**		**23.82**	**27.09**	**29.60**	**32.59**		**27.28**	**30.94**	**33.79**	**36.54**		**18.48**	**21.20**	**23.43**	**25.13**	

	30 DAS S.Ed±	30 DAS CD (0.05)	60 DAS S.Ed±	60 DAS CD (0.05)	Plant (90 DAS) S.Ed±	Plant (90 DAS) CD (0.05)	Pod (90 DAS) S.Ed±	Pod (90 DAS) CD (0.05)
N	0.73	1.48	0.44	0.90	0.61	1.25	0.21	0.43
K	0.73	1.48	0.44	0.90	0.61	1.25	0.21	0.43
N×K	1.45	N.S.	0.88	N.S.	1.22	N.S.	0.42	0.86

Table 5: Effect of levels of nitrogen, potassium and their interactions on potassium uptake (kg ha^{-1}) by okra at 30, 60 and 90 DAS

Levels	30 DAS					60 DAS					Plant (90 DAS)					Pod (90 DAS)				
	K_0	K_1	K_2	K_3	**Mean**	K_0	K_1	K_2	K_3	**Mean**	K_0	K_1	K_2	K_3	**Mean**	K_0	K_1	K_2	K_3	**Mean**
N_0	4.13	5.46	6.21	8.79	**6.15**	8.55	10.58	12.75	15.77	**11.91**	14.66	17.61	20.37	25.50	**19.54**	9.99	12.05	15.49	17.94	**13.87**
N_1	7.32	7.59	10.03	12.28	**9.30**	13.50	16.74	18.85	22.10	**17.80**	21.42	24.65	28.17	34.29	**27.13**	14.30	17.51	19.41	22.48	**18.43**
N_2	9.89	10.41	12.88	14.46	**11.91**	18.88	22.91	26.11	29.32	**24.30**	29.23	33.91	36.58	40.54	**35.07**	17.99	20.39	22.10	24.54	**21.26**
N_3	11.85	15.14	17.24	17.54	**15.44**	28.47	31.76	34.83	37.99	**33.26**	39.99	43.96	46.93	48.90	**44.95**	20.76	23.61	25.72	26.29	**24.10**
Mean	**8.30**	**9.65**	**11.59**	**13.27**		**17.35**	**20.50**	**23.13**	**26.29**		**26.33**	**30.03**	**33.01**	**37.31**		**15.76**	**18.39**	**20.68**	**22.81**	

	30 DAS S.Ed±	30 DAS CD (0.05)	60 DAS S.Ed±	60 DAS CD (0.05)	Plant (90 DAS) S.Ed±	Plant (90 DAS) CD (0.05)	Pod (90 DAS) S.Ed±	Pod (90 DAS) CD (0.05)
N	0.30	0.62	0.27	0.55	0.43	0.89	0.20	0.42
K	0.30	0.62	0.29	0.55	0.43	0.89	0.20	0.42
N×K	0.61	1.24	0.54	1.11	0.87	1.77	0.41	0.84

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