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Effect of Different Levels of Nitrogen and Potassium on Growth, Yield and Quality of Sweet Potato [*Ipomoea batatas* (L.) Lam.] cv. NFSP-1

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A field investigation was conducted at College of Agriculture, CAU, Imphal, Manipur, India during session 2019-20. Nitrogen and potassium are limiting factors when it comes to influence on growth, yield and quality of sweet potato cultivation. The study consisted of 16 treatment combinations with 4 levels of N (0, 35, 50 and 65 kg/ha of N respectively) and 4 levels of K (0, 35, 50, 65 kg/ha of K respectively) with 3 replications in FRBD on variety NFSP-1. The findings of the experiment are as follows. Pertaining to growth and yield, highest level of N i.e., 65 kg/ha (N_3) and highest level of K i.e., 65 kg/ha (K_3) gave highest values. N_3 and K_3 also gave better values for quality characters like DM, TSS, starch, sugar, crude protein, ash and NPK content of tubers. N x K interactions did not show any significant differences between the treatments for the aforementioned characters. A combination of 65 kg/ha of N and 50 kg/ha of K (N_3 x K_2) gave highest B: C ratio of 3.33.

Introduction

Sweet potato [*Ipomoea batatas* (L.) Lam.] is an important tuber crop grown mostly in tropical and subtropical regions of Asia, the tropical Americas, the Pacific Islands and Papua New Guinea. India and China are the leading sweet potato growing countries in the world. It is one of the world's highest yielding crops with reference to total food production and requires low inputs. It can be grown throughout year where even marginal farmers can get some income. Sweet potato originated from the northern part of South America and southern region of Central America. It was grown in Peru in ancient times as evident from the excavation of caves. It was domesticated in Tropical America and Polynesia. *Ipomoeatriloba* and *Ipomoea trifida* are two closest relatives of sweet potato.

Sweet potato [*Ipomoea batatas* (L.) Lam.] belongs to the Convolvulaceae family. It is a natural hexaploid (2n=6x=90) with chromosome irregularities are common leading to infertility. It is a morning glory family, the basic chromosome number of which is x=15 in *Ipomoea* species and there are also diploids (2n=2x=30) and tetraploids (2n=4x=60). Characters of sweet potato are mostly quantitative in nature with high heritability for several traits.

The total global area and production of sweet potato are 8.06million hectares and 91.94 million tonnes respectively as of 2018. Asia is the largest producer of sweet potato, about 66.03 percent of world production and 36.68 percent of the area in the world. Area of production under sweet potato in India as of 2018-19 was 0.116million hectares with a production of 1.21million tonnes with a productivity of 10.40Mt ha^{-1}. Largest sweet potato cultivating state in India is Odisha with a total production of 0.381 million tonnes.

Assam has highest production of sweet potato among North Eastern states of India with a production of 29.20 thousand metric tonnes. Area and production of sweet potato in Manipur as of 2017-18 was 0.001 thousand hectares and 750.9 quintals respectively with a productivity of 7.509 qha^{-1}. It is an important staple food in the state especially in hilly areas. Sweet potato is one of the main tuber crops grown for improving livelihoods, increasing food security and contributing to long term and broad based economic growth of the population in Manipur.

Manures and fertilizers

Manures and fertilizers are important aspects in cultivation of tuber crops because they improve soil structure and soil productivity. Nitrogen, Phosphorus and Potassium are important nutrients for growth, yield and quality of tuber crops. N is an essential constituent of proteins and is present in many other compounds of great physiological importance in plant metabolism.

It is an integral part of chlorophyll which is primary absorber of light energy needed for photosynthesis and also imparts vigorous vegetative growth and dark green colour to plants. It produces early green and delay in maturity to plants. It governs the utilization of K, P and other elements. Phosphorus has a greater role in energy storage and transfer; it is a constituent of nucleic acid, phytin and phospholipids and is essential for cell division and development. It stimulates early root development and growth and there by helps to establish seedlings quickly. P gives rapid and vigorous start to plants, strengthens straw and decreases lodging tendency.

The potassium ion (K^+) is actively taken up from soil solution by plant roots. K is essential for photosynthesis, development of chlorophyll and it improves vigour of the plants to enable to withstand adverse climatic conditions. It regulates stomata opening and closing and regulates the movement of ions with in the plants. It also acts in activation of enzymes, enzyme synthesis, peptide bonds synthesis and regulates H_2O imbalance within the plant.

Different regions of India have different requirements of fertilizer dose; the quantities of NPK fertilizers to be applied vary with the soil, climate and location in which the crop is grown.

The applications of NPK for cultivation of sweet potato per hectare in Bihar, West Bengal and Assam are 40-60 kg ha^{-1} Nitrogen (N), 40 kg ha^{-1}Phosphorus (P) and 40-60 kg ha^{-1}Potassium (K); in Andhra Pradesh it is 60 kg ha^{-1}N, 60 kg ha^{-1}P and 60 kg ha^{-1}K, and in Karnataka it requires 60 kg ha^{-1}N, 60 kg ha^{-1}P and 90 kg ha^{-1}K (Singh, 1989).

In Manipur conditions, the quantity of N: P: K has not yet been standardized for maximizing yield and quality of sweet potato. As N and K are limiting factors when it comes to sweet potato cultivation, hence, it would be beneficial to conduct a study to find out the most beneficial dose of Nitrogen and Potassium i.e., N and K requirement for sweet potato cultivation for the aforementioned conditions especially pertaining to the variety NFSP-1. Hence, keeping this view in mind, a research study entitled "Effect of different levels of nitrogen and potassium on growth, yield and quality of sweet potato [*Ipomoea batatas* (L.) Lam.] cv. NFSP-1" was conducted with the following objectives include to find out the best level of Nitrogen and Potassium for growth, yield and quality of sweet potato. And also to study the economics of treatments on sweet potato.

Materials and Methods

The experiment was conducted at College of Agriculture, Central Agricultural University located at Iroisemba, Imphal West, Manipur, India; during the session 2019-2020. The study was laid out in Factorial Randomized Block Design consisting of 16 treatment combinations with 4 levels of N i.e., 0, 35, 50 and 65 (all in kg ha^{-1}) of N denoted as N_0, N_1, N_2 and N_3 respectively and 4 levels of K i.e., 0, 35, 50, 65 (all in kg ha^{-1}) of K denoted as K_0, K_1, K_2 and K_3respectively with 3 replications.

Inputs used in the experiment were FYM and inorganic sources of nitrogen, phosphorus and potassium, i.e., Urea, Single Super Phosphate (SSP) and Muriate of Potash (MOP) respectively.

The quantities of fertilizers applied were as per the treatment requirements. Urea and MOP were applied in two splits; first 50 % at the time of planting and the remaining 50 % after first weeding and earthing up i.e., at 30 DAP (days after planting) as topdressing. Whole dose of recommended P was applied at planting stage. Vine cuttings of cultivar NFSP-1 were utilized for the experiment which was procured locally. This is a *khariff* season cultivar with multi-lobed leaves and orange-tinged tubers. It matures at about 110-140 days after planting.

Five plants per plot per replication were selected and tagged at random for recording growth parameters such as vine length, vine internode length, number of active leaves per plant and number of branches per plant whereas three plants from one plot were used for destructive sampling so as to study fresh weight of whole plant, dry weight of whole plant number of tubers per plant, length of tuber, diameter of tuber, fresh weight of tuber, dry weight of tuber, and leaf area.

All the growth characters were recorded with effect from 30 days after planting at 20 days interval viz. 30, 50, 70 and 90 days after planting and observations from the destructive samples were also studied at 30, 50, 70 and 90 days after planting. At harvest, number of tubers per plant, length of tuber, diameter of tuber, fresh weight of tuber, dry weight of tuber, weight of tuber per plant, weight of tuber per plot and weight of tuber per hectare were recorded. For recording quality parameters, five tubers from one plot were randomly selected after harvesting; quality parameters viz. dry matter of tubers, TSS, starch content, crude protein, ash content and nutrient content (NPK) were analysed as per appropriate methods and values were recorded.

Data recorded on growth attributing characters, yield characters were subjected to analysis of variance of $p \leq 0.05$ and quality characters were subjected to analysis of variance of $p \leq 0.01$.

Results and Discussion

Growth attributing characters

The growth parameters were recorded from 30 days after planting (DAP) as in all of the treatments, sweet potato plants had been completely established at this stage. Measurements for growth parameters were taken at an interval of 20 days i.e., at 30 DAP, 50 DAP, 70 DAP and 90 DAP. Results of effect of different doses or levels of N and K and the interaction between them on growth attributing characters of sweet potato are as follows.

Vine length (cm)

The data on effect of different levels of N and K and the interaction between them on vine length is represented in Table 1. Vine length had increased with an increasing dosage of N. At 90 DAP, the maximum vine length (368.54 cm) was exhibited by N_3 which was statistically at par with N_2 (366.62 cm) in which both treatments were significantly higher than N_1 and N_0. Minimum vine length (321.96 cm) at 90 DAP was exhibited by N_0.

Similarly, increase in dose of K brought about an increase in vine length of sweet potato plant. At 90 DAP, maximum vine length (376.69 cm) was exhibited by K_3 which was significantly higher compared to other treatments. Minimum vine length (330.30 cm) at 90 DAP was exhibited by K_0.

Vine internode length (cm)

The data on length of vine internode is represented in Table 2. At all 20 days intervals, N_3 produced longest vine internode length but with a linear response starting from 50 DAP up to 90 DAP. At 90 DAP, the maximum vine internode length (9.23 cm) was exhibited by N_3, which was significantly higher compared to other treatments. Minimum vine internode length (8.58 cm) at 90 DAP was exhibited by N_0.

Similarly, increase in dose of K brought about an increase in vine internode length of sweet potato. At 90 DAP, the maximum vine internode length (9.04 cm) was exhibited by K_3 which was significantly higher compared to other treatments. Minimum vine internode length (8.81 cm) at 90 DAP was exhibited by K_0 which was statistically at par with K_1 (8.84 cm) and K_2 (8.88 cm).

Number of active leaves per plant

Data on total number of active leaves per plant is represented in Table 3. Number of active leaves per plant increased throughout the growing period with increasing dose of N. At 90 DAP, the maximum number of active leaves (272.80) was exhibited by N_3, which was significantly higher compared to other treatments. Minimum number of active leaves (209.96) at 90 DAP was exhibited by N_0.

Increase in dosage of K dose brought about an increase in number of active leaves of sweet potato. At 90 DAP, the maximum number of active leaves (252.18) was exhibited by K_3 which was statistically at par with K_2 (242.60) and K_1 (241.21). Minimum number of active leaves (230.00) at 90 DAP was exhibited by K_0 which was statistically at par with K_1 (241.21).

Number of primary branches per plant

Data on total number of primary branches per plant is represented in Table 4. In the experiment, there were no significant differences in the number of primary branches between the treatments in the first 30 days after planting. However, from 50 DAP onwards there was increase in the number of primary branches per plant with an increase in dosage of N. At 90 DAP, maximum number of primary branches (8.31) was exhibited by N_3 which was statistically at par with K_2 (8.00). Minimum value for number of primary branches (7.21) was exhibited by N_0 which was statistically at par with N_2 (7.56).

Similar case is seen with effect of K. At 90 DAP, the maximum value for number of primary branches (8.19) was exhibited by K_3 which was statistically at par with K_2 (8.04) and were significantly higher than K_1 and K_0. Minimum number of primary branches (7.31) at 90 DAP was exhibited by K_0 which was statistically at par with K_1 (7.54).

Leaf area (cm^2)

Data on leaf area (cm^2) of sweet potato plant is represented in Table 5. The leaf area at 30 DAP and 50 DAP were found to be non-significant with increasing doses of N. However, at 70 DAP and 90 DAP, N_3 produced maximum leaf area while N_0 produced minimum leaf area of sweet potato plant with an increasing trend. At 90 DAP, the maximum leaf area (161.36 cm^2) was exhibited by N_3 which was statistically at par with N_2 (155.43 cm^2). Minimum leaf area (141.68 cm^2) at 90 DAP was exhibited by N_0. Different doses of K did show any significant difference between the treatments although there was a trend of increase in leaf area throughout the growing period.

Data from destructive samples

The following observations were taken at 30, 50, 70 and 90 days after planting (DAP) from the destructive samples.

Fresh weight of whole plant (g)

The data on fresh weight of whole plant as influenced by different levels or doses of N and K and the interaction between them at 20 days interval is represented in Table 6. At all 20 days intervals, N_3 produced maximum value for fresh weight of whole plant, while N_0 produced minimum fresh weight of whole plant at all stages of sweet potato plant with an increasing trend. At 90 DAP, the maximum fresh weight of whole plant (1322.45 g) was exhibited by N_3 which was statistically at par with N_2 (1229.59 g). Minimum fresh weight of whole plant (992.50 g) at 90 DAP was exhibited by N_0.

Increase in dosage of K also brought about an increase fresh weight of whole plant. At 90 DAP, the maximum fresh weight of whole plant (1322.38 g) was exhibited by K_3 which was significantly higher compared to other treatments. Minimum fresh weight of whole plant (1053.32 g) at 90 DAP was exhibited by K_0 which was statistically at par with K_1 (1156.87 g).

Dry weight of whole plant (g)

The data on dry weight of whole plant as influenced by different levels or doses of N and K and the interaction between them at 20 days interval is represented in Table 7. At all 20 days intervals, N_3 produced maximum dry weight of whole plant, while N_0 produced minimum dry weight of whole plant at all stages of sweet potato plant with an increasing trend. At 90 DAP, the maximum dry weight of whole plant (150.48 g) was exhibited by N_3 which was significantly higher compared to other treatments. Minimum dry weight of whole plant (117.80 g) at 90 DAP was exhibited by N_0 which was statistically at par with N_1 (121.17 g).

Increase in dosage of K also brought about an increase dry weight of whole plant. At 90 DAP, the maximum dry weight of whole plant (143.44 g) was exhibited by, K_3 which was statistically at par with K_2 (138.89 g). Minimum dry weight of whole plant (109.41 g) at 90 DAP was exhibited by K_0.

Number of tubers per plant

The observations on number of tubers per plant as influenced by different levels or dosage of N and K and the interaction between them at 20 days interval are represented in Table 8. There was no tuber initiation at 30 DAP, from 50 DAP onwards, number of tubers per plant increased with higher level of N, this difference was, however, observed from 70 DAP onwards. At 90 DAP, the maximum number of tubers per plant (2.10) was exhibited by N_3 which was statistically at par with N_1 and N_2 with 1.85

and 1.95 number of tubers per plant respectively. Minimum number of tubers per plant (1.73) at 90 DAP was exhibited by N_0.

Similar effects of K were also observed pertaining to number of tubers per plant. At 90 DAP, the maximum number of tubers per plant (2.20) was exhibited by K_3 which was statistically at par with K_2 (1.97). Minimum number of tubers per plant (1.58) at 90 DAP was exhibited by K_0.

Length of tubers (cm)

The data on length of tubers (cm) as influenced by different levels or doses of N and K and the interaction between them at 20 days interval is represented in Table 9. At 90 DAP, the maximum length of tubers (11.59 cm) was exhibited by N_3 which was statistically at par with N_1 and N_2at 10.55 cm and 10.91 cm respectively. Minimum length of tubers per plant (9.50 cm) was exhibited by N_0 which was statistically at par with N_1 (10.55 cm).

Similarly, the maximum tuber length (11.75 cm) was exhibited by K_3 which was statistically at par with K_2 (11.06 cm). Minimum length of tuber (9.35 cm) at 90 DAP was exhibited by K_0 which was statistically at par with K_1 (10.40 cm).

Diameter of tubers (cm)

The data on diameter of tubers (cm) as influenced by different levels or doses of N and K and the interaction between them at 20 days interval is represented in Table 10. At 90 DAP, the maximum diameter of tubers (5.51 cm) was exhibited byN_3 which was statistically at par with N_2 (4.69 cm). Minimum diameter of tubers (3.70 cm) at 90 DAP was exhibited by N_0 which was statistically at par with N_1 (4.55 cm).

Similar effects of different rates of K were also seen. At 90 DAP, the maximum diameter of tuber (5.33 cm) was exhibited by K_3 which was statistically at par (5.02 cm) with K_2. Minimum diameter of tuber (3.55 cm) at 90 DAP was exhibited by K_0 which was at par with N_1 (4.30 cm).

Fresh weight of tubers (g)

The data on fresh weight of tubers (g) as influenced by different levels or doses of N and K and the interaction between them at 20 days interval is represented in Table 11 and at 90 DAP, the maximum fresh weight of tubers (125.43 g) was exhibited by N_3 which was significantly higher compared to other treatments. Minimum fresh weight of tubers (75.58 g) at 90 DAP was exhibited by N_0. At all 20 daysintervalK_3 produced maximum fresh weight of tubers while K_0 produced minimum fresh weight of tubers with an increasing trend. At 90 DAP, the maximum fresh weight of tubers (136.00 g) was exhibited byK_3 which was significantly higher compared to other treatments. Minimum fresh weight of tubers (69.58 g) at 90 DAP was exhibited by K_0.

Dry weight of tubers (g)

The data on dry weight of tubers (g) as influenced by different levels or doses of N and K and the interaction between them at 20 days interval is represented in Table 12. At 90 DAP, the maximum dry weight of tubers (34.99 g) was exhibited by N_3 which was significantly higher compared to other treatments. Minimum dry weight of tubers (18.89 g) at 90 DAP was exhibited by N_0 which was at par (21.52 g) with $N_{1.}$ At all 20 days interval, K_3 produced maximum dry weight of tubers while K_0 produced minimum dry weight of tubers with an increasing trend. At 90 DAP, the maximum dry weight of tubers (34.65 g) was exhibited by K_3 which was statistically at par (29.05 g) with K_2 both of which were significantly higher to other treatments viz., K_0 and K_1. Minimum dry weight of tubers (13.79 g) at 90 DAP was exhibited by K_0.

Table.1 Effect of different levels of N and K on vine length (cm)

Treatments	30 DAP	50 DAP	70 DAP	90 DAP
N_0	89.61	207.49	279.40	321.96
N_1	92.58	220.08	303.63	353.08
N_2	98.20	230.76	336.06	366.62
N_3	102.50	252.00	337.44	368.54
S.E(d) (±)	**2.32**	**7.12**	**7.85**	**6.15**
C.D (0.05)	**4.73**	**14.53**	**16.03**	**12.56**
K_0	85.98	209.66	286.06	330.30
K_1	88.66	228.57	314.90	348.93
K_2	102.40	227.58	320.67	354.35
K_3	105.87	244.51	334.90	376.69
S.E(d) (±)	**2.32**	**7.12**	**7.85**	**6.15**
C.D (0.05)	**4.73**	**14.53**	**16.03**	**12.56**
Interaction (N x K)				
S.E(d) (±)	**4.63**	**14.23**	**15.70**	**12.31**
C.D (0.05)	**(NS)**	**(NS)**	**(NS)**	**(NS)**
General Mean	**95.73**	**227.58**	**314.13**	**352.55**

Table.2 Effect of different levels of N and K on vine internode length (cm)

Treatments	30 DAP	50 DAP	70 DAP	90 DAP
N_0	6.31	7.93	8.31	8.58
N_1	7.26	8.26	8.61	8.82
N_2	7.37	8.37	8.67	8.93
N_3	7.77	8.74	8.97	9.23
S.E(d) (±)	**0.13**	**0.10**	**0.07**	**0.08**
C.D (0.05)	**0.26**	**0.20**	**0.14**	**0.15**
K_0	6.69	8.19	8.44	8.81
K_1	7.26	8.26	8.61	8.84
K_2	7.35	8.38	8.71	8.88
K_3	7.41	8.47	8.80	9.04
S.E(d) (±)	**0.13**	**0.10**	**0.07**	**0.08**
C.D (0.05)	**0.26**	**0.20**	**0.14**	**0.15**
Interaction (N x K)				
S.E(d) (±)	**0.25**	**0.20**	**0.14**	**0.15**
C.D (0.05)	**(NS)**	**(NS)**	**(NS)**	**(NS)**
General Mean	**7.18**	**8.32**	**8.64**	**8.89**

Table.3 Effect of different levels of N and K on number of active leaves per plant

Treatments	30 DAP	50 DAP	70 DAP	90 DAP
N_0	33.47	126.59	175.61	209.96
N_1	39.74	158.04	205.21	230.42
N_2	40.75	162.83	216.74	252.81
N_3	45.19	185.56	235.23	272.80
S.E(d) (±)	**2.79**	**4.53**	**10.06**	**6.40**
C.D (0.05)	**5.71**	**9.24**	**20.55**	**13.07**
K_0	36.69	142.26	191.17	230.00
K_1	36.36	145.08	207.26	241.21
K_2	41.61	168.02	215.25	242.60
K_3	44.48	177.67	219.10	252.18
S.E(d) (±)	**2.79**	**4.53**	**10.06**	**6.40**
C.D (0.05)	**5.71**	**9.24**	**20.55**	**13.07**
Interaction (N x K)				
S.E(d) (±)	**5.59**	**9.05**	**20.12**	**12.80**
C.D (0.05)	**(NS)**	**(NS)**	**(NS)**	**(NS)**
General Mean	**39.79**	**158.26**	**208.20**	**241.50**

Table.4 Effect of different levels of N and K on number of primary branches per plant

Treatments	30 DAP	50 DAP	70 DAP	90 DAP
N_0	1.33	4.10	6.43	7.21
N_1	1.39	5.06	6.96	7.56
N_2	1.42	4.64	6.98	8.00
N_3	1.42	5.08	7.52	8.31
S.E(d) (±)	**0.130**	**0.265**	**0.309**	**0.305**
C.D (0.05)	**(NS)**	**0.542**	**0.631**	**0.622**
K_0	1.31	4.39	6.27	7.31
K_1	1.42	4.52	7.21	7.54
K_2	1.36	4.88	6.85	8.04
K_3	1.47	5.10	7.55	8.19
S.E(d) (±)	**0.130**	**0.265**	**0.309**	**0.305**
C.D (0.05)	**(NS)**	**0.542**	**0.631**	**0.622**
Interaction (N x K)				
S.E(d) (±)	**0.259**	**0.531**	**0.618**	**0.610**
C.D (0.05)	**(NS)**	**(NS)**	**(NS)**	**(NS)**
General Mean	**1.39**	**4.72**	**6.98**	**7.77**

Table.5 Effect of different levels of N and K on leaf area (cm^2)

Treatments	30 DAP	50 DAP	70 DAP	90 DAP
N_0	87.61	107.35	130.84	141.68
N_1	92.82	109.09	139.13	146.07
N_2	95.74	115.35	148.60	155.43
N_3	97.87	119.27	155.87	161.36
S.E(d) (±)	**3.71**	**4.82**	**4.42**	**3.11**
C.D (0.05)	**(NS)**	**(NS)**	**9.03**	**6.36**
K_0	89.35	106.07	138.99	147.87
K_1	92.90	111.76	142.30	148.68
K_2	94.22	115.13	145.53	152.87
K_3	97.57	118.11	147.62	155.12
S.E(d) (±)	**3.71**	**4.82**	**4.42**	**3.11**
C.D (0.05)	**(NS)**	**(NS)**	**(NS)**	**(NS)**
Interaction (N x K)				
S.E(d) (±)	**7.42**	**9.64**	**8.84**	**6.23**
C.D (0.05)	**(NS)**	**(NS)**	**(NS)**	**(NS)**
General Mean	**93.51**	**112.77**	**143.61**	**153.13**

Table.6 Effect of different levels of N and K on fresh weight of whole plant (g)

Treatments	30 DAP	50 DAP	70 DAP	90 DAP
N_0	84.08	390.92	815.64	992.50
N_1	91.26	490.08	871.59	1172.11
N_2	96.14	547.43	916.10	1229.59
N_3	106.45	611.51	988.39	1322.45
S.E(d) (±)	**6.17**	**43.60**	**42.54**	**58.22**
C.D (0.05)	**12.61**	**89.03**	**86.87**	**118.88**
K_0	78.96	400.55	693.48	1053.32
K_1	95.85	483.04	944.38	1156.87
K_2	96.89	571.99	975.12	1184.08
K_3	106.23	584.36	978.74	1322.38
S.E(d) (±)	**6.17**	**43.60**	**42.54**	**58.22**
C.D (0.05)	**12.61**	**89.03**	**86.87**	**118.88**
Interaction (N x K)				
S.E(d) (±)	**12.35**	**87.20**	**85.09**	**116.44**
C.D (0.05)	**(NS)**	**(NS)**	**(NS)**	**(NS)**
General Mean	**94.48**	**509.99**	**897.93**	**1179.16**

Table.7 Effect of different levels of N and K on dry weight whole plant (g)

Treatments	30 DAP	50 DAP	70 DAP	90 DAP
N_0	11.24	45.13	93.55	117.80
N_1	11.83	45.33	94.24	121.17
N_2	12.34	53.40	102.53	133.25
N_3	12.92	57.67	113.16	150.48
S.E(d) (±)	**0.39**	**3.99**	**3.03**	**4.58**
C.D (0.05)	**0.80**	**8.15**	**6.19**	**9.35**
K_0	9.59	38.75	80.97	109.41
K_1	12.50	50.39	100.41	130.96
K_2	12.81	56.19	108.54	138.89
K_3	13.43	56.21	113.56	143.44
S.E(d) (±)	**0.39**	**3.993**	**3.03**	**4.58**
C.D (0.05)	**0.80**	**8.15**	**6.19**	**9.35**
Interaction (N x K)				
S.E(d) (±)	**0.78**	**7.99**	**6.06**	**9.16**
C.D (0.05)	**(NS)**	**(NS)**	**(NS)**	**(NS)**
General Mean	**12.08**	**50.38**	**100.87**	**130.67**

Table.8 Effect of different levels of N and K on number of tubers per plant

Treatments	50 DAP	70 DAP	90 DAP
N_0	0.84	1.40	1.73
N_1	1.11	1.59	1.85
N_2	1.19	1.66	1.95
N_3	1.25	1.81	2.10
S.E(d) (±)	**0.09**	**0.12**	**0.13**
C.D (0.05)	**(NS)**	**0.23**	**0.26**
K_0	0.65	1.30	1.58
K_1	1.18	1.53	1.87
K_2	1.21	1.76	1.97
K_3	1.35	1.88	2.20
S.E(d) (±)	**0.09**	**0.12**	**0.13**
C.D (0.05)	**(NS)**	**0.23**	**0.26**
Interaction (N x K)			
S.E(d) (±)	**0.17**	**0.23**	**0.25**
C.D (0.05)	**(NS)**	**(NS)**	**(NS)**
General Mean	**1.10**	**1.62**	**1.91**

Table.9 Effect of different levels of N and K on length of tubers (cm)

Treatments	50 DAP	70 DAP	90 DAP
N_0	6.73	8.56	9.50
N_1	7.50	9.01	10.55
N_2	7.79	9.36	10.91
N_3	7.97	9.64	11.59
S.E(d) (±)	**0.56**	**0.36**	**0.62**
C.D (0.05)	**(NS)**	**0.73**	**1.27**
K_0	6.70	8.15	9.35
K_1	7.52	8.86	10.40
K_2	7.80	9.61	11.06
K_3	7.97	9.94	11.75
S.E(d) (±)	**0.56**	**0.36**	**0.62**
C.D (0.05)	**(NS)**	**0.73**	**1.27**
Interaction (N x K)			
S.E(d) (±)	**1.13**	**0.71**	**1.25**
C.D (0.05)	**(NS)**	**(NS)**	**(NS)**
General Mean	**7.50**	**9.14**	**10.64**

Table.10 Effect of different levels of N and K on diameter of tubers (cm)

Treatments	50 DAP	70 DAP	90 DAP
N_0	1.54	2.27	3.70
N_1	1.88	2.46	4.30
N_2	1.88	2.80	4.69
N_3	1.97	3.27	5.51
S.E(d) (±)	**0.24**	**0.30**	**0.42**
C.D (0.05)	**(NS)**	**0.62**	**0.85**
K_0	1.47	2.16	3.55
K_1	1.89	2.58	4.30
K_2	1.93	2.92	5.02
K_3	1.98	3.15	5.33
S.E(d) (±)	**0.24**	**0.30**	**0.42**
C.D (0.05)	**(NS)**	**0.62**	**0.85**
Interaction (N x K)			
S.E(d) (±)	**0.48**	**0.60**	**0.84**
C.D (0.05)	**(NS)**	**(NS)**	**(NS)**
General Mean	**1.82**	**2.70**	**4.55**

Table.11 Effect of different levels of N and K on fresh weight of tubers (g)

Treatments	50 DAP	70 DAP	90 DAP
N_0	10.33	32.63	75.58
N_1	13.71	43.57	94.30
N_2	17.52	49.48	102.81
N_3	19.98	55.23	125.43
S.E(d) (±)	**1.31**	**2.87**	**8.20**
C.D (0.05)	**2.68**	**5.87**	**16.75**
K_0	11.63	28.27	69.58
K_1	15.02	30.99	84.90
K_2	15.62	55.84	107.62
K_3	19.26	65.80	136.00
S.E(d) (±)	**1.31**	**2.87**	**8.20**
C.D (0.05)	**2.68**	**5.87**	**16.75**
Interaction (N x K)			
S.E(d) (±)	**2.62**	**5.75**	**16.40**
C.D (0.05)	**(NS)**	**(NS)**	**(NS)**
General Mean	**15.38**	**45.23**	**99.53**

Table.12 Effect of different levels of N and K on dry weight of tubers (g)

Treatments	50 DAP	70 DAP	90 DAP
N_0	3.07	7.54	18.89
N_1	3.34	8.19	21.52
N_2	3.82	12.73	25.63
N_3	4.72	14.48	34.99
S.E(d) (±)	**0.48**	**1.71**	**2.93**
C.D (0.05)	**0.99**	**3.49**	**5.99**
K_0	3.14	5.74	13.79
K_1	3.36	7.14	23.55
K_2	3.62	14.78	29.05
K_3	4.82	15.27	34.65
S.E(d) (±)	**0.48**	**1.71**	**2.93**
C.D (0.05)	**0.99**	**3.49**	**5.99**
Interaction (N x K)			
S.E(d) (±)	**0.97**	**3.42**	**5.87**
C.D (0.05)	**(NS)**	**(NS)**	**(NS)**
General Mean	**3.74**	**10.74**	**25.26**

Table.13 Effect of different levels of N and K on yield characters of sweet potato tubers

Treatments	No of tubers per plant	Length of tubers (cm)	Diameter of tubers (cm)	Fresh weight tubers (g)	Dry weight of tubers (g)	Weight of tubers per plant (kg/plant)	Weight of Tubers per plot (kg/plot)	Weight of Tubers (q/ha)
N_0	1.77	11.16	7.36	179.91	37.88	0.32	9.09	164.91
N_1	1.99	11.90	7.86	221.57	48.38	0.44	12.46	226.06
N_2	2.10	12.49	8.29	224.51	51.56	0.48	13.47	244.51
N_3	2.26	13.29	8.89	245.23	51.58	0.56	15.67	284.46
S.E(d) (±)	0.14	0.54	0.38	9.08	1.86	0.05	1.29	23.46
C.D (0.05)	0.29	1.11	0.78	18.54	3.80	0.09	2.64	47.91
K_0	1.73	11.25	7.40	180.31	37.77	0.32	8.89	161.40
K_1	2.02	11.96	7.69	213.60	46.28	0.44	12.23	221.96
K_2	2.09	12.63	8.53	233.63	51.15	0.50	13.88	251.90
K_3	2.28	12.99	8.78	243.69	54.20	0.56	15.69	284.68
S.E(d) (±)	0.14	0.54	0.38	9.08	1.86	0.05	1.29	23.46
C.D (0.05)	0.29	1.11	0.78	18.54	3.80	0.09	2.64	47.91
Interaction (N x K)								
S.E(d) (±)	0.28	1.09	0.76	18.16	3.72	0.09	2.59	46.93
C.D (0.05)	NS	NS	NS	NS	NS	NS	NS	NS
General Mean	2.03	12.21	8.1	217.81	47.35	0.45	12.67	229.98

Table.14 Effect of different levels of N and K on quality characters of sweet potato

Treatments	No of tubers per plant	Length of tubers (cm)	Diameter of tubers (cm)	Fresh weight tubers (g)	Dry weight of tubers (g)	Weight of tubers per plant (kg/plant)	Weight of Tubers per plot (kg/plot)	Weight of Tubers (q/ha)
N_0	1.77	11.16	7.36	179.91	37.88	0.32	9.09	164.91
N_1	1.99	11.90	7.86	221.57	48.38	0.44	12.46	226.06
N_2	2.10	12.49	8.29	224.51	51.56	0.48	13.47	244.51
N_3	2.26	13.29	8.89	245.23	51.58	0.56	15.67	284.46
S.E(d) (±)	0.14	0.54	0.38	9.08	1.86	0.05	1.29	23.46
C.D (0.05)	0.29	1.11	0.78	18.54	3.80	0.09	2.64	47.91
K_0	1.73	11.25	7.40	180.31	37.77	0.32	8.89	161.40
K_1	2.02	11.96	7.69	213.60	46.28	0.44	12.23	221.96
K_2	2.09	12.63	8.53	233.63	51.15	0.50	13.88	251.90
K_3	2.28	12.99	8.78	243.69	54.20	0.56	15.69	284.68
S.E(d) (±)	0.14	0.54	0.38	9.08	1.86	0.05	1.29	23.46
C.D (0.05)	0.29	1.11	0.78	18.54	3.80	0.09	2.64	47.91
Interaction (N x K)								
S.E(d) (±)	0.28	1.09	0.76	18.16	3.72	0.09	2.59	46.93
C.D (0.05)	NS	NS	NS	NS	NS	NS	NS	NS
General Mean	2.03	12.21	8.1	217.81	47.35	0.45	12.67	229.98

Table.15 Effect of different levels of N and K on NPK content of tubers (%)

Treatments	N (%)	P (%)	K (%)
N_0	0.29	0.28	0.79
N_1	0.31	0.29	0.89
N_2	0.34	0.30	0.95
N_3	0.36	0.31	1.07
S.E(d) (±)	**0.013**	**0.009**	**0.067**
C.D (0.01)	**0.036**	**0.024**	**0.183**
K_0	0.27	0.27	0.70
K_1	0.32	0.29	0.84
K_2	0.33	0.30	1.00
K_3	0.38	0.32	1.16
S.E(d) (±)	**0.013**	**0.009**	**0.067**
C.D (0.01)	**0.036**	**0.024**	**0.183**
Interaction (N x K)			
S.E(d) (±)	**0.026**	**0.017**	**0.133**
C.D (0.01)	**(NS)**	**(NS)**	**(NS)**
General Mean	**0.33**	**0.30**	**0.93**

Table.16 Effect of different levels of N and K on economics of sweet potato cultivation

Treat ment	Notat ion	Total cost (₹ /ha)	Yield (q/ha)	Rate (₹ /q)	Gross returns (₹ /ha)	Net returns (₹ /ha)	B: C ratio
T_1	N_0K_0	92214.00	101.19	1300	131550.33	39336.33	0.43
T_2	N_0K_1	93967.50	154.36	1300	200665.74	106698.24	1.14
T_3	N_0K_2	94719.00	179.33	1300	233130.11	138411.11	1.46
T_4	N_0K_3	95470.50	224.75	1300	292168.91	196698.41	2.06
T_5	N_1K_0	94872.25	157.26	1300	204433.61	109561.36	1.15
T_6	N_1K_1	96625.75	246.03	1300	319833.90	223208.15	2.31
T_7	N_1K_2	97377.25	229.11	1300	297837.09	200459.84	2.06
T_8	N_1K_3	98128.75	271.86	1300	353419.12	255290.37	2.60
T_9	N_2K_0	96011.50	166.48	1300	216419.25	120407.75	1.25
T_{10}	N_2K_1	97765.00	227.26	1300	295443.12	197678.12	2.02
T_{11}	N_2K_2	98516.50	266.97	1300	347062.72	248546.22	2.52
T_{12}	N_2K_3	99268.00	317.33	1300	412533.49	313265.49	3.16
T_{13}	N_3K_0	97150.75	220.67	1300	286866.90	189716.15	1.95
T_{14}	N_3K_1	98904.25	260.18	1300	338233.73	239329.48	2.42
T_{15}	N_3K_2	99655.75	332.21	1300	431874.00	332218.25	3.33
T_{16}	N_3K_3	100407.25	324.77	1300	422200.99	321793.74	3.20

Discussions on effect of N on Growth characters

As seen from the results, growth attributing characters increased significantly with increasing levels of nitrogenous fertilizer which could be due to the role of nitrogen in improving plant vigour during growth and stimulating the meristematic activity which contributes to increased vegetative growth. Similar results were observed by Abd El-Baky *et al.,* (2010) in sweet potato, Uwah *et al.,* (2013) in cassava, Yourtchi *et al.,* (2013) in potato, Sanjana *et al.,* (2014) in potato, Prabawardani and Suparno (2015) in sweet potato, Makokha *et al.,* (2018) in sweet potato.

Discussions on effect of K on Growth characters

In terms of effect of K on growth attributing characters, increasing dose or level of K showed increasing and significant effect which could be due to increase in cellular activity brought about by its application. This is in accordance with the findings of Knavel (1971) in sweet potato, Abd El-Baky *et al.,* (2010) in sweet potato and Uwah *et al.,* (2013) in sweet potato.

Effect of interaction on growth characters

Interaction between N and K did not exhibit any significant difference between the treatments in regards to the above mentioned growth attributing characters.

Yield characters

Results of effect of different levels or doses of N and K and their interaction on yield characters of sweet potato are as follows. The data regarding effect of different levels or doses of N and K are represented in Table 13.

Number of tubers perplant at harvest

Number of tubers per plant increased with increasing level of N and was maximum (2.26) with N_3 which was statistically at par with N_1 and N_2 which gave 1.99 and 2.10 number of tubers per plant respectively. Minimum value for number of tubers (1.77) was exhibited by N_0 which was at par with N_2 at 1.99 cm tuber length. Number of tubers per plant increased with higher dose of N. Increase in level of K also brought more number of tubers per plant. Maximum number of tubers (2.28) was obtained from K_3 which was at par with K_1 and K_2 which gave 2.02 and 2.09 number of tubers per plant respectively. Minimum number of tubers (1.73) was observed fromK_0.

Length of tubers at harvest (cm)

Length of tubers increased with higher dose of N and was maximum (13.29 cm) with N_3 which was statistically at par with $N_2$with tuber length of 12.49 cm. Minimum length of tubers (11.16 cm) was exhibited by N_0 which was statistically at par with N_1 with tuber length of 11.90 cm.

Increase in levels of K also brought an increased value in length of tubers. Maximum length of tubers (12.99 cm) was observed from K_3 which was statistically at par with K_2 and K_1 with tuber length of 12.63 cm and 11.96 cm respectively. Minimum length of tubers (11.25 cm) was obtained from K_0.

Diameter of tubers at harvest (cm)

Diameter of tubers increased with higher dose of N and was maximum (8.89 cm) with N_3 which was statistically at par with N_2giving tuber diameter of 8.29 cm. Minimum diameter of tubers (7.36 cm) was exhibited by N_0 which was at par with N_1(7.86 cm).

Increase in level or dosage of K also brought an increase in diameter of tubers. Maximum diameter of tubers (8.78 cm) was observed from K_3 which was statistically at par with $K_2$with tuber diameter of 8.53 cm. Minimum diameter of tubers (7.40 cm) was observed K_0 which was statistically at par with K_1 (7.69 cm).

Fresh weight of tubers at harvest (g)

Fresh weight of tubers increased with higher level of N and was maximum (245.23 g) with N_3 which was significantly higher compared to other treatments. Minimum fresh weight of tubers (179.91 g) was exhibited by N_0. Increase in level of K also brought an increase in fresh weight of tubers. Maximum fresh weight of tubers (243.69 g) was observed from K_3 which was at par with K_2 with tuber fresh weight of 233.63 g. Minimum fresh weight of tubers (180.31 g) was obtained from K_0.

Dry weight of tubers at harvest (g)

Dry weight of tubers at harvest increased with higher level of N and was maximum (51.58 g) with N_3 which was at par with N_2 (51.56 g) and N_1 (48.38 g). Minimum dry weight of tubers (37.88 g) was exhibited by $N_{0.}$ Increase in level or dosage of K also brought an increase in dry of tubers at harvest. Maximum dry weight of tubers (54.20 g) was observed from K_3 which was at par with K_2(51.15 g). Minimum dry weight of tubers (37.77 g) was obtained from K_0.

Weight of tubers per plant (kg/plant)

Weight of tubers per plant (in kg) increased with higher level of N and was maximum (0.56 kg/plant) with N_3 which was at par with N_2(0.48 kg/plant). Minimum weight of tubers per plant (0.32 kg/plant) was exhibited by $N_{0.}$ Increase in level of K also brought an increase in weight of tubers per plant. Maximum weight of tubers per plant(0.56 kg/plant) was obtained from K_3 which was at par with K_2(50 kg/plant). Minimum weight of tubers per plant (0.32 kg/plant) was obtained $K_{0.}$

Weight of tuber per plot (kg/plot)

Weight of tubers per plot (kg/plot) increased with higher level of N and was maximum (15.67 kg/plot) from N_3 which was at par with N_2 (13.47 kg/plot). Minimum weight of tubers per plot (9.09 kg/plot) was exhibited by $N_{0.}$ Increase in level of K also brought an increase in weight of tubers per plot. Maximum weight of tubers per plot (15.69 kg/plot) was obtained from K_3 which was at par with K_2 (13.88 kg/plot). Minimum weight of tubers per plot (8.89 kg/plot) was obtained from $K_{0.}$

Weight of tuber per hectare (q/ha)

Weight of tubers in quintal per hectare (q/ha) increased with higher level of N and was maximum (284.46 q/ha) with N_3 which was at par with 50 kg/ha of N i.e., N_2 (244.51 q/ha). Minimum weight of tubers in quintal per hectare (164.91 q/ha) was exhibited by N_0.

Increase in level of K also brought an increase in weight of tubers in quintal per hectare. Maximum weight of tubers in quintal per hectare was obtained from K_3 which was at par with K_2 (251.90 q/ha). Minimum weight of tubers in quintal per hectare (161.40 q/ha) was obtained from $K_{0.}$

Discussions on effect of N on Yield characters

Higher levels of N might have helped improve the tuber size and development of more number tubers per plant resulting in higher yield of tubers per hectare. This may be due to the role of N in improving the plant vigour which stimulates the meristematic activity thus leading to increase in number of cells along with cell enlargement. This also led to an increase in net assimilation rate and accumulation of dry matter which in turn improves weight of tubers. Similarly observations were made by Yourtchi *et al.*, (2013) in potato and Sanjana *et al.*, (2014) in potato.

Discussions on effect of K on Yield characters

Increase in level of K also brought an increase in weight of tubers in quintal per hectare. This effect is possibly due to the importance of K in promoting synthesis of photosynthates and their subsequent transport to tubers. This may also be due to potassium's role in improving the quantitative characteristics of sweet potato.

Similar result was observed by Bansal and Trehan (2011) in potato and Uwah *et al.*, (2013) in sweet potato.

Effect of interaction on yield characters

Interaction between the different levels of N and K did not exhibit any significant difference between the treatments in relation to any of the yield characters mentioned above.

Quality characters

Results of effect of different doses or levels of N and K and their interaction on quality characters of sweet potato are as follows. The data regarding effect of different doses or levels of N are represented in Table 14.

Dry matter of tubers at harvest (%)

Dry matter content of tubers (%) increased with higher level of N and was maximum (22.40 %) from N_3 which was at par with N_1 (21.57 %) and N_2 (22.00 %). Minimum dry matter content of tubers (20.98 %) was exhibited by N_0. Increase in level of K also brought an increase in dry matter content. Maximum dry matter content (22.31 %) was obtained from K_3 which was at par with K_2 (22.04 %) and K_1 (21.60 %). Minimum dry matter content (20.99 %) was obtained fromK_0.

Total Soluble Solids or TSS (%)

Total soluble solids (TSS) increased with higher level of N and was maximum (7.07 %) from N_3 which was at par with N_2 (6.81 %). Minimum TSS (5.73 %) was exhibited by N_0. Increase in level of K also brought an increase in TSS. Maximum TSS (6.95 %) was obtained from K_3 which was at par with K_2 (6.90 %). Minimum TSS (5.90 %) was obtained from K_0.

Starch content (%) on fresh weight basis

Starch content of tubers (%) on fresh weight basis increased with higher level of N and was maximum (14.55 %) from N_3 which was significantly higher compared to other treatments. Minimum starch content of tubers (11.38 %) was exhibited by N_0 which was at par with N_1 (11.65 %).

Starch content of tubers (%) increased with higher level of N.

Increase in level of K also brought an increase in starch content of tubers on fresh weight basis. Maximum starch content (13.97 %) was observed from K_3 which was significantly higher compared to other doses of K. Minimum starch content of tubers (11.41 %) was obtained from K_0 which was at par with K_1 (11.95 %).

Sugar content (%) on fresh weight basis

Sugar content of tubers (%) on fresh weight basis increased with higher level of N and was maximum (3.91 %) from N_3 which was at par with N_2 (3.21 %) and N_1 (3.10 %). Minimum value for sugar content of tubers (2.82 %) was exhibited by N_0.

Increase in level of K also brought an increase in sugar content of tubers on fresh weight basis. Maximum value for sugar content (3.40 %) was obtained from K_3 which was at par with K_2 (3.30 %). Minimum sugar content of tubers (2.70 %) was obtained from K_0.

Crude protein (%)

Crude protein content of tubers (%) increased with higher levels of N and found to be maximum (2.23 %) from N_3 which was at par with N_2 (2.14 %). Minimum crude protein content of tubers (1.84 %) was exhibited by N_0 which was at par with N_1(1.92 %).

Increase in dosage or level of K also brought an increase in crude protein content of tubers. Maximum value for crude protein content (2.36 %) was obtained from K_3 which was significantly higher compared to other doses of K. Minimum crude protein content of tubers was obtained from K_0 (1.66 %).

Ash content (%)

Ash content of tubers (%) increased with higher level of N and was maximum (5.13 %) from N_3 which was significantly higher compared to other treatments. Minimum ash content of tubers (3.79 %) was exhibited by N_0 which was observed to be at par with N_1 (4.09 %) and N_2 (4.18 %).

Increase in level of K also brought an increase in ash content of tubers. Maximum ash content (4.82 %) was obtained from K_3 which was at par with K_2 (4.63 %). Minimum ash content of tubers (3.68 %) was observed from K_0 which was found to be at par with K_1 (4.06 %).

Discussions on effect of N on Quality characters

TSS, starch and sugar contents in tubers were better with higher level of N. This may be due to positive effect of N in increasing sucrose contents and recoverable sugar yield. There is also an association between uptake and accumulation of nutrients in tuber and also because of their collaborated role in enhancing the sucrose content synthesis and their subsequent accumulation in tubers. This result was similar to the observations shown by Patil *et al.,* (1990) in sweet potato, Ismail and Abu-Zinada (2009) in potato, Gehan *et al.,* (2013)in sugarbeet, Mehran and Samad (2013) in sugarbeet, Bashir and Qureshi (2014) in potato.

Crude protein content of tubers (%) increased with higher levels of N. This may be due to nitrogen being an essential component of amino acid and proteins. N also plays a major role in protein improvement. This result is in accordance with observations made by Phillips *et al.,* (2005) and Ukom *et al.,* (2009) in sweet potato.

Ash content of tubers (%) increased with higher level of N and may be due to the fact that higher quantity of N encourages higher photosynthetic activity leading to luxurious development of plant parts which in turn leads to higher production photosynthates and subsequently their translocation and accumulation in the tubers. This result is in accordance with findings of Anand (1986) in potato.

Discussions on effect of K on Quality characters

TSS, starch and sugar contents in tubers improves with increase in K application, this may be due its role in production and transfer of carbohydrates as well as in their process of sucrose conversion, translocation of sucrose from the leaves and its accumulation in the tubers and enhancing their conversion into carbohydrates. Similar result was reported by Al-Moshileh and Errebi (2005) in potato, El-Tohamy *et al.,* (2011) in potato.

Increase in dosage or level of K also brought an increase in crude protein content of tubers. This may be due to the role of K in promoting synthesis of photosynthates in leaves and their translocation to tubers and assisting in their conversion into proteins and vitamins. K also plays an important part in N metabolism. This result is in accordance with observation made by Abd El-Latif *et al.,* (2011).

Increase in dosage or level of K also brought an increase in ash content of tubers (%). This may be due to the fact that higher quantity of K encourages higher absorption of minerals and their subsequent translocation from the leaves and accumulation in the tubers and enhancing ash content. This result is in accordance with observations made by Khan *et al.,* (2012) in potato.

Nutrient content of tubers at harvest

Effect of different doses or levels of N and K on nutrient content viz., Nitrogen (N) content, Phosphorus (P) content and Potassium (K) content of sweet potato tubers are discussed as follows along with the data represented in Table 15.

Nitrogen content of tubers (%)

The nitrogen content (%) of the tubers showed an increasing trend with an increased application of N. Maximum nitrogen content in tubers was exhibited from N_3 (0.36 %) which was found to be at par with N_2 (0.34 %). Minimum nitrogen content was observed from N_0 (0.29 %)which was found to be at par with N_1 (0.31 %).

Increase in dosage or level of K also brought about an increase in nitrogen content of tubers. Highest nitrogen (N) content in tubers was observed from K_3 with 0.38 % which was significantly higher compared to other doses of K. Minimum nitrogen content (0.27%) in tubers was observed from K_0.

Phosphorus content of tubers (%)

The total phosphorus content (%) of the tubers showed an increasing trend with an increased application of N. Maximum phosphorus content in tubers was exhibited from N_3 (0.31%) which was found to be at par with N_2 (0.30%) and N_1 (0.29 %). Minimum phosphorus content was observed from N_0 which was 0.28 % which was observed to be at par with N_1 (0.29%). Increase in dosage or level of K also brought about an increase in phosphorus content of tubers. Highest phosphorus (P) content in tubers was obtained from K_3 with 0.32 % which was found to be at par with K_2 (0.30 %). Minimum P content in tubers (0.27%) was observed from K_0 which was observed to be at par with K_1 (0.29 %).

Potassium content of tubers (%)

The potassium content (%) of the tubers showed an increasing trend with an increased application of N. Maximum potassium content in tubers was exhibited from N_3 (1.07 %) which was found to be at par with N_2 (0.95 %) and N_1 (0.89 %). Minimum potassium content was observed from N_0 (0.79%).

Increase in dosage or level of K also brought about an increase in potassium content of tubers. Highest potassium content in tubers was observed from K_3 with 1.16 % which was at par with K_2 (1.00 %). Minimum potassium content (0.70 %) in tubers was observed from K_0 which was found to be at par with K_1 (0.84 %).

Discussions on effect of N on NPK content of tubers

The nutrient content (NPK) of the tubers showed an increasing trend with an increased application of N. The increase may be due to availability of more nitrogen in the soil which enabled the plants to absorb more of these nutrients over a large area of soil stimulating the tuber growth and in turn, increased the content of N. This observation in which N content in tubers increased with increasing level of N application in tubers was also observed by Anand (1986) in potato, Mehran and Samad (2013) in sugarbeet and Yourtchi *et al.,* (2013) in potato.

Discussions on effect of K on NPK content of tubers

Increasing dosage or level of K also brought about an increase in nutrient (NPK) content of tubers. This may be due to potassium's role in enhancing cellular activity and due to the high mobility of K nutrient in the plant which may have led to better shoot and root growth and development of plant parts leading to better absorption of nutrients, and hence leading to higher concentration of potassium in tubers. This is in accordance with the results of Anand (1986) in potato, Abdel-Mawly and Zanouny (2004) in sugar beet and by Abd El-Baky *et al.,* (2010) in sweet potato.

Effect of interaction on quality characters

Interaction between the different levels of N and K did not exhibit any significant difference between the treatments in relation to quality characters mentioned above.

Economics

During the experiment, the details of materials utilized, operation carried out and labour engaged during the study were recorded. The cost of cultivation of sweet potato per hectare, cultivation cost of each treatment combination and value of returns per hectare for different treatment combinations are indicated in Table 16.

Cost of cultivation (₹)

Highest cost of cultivation was observed in N_3 x K_3 i.e., in a combination of 65 kg/ha of N and 65 kg/ha of K with a total cost of cultivation adding up to ₹ 1,00,407.25 and lowest cost of cultivation observed in N_0 x K_0 i.e., a combination of 0 kg/ha of both N and K which cost ₹ 92,214.00 for sweet potato cultivation under the current study.

Gross monetary returns (₹ /ha)

The treatment combination of 65 kg/ha of N and 50 kg/ha of K i.e., N_3 x K_2 recorded highest gross returns of ₹ 4, 31,874.00/ha which was followed by a combination of 65 kg/ha of N and 65 kg/ha of K i.e., N_3 x K_3 with gross returns of ₹ 4,22,200.99/ha and in a combination of 50 kg/ha of N and 50 kg/ha of K i.e., N_2 x K_3 which gave gross monetary returns of ₹ 4,12,533.49/ha. Minimum gross returns was fetched from a combination of 0 kg/ha of both N and K i.e., N_0 x K_0 with a return of ₹ 1, 31,550.33/ha.

Net monetary returns (₹ /ha)

Highest net return was fetched from a combination of 65 kg/ha of N and 50 kg/ha of K i.e., N_3 x K_2 recorded highest net return of ₹ 3,32,218.25/ha followed by a combination of 65 kg/ha of N and 65 kg/ha of K i.e., N_3 x K_3 (T_{16}) with net return of ₹ 3,21,793.74/ha and in a combination of 50 kg/ha of N and 50 kg/ha of K i.e., N_2 x K_3 which gave net monetary return of ₹ 3,13,265.49/ha. Minimum net returns was fetched from a combination of 0 kg/ha of both N and K i.e., N_0 x K_0 with a return of ₹ 39,336.33/ha.

B: C ratio

As per the data, it was revealed that the highest benefit:cost ratio was obtained from a combination of 65 kg/ha of N and 50 kg/ha of K i.e., N_3 x K_2 which recorded a value of 3.33 which was followed by a combination of 65 kg/ha of N and 65 kg/ha of K i.e., N_3 x K_3 with B: C ratio of 3.20 and in a combination of 50 kg/ha of N and 50 kg/ha of K i.e., N_2 x K_3 which gave B: C ratio of 3.16 while minimum B: C ratio was recorded in a combination of 0 kg/ha of both N and K i.e., N_0 x K_0 with a B: C ratio of 0.43.

Based on the current research findings, it can be concluded that different levels of nitrogen and potassium influenced the growth, yield and quality of sweet potato and it can be inferred that 65 kg/ha of N i.e., N_3 and 65 kg/ha of K i.e., K_3 were better in increasing the aforementioned characters.

The benefit cost ratio (B: C ratio) can be increased by a combination of 65 kg/ha of N and 50 kg/ha of K i.e., N_3 x K_2 (T_{15}) which gave a B: C ratio of 3.33 followed by a combination of 65 kg/ha of N (N_3) and 65 kg/ha of K (K_3) i.e., N_3 x K_3 (T_{16}) which gave a B: C ratio of 3.20. Therefore, application of 65 kg/ha N + 50 kg/ha K_2O per hectare can be recommended for sweet potato cultivation on the basis of B: C ratio while 65 kg/ha of N and 65 kg/ha of K_2O can be recommended on the basis of overall performance of the crop in Imphal area.

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