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Effect of Graded Levels of Nitrogen and Potassium on Growth, Nutrient Content and Uptake of Sweet Potato (*Ipomoea batatas*. L.) in Vertisols of Maharashtra

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Authors' contributions

This work was carried out in collaboration between all authors. Author MP carried out the entire research work and wrote the paper. Authors PHV and BHS performed as a chairman and advisory committee member. Author PBA helped to carried out research work. All authors read and approved the final manuscript.

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ABSTRACT

An investigation was carried out to assess nutrient content and uptake of sweet potato under application of nitrogen and potassium. Sweet potato is an important tuber crop which requires an efficient cropping management to ensure adequate nutrient content and uptake for growth and development of the crop. The experiment was conducted with four levels of nitrogen (0, 75, 100 and 125 kg/ha) and three levels of potassium (0, 75 and 100 kg/ha) in a factorial randomized complete block design with three replications and twelve treatments. The field Experiment was conducted in *kharif* season during the year 2015-2016 on fine texture Vertisols. Data was recorded on length of main vine, length of subsidiary vine, leaf area index and nutrient content and uptake. The results indicated clearly that main vine and subsidiary vine length, leaf area index and

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concentration of nutrients in leaf, stem and tubers of sweet potato were significantly higher at 125 kg of nitrogen from urea + 100 kg potassium ha^{-1} from muriate of potash treatment. In general, higher nitrogen, phosphorus and potassium content in tuber were found as compared to stem and leaf. The higher N, P, K and S content and uptake were recorded by application of 125 kg N and 100 kg K ha^{-1} in block soils of Marathwad region of Maharashtra.

Keywords: Nitrogen; potassium; leaf area index; nutrient content; nutrient uptake; sweet potato.

1. INTRODUCTION

Knowledge of growth patterns like leaf area index and nutrient uptake of sweet potato is very important for understanding the optimum fertilizer requirements for producing high yield and quality tubers. Sweet potato is an important starchy crop in the country. Among the different practices, fertilization plays a significant role in enhancing the growth and uptake of nutrients in tubers. Inefficient nutrient management results in reduction in tuber quality, yield, and environmental degradation [1]. Nutrient supply plays a major role in growth and development of plants as well as yield. Among fertilizers, nitrogen is the second most important nutrient after potassium. Nitrogen is essential for maintaining higher vine growth, increased bulking rate, quality of tuber and more dry matter production [2]. Also nitrogen is an essential constituent of protein and chlorophyll. Moreover, is an important factor in determining the yield and nutrient composition of root tubers, especially sweet potato [3]. On the other hand, potassium is an essential nutrient element required by all living organisms including plant and animals. It is found in large concentrations in the plant cell sap. Potassium is not incorporated into structure of organic compounds but remains in ionic (K^+) form in the solution in the cell and is mobile in plant. It is responsible for translocation of carbohydrates and increased resistance to withstand drought and frost stresses. Potassium expedites the transport of carbohydrates from the leaves to the tubers. Higher shoot: tuber ratios [4] were found for plants treated with KCl. The chloride functions as an osmotic ion as well as essential plant nutrient. Both K & N fertilization can influence tuber yield and quality.

Nitrogen and potassium play an important role in growth, yield and quality of tuber crops and also improve the fertility status of soil. Marathwada region soils are considered to be low in organic matter and available nitrogen but rich in mineral potassium. No scientific information are available on application of N and K fertilizers to the sweet potato in Marathwada region. Therefore in order to work out nitrogen and potassium requirement for sweet potato and to increase the importance of sweet potato in Marathwada region. The main objective of this study was to investigate the effect of graded levels of nitrogen and potassium on growth and their uptake by sweet potato in the Marathwada region of Maharashtra.

2. MATERIALS AND METHODS

The field experiment was conducted at the College of Agriculture Latur farm during the *kharif* season 2015-2016.The experiment was laid out in a factorial randomized complete block design with three replications and 12 treatments. Factors included nitrogen fertilizer levels (0, 75, 100, 125 kg/ha); potassium fertilizer levels (0, 75, 100 kg/ha) and 3 different combinations of Nitrogen and Potassium. A plot size of 3 x 2 m^2 with inter and intra row spacing of 60 cm and 20 cm respectively was used. A local variety of sweet potato was used for this study. Application of fertilizer at time of planting, full dose of potassium and recommended dose of phosphorous (60 P_2O_5 kg/ ha) was given and half dose of nitrogen was applied at the time of planting and the remaining was applied at 30 days after planting. The initial soil sample was taken before planting, neutral to alkaline pH (7.95) by using potentiometer method 1 : 2 soil water suspension on digital pH meter, low organic carbon content (3.8 g/kg) analyzed by using Walkely and Black method [5] (wet oxidation method) and available nutrients like low nitrogen (275.98 kg/ha) by Alkaline potassium permanganate method, low available phosphorous (15.75 kg/ha) by 0.5 M sodium bicarbonate as an extractent and read absorbance in spectrophotometer and high in available potassium (559.58 kg/ha) by using neutral normal ammonium acetate in flame photometer and low available sulphur (12.30 mg/kg) in spectrophotometer method and also exchangeable Calcium (20.10 meq/100 g) and Mg (10.18 meq/100 g) by using Ammonium acetate extraction method. Growth parameters like length of subsidiary vine and length of main vine was measured using scales and leaf area index was recorded by using leaf area meter and calculated based on ground area basis at 60 and 120 days after planting and plant samples were collected for nutrient analysis at the time of harvesting (3/2/2016) of sweet potato. Nutrient viz., nitrogen in different parts of plant samples analyzed by digestion, distillation and titration method and di- acid mixture (HNO_3 and $HCLO_4$ and 9:4) used for analysis of different parts of plant digestion for phosphorous, potassium and sulphur analysis.

2.1 Statistical Analysis

Data obtained was statistically analyzed as per the methods given in "Statistical methods for agriculture workers" by Panse and Sukhatme [6] by using Analysis of variance (ANOVA) and the level of significance on F test was treated as 5 % and results have been discussed based on critical difference at P= 0.05, wherever the treatment differences were found non-significant it is denotes as NS.

3. RESULTS AND DISCUSSION

3.1 Growth Attributes

Length of main vine, subsidiary vine and leaf area index of sweet potato (Table 1) increased significantly ($p< 0.05$) due to application of N at 125 kg ha^{-1} along with 100 kg K ha^{-1} statistically at par with 100 kg N ha^{-1} and 75 kg K ha^{-1}. Significant increase in vine length, number of leaves and leaf area index of sweet potato in the early and middle growth stages were observed with increased application of nitrogen and potassium fertilizers.

The significant increase in length of main and subsidiary vine increased significantly with increasing rate of application of nitrogen fertilizer. This could be due to the role of nitrogen in plant growth, stimulating and the meristematic activity which contributes to the increases vegetative growth, Similar result was observed by Knavel [7] and Nand Puri et al. [8]. Also there was significant increase leaf area index with application of nitrogen and potassium fertilizes. This is possibly due to the effect of nitrogen fertilizer in the vegetative growth of plants thereby increasing the number of leaves and leaf area under the different levels of nitrogen application. Similar findings were Ismail and Abu [9] in potato crop. Sandhu et al. [10] inferred that the sufficient use of nitrogen fertilizer in the beginning growth stage caused the extension of leaf surface which increased the photosynthetic capacity of leaves. Similar findings were reported by Bourke [11] and Mojtaba et al. [12] in sweet potato and potato, respectively.

Table 1. Length of subsidiary vines, main vines and leaf area index as influenced by nitrogen and potassium fertilizers at Maharashtra, 2015/2016

Treatments	Length of subsidiary vines (cm)		Length of main vines (cm)		Leaf area index (LAI)	
	60 DAP	120 DAP	60 DAP	120 DAP	60 DAP	120 DAP
Nitrogen Levels (kg N ha^{-1})						
N_0: 0	19.64	46.19	67.43	123.23	0.50	1.34
N_1: 75	22.82	51.18	74.91	132.05	0.88	1.83
N_2: 100	26.29	58.18	77.71	150.58	0.96	2.09
N_3: 125	29.57	63.18	82.63	157.92	1.03	2.14
SE (m) ±	0.79	1.28	1.85	2.92	0.033	0.071
CD at 5%	2.31	3.76	5.44	8.56	0.096	0.207
Potassium Levels (kg K_2O ha^{-1})						
K_0: 0	21.32	53.28	71.16	137.75	0.72	1.53
K_1: 75	24.85	53.81	76.90	138.56	0.86	1.87
K_2 : 100	27.58	56.96	78.96	146.52	0.94	1.90
SE (m) ±	0.68	1.11	1.61	2.53	0.028	0.061
CD at 5%	2.00	3.26	4.71	7.42	0.083	0.18
Interaction (N x K)						
SE (m) ±	1.36	2.22	3.21	5.06	0.056	0.12
CD at 5%	NS	NS	NS	NS	NS	NS

DAP- Days after planting, NS- Non significant, CD – Critical difference at 5%, SE(m) - Standard error mean

Potassium plays a crucial role in maintenance of tissue water relation and aids in photosynthesis and enhances protein synthesis resulting in better foliage growth in sweet potato crop [13]. Trehan et al. [14] observed that potassium increased crop vigour, leaf expansion particularly at early growth stage and extended leaf area duration. Leaf area index increased significantly in the early and middle growth stages and it declined in the late growth stages. This could be due to potassium fertilizer in the late growth stage reduces the translocation of dry matter from functional leaves to storage part of the plant as reported by Hongjuan Liu et al. [15] and Bourke [11]. Application of potassium at highest rate, influences the growth of vine. In the present study, length of vine (main and subsidiary vine) showed positive significant effect with increasing potassium level these result conforms with findings reported Abd El-Baky et al. [4] and Uwah et al. (2013).

3.2 Nitrogen, Phosphorus and Potassium Contents in Different Parts of Plants

Among the different levels of nitrogen and potassium, the application of 125 kg ha^{-1} of nitrogen and 100 kg ha^{-1} of potassium recorded significantly at $P<0.05$ higher nitrogen, phosphorus and potassium concentration in leaves, stems and tubers. Among the different parts of sweet potato plants, the tubers showed higher concentration of nutrients than leaves and stems due to high rate of fertilizers which increased the concentration of nutrients in different parts and also more accumulation of photosynthates and sugars in tubers and more translocation from sources to sink. Similar results were found by Roghayyeh et al. [16] and Ukom et al. [3]. Lower accumulation of nutrient content was observed in 0 kg ha^{-1} N and 0 kg ha^{-1} K treatments compared to the others. Nitrogen content of tuber was significantly influenced by N at 150 kg/ ha reported by Mehran and Samod [17] in different parts of sugar beet. Phosphorous content in tubers was affected by nitrogenous fertilizers, the highest percentage of tuber phosphorous was observed at 100 kg N ha^{-1} was reported by Mojtaba et al. [12]. In case of potassium the similar results were found by Abdel and Zanouny [18] and Abd El-Baky et al. [4] reported that in sweet potato increase in the concentration of K in leaves in response to the high rate of potassium this may be due to the high mobility of K nutrient in the plant.

3.3 Nitrogen, Phosphorus and Potassium Uptake in Leafs, Stems and Tubers

The uptake of nutrients by sweet potato stem, leaf and tuber and total uptake (stem+ leaf + tuber) were affected significantly by the application of nitrogen and potassium at 125 kg ha^{-1} + 100 kg ha^{-1} respectively. Application of nitrogen at 125 kg ha^{-1} and potassium at 100 kg ha^{-1} recorded significantly ($P<0.05$) higher N, P and K total uptake in tubers followed by leaves and stems as compared to the other treatments. Among stem and leaves, the leaves show the higher uptake of nutrients than stem due to higher translocation of nutrients from root to leaves, stem acts as mediator between that and also increases higher application of fertilize increased the uptake as well as total uptake of nutrients in plants. Lower uptakes of nutrients were observed in application of nutrient 0 kg N ha^{-1} + 0 kg K ha^{-1}. There were no interaction effects between applications of both nutrient fertilizers.

The nitrogen, phosphorus and potassium uptake in sweet potato increased with increasing levels of nitrogen and potassium fertilizers. This might be due to increased growth and development of the plants Luxurious uptake of nutrients by the plants and led to increased concentration of nutrients in different parts of plant. The production of aerial parts like higher number of leaves, stems and tubers consequently increases the dry matter production which ultimately increase the uptake of nutrients in sweet potato. These results agree with Roghayyeh et al. [16] Haase & Schuler [19] and Singh and Lal [13] in potato. Abd et al. [20] reported higher nutrient content at higher levels of fertilizer application together with higher dry matter production.

Increase in the availability of nutrients from soil, the nutrient uptake by tubers, stem and leaves were found closely linked with productivity and their concentration in plant by Shaheen et al. [21]. The differential release pattern of non-exchangeable K from the soil reserve, besides variation in K uptake by the crop could be responsible for such differences in the available K status of the soil by Svotwa and Jiyane [22]. Potassium uptake recorded highest in stem leaves and tuber due to increases in fertilizer doses [20]. Increase with increasing fertilizer dose was recorded highest stem, leaves and tuber uptake K in potato plants by Sandhu et al. [10].

Table 2. Nitrogen, phosphorus and potassium content in leaves, stems and tubers of sweet potato as influenced by nitrogen and potassium fertilizers application at Maharashtra, 2015/2016

Treatments	N content in leaf (%)	N content in stem (%)	N content in tuber (%)	P content in leaf (%)	P content in stem (%)	P content in tuber (%)	K content in leaf (%)	K content in stem (%)	K content in tuber (%)
Nitrogen Levels (kg N ha^{-1})									
N_0: 0	1.037	0.666	1.077	0.19	0.13	0.29	1.04	0.18	1.31
N_1: 75	1.175	0.822	1.184	0.23	0.14	0.33	1.15	0.21	1.40
N_2: 100	1.297	1.036	1.351	0.27	0.15	0.37	1.34	0.26	1.56
N_3: 125	1.446	1.191	1.595	0.28	0.18	0.39	1.37	0.27	1.62
SE (m) ±	0.031	0.021	0.036	0.005	0.005	0.005	0.020	0.003	0.020
CD at 5%	0.092	0.063	0.105	0.014	0.013	0.014	0.059	0.010	0.060
Potassium Levels (kg K_2O ha^{-1})									
K_0: 0	1.15	0.88	1.23	0.23	0.14	0.33	1.16	0.22	1.43
K_1: 75	1.26	0.91	1.28	0.24	0.15	0.34	1.23	0.23	1.48
K_2 : 100	1.31	1.00	1.40	0.25	0.16	0.35	1.27	0.25	1.52
SE (m) ±	0.027	0.019	0.031	0.004	0.004	0.004	0.018	0.003	0.018
CD at 5%	0.080	0.054	0.091	0.12	0.012	0.012	0.052	0.009	0.053
Interaction (Nx K)									
SE±	0.054	0.037	0.062	0.008	0.008	0.008	0.035	0.006	0.035
CD (5%)	NS	NS	NS	NS	NS	NS	NS	NS	NS

DAP- Days after planting, NS- Non significant, CD – Critical difference at 5%, SE(m) – Standard error mean

Table 3a. Nitrogen, phosphorous and potassium uptake in leaves, stems, tubers and their total of sweet potato as influenced by nitrogen and potassium fertilizers application at Maharashtra, 2015/2016

Treatments	Uptake of N in leaf (kg ha^{-1})	Uptake of N in stem (kg ha^{-1})	N uptake in tuber (kg ha^{-1})	Total uptake of N (kg ha^{-1})	Uptake of P in leaf (kg ha^{-1})	Uptake of P in stem (kg ha^{-1})	Uptake of P in tuber (kg ha^{-1})	Total P uptake (kg ha^{-1})
Nitrogen Levels (kg N ha^{-1})								
N_0: 0	39.24	36.76	51.41	127.41	6.69	5.95	7.69	19.78
N_1: 75	46.31	45.39	77.34	169.05	8.46	7.36	9.46	25.29
N_2: 100	46.99	48.16	86.02	181.19	11.13	10.03	12.13	33.29
N_3: 125	51.19	50.29	95.60	197.09	11.87	10.78	12.87	35.52
SE (m) ±	1.25	0.70	3.67	4.29	0.19	0.18	0.19	0.55
CD at 5%	3.67	2.05	10.76	12.61	0.55	0.53	0.55	1.62
Potassium Levels (kg K_2O ha^{-1})								
K_0: 0	43.84	39.08	69.98	152.90	8.77	7.68	9.76	26.22
K_1: 75	45.99	45.10	72.74	163.82	9.40	8.30	10.40	28.11
K_2 : 100	47.98	51.59	90.07	189.34	10.44	9.34	11.44	31.23
SE (m) ±	1.08	0.601	3.17	3.72	0.16	0.15	0.16	0.478
CD at 5%	3.17	1.78	9.32	10.92	0.48	0.46	0.47	1.402
Interaction (NxK)								
SE±	2.16	1.21	0.35	7.44	0.33	0.3	0.33	0.96
CD @ 5%	NS	NS	NS	NS	NS	NS	NS	NS

DAP- Days after planting, NS- Non significant, CD – Critical difference at 5%, SE (m) - Standard error mean

Table 3b. Potassium uptake in leaves, stems, tubers and their total of sweet potato as influenced by nitrogen and potassium fertilizer application at Maharashtra 2015/2016

Treatments	Uptake of K in leaf (kg ha^{-1})	Uptake of K in stem (kg ha^{-1})	Uptake of K in Tuber (kg ha^{-1})	Total uptake of K (kg ha^{-1})
Nitrogen Levels (kg N ha^{-1})				
N_0: 0	52.15	26.08	69.54	147.77
N_1: 75	62.56	31.39	83.71	177.65
N_2: 100	78.79	39.39	105.06	233.25
N_3: 125	83.22	41.61	110.95	235.78
SE (m) ±	1.11	0.55	1.49	3.16
CD at 5%	3.26	1.65	4.38	9.28
Potassium Levels (kg K_2O ha^{-1})				
K_0: 0	64.54	32.31	86.16	182.93
K_1: 75	68.42	34.21	91.23	193.85
K_2 : 100	74.67	37.33	99.56	211.56
SE (m) ±	0.96	0.49	1.295	2.74
CD at 5%	2.83	1.43	3.79	8.04
Interaction (NxK)				
SE±	1.93	0.97	2.59	5.48
CD (5%)	NS	NS	NS	NS

DAP- Days after planting, NS- Non significant, CD – Critical difference at 5%, SE(m) - Standard error mean

4. CONCLUSION

From the result and discussion of this study, it can be concluded that the growth parameters of vine length and leaf area index and N, P and K content as well as their uptake by sweet potato were improved with the application of 125 Kg ha^{-1} nitrogen and 100 kg ha^{-1} of potassium. From the above however concluded that the application of nitrogen 125 kg ha^{-1} and potassium 100 kg K_2O ha^{-1} improves the growth, nutrient content and uptake of sweet potato in soils of Marathwada region of Maharashtra.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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