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Studies on effect of nitrogen and potassium nutrition on growth of potato (*Solanum tuberosum* L.) under Southern Telangana Zone

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Abstract
In an experiment laid out in FRBD to evaluate the growth characteristics of potato grown under different fertilizer regimes *viz*., four nitrogen levels [85 kg ha^{-1}, 115 kg ha^{-1}, 145 kg ha^{-1} and 175 kg ha^{-1}] and five potassium levels [60 kg ha^{-1}, 90 kg ha^{-1}, 120 kg ha^{-1}, 150 kg ha^{-1} and 180 kg ha^{-1}] to evaluate the growth characters like plant height (cm), number of leaves, fresh and dry weight of roots (g), fresh and dry weight of haulms (g) and root to shoot ratio, it was revealed that the highest plant height was recorded in N_4K_2 (68.26 cm) and number of leaves in N_3K_2 (17.47).

Keywords: *Solanum tuberosum*, fertilizer, drip irrigation

Introduction
Potato (*Solanum tuberosum* L.) produces more dry-matter, balanced protein and more calories from unit area of land and time compared to other major food crops. It is an important source of energy in human nutrition all over the world.

Nitrogen is the crucial macronutrient for plant growth and biomass development. It is an essential constituent of various metabolically active compounds like amino acids, proteins, nucleic acids, pyrimidines, flavines, purines, nucleoproteins, enzymes, alkaloids *etc*. Potato responds well for supplemental application of nitrogen and amounts less or more than its requirements or early and late application of nitrogen will affect quantitative and qualitative yield of tuber (Rezaei and Soltani, 1996) [5]. Sufficient use of nitrogen fertilizers in early growth season will help in leaf expansion and increase photo assimilates. Potassium has a crucial role in higher productivity of potato tubers because it plays an important role in photosynthesis, regulation of opening and closing of stomata, favors high energy status which helps in timely and appropriate nutrients translocation and water uptake in plants (Bergmann, 1992) [1]. It also affects yield, quality, general health and vigor of plant. Hence, the present experiment was planned to study the effect of different levels of nitrogen and potassium on growth characteristics of potato.

Materials and Methods
The seed material of potato variety kufri phukraj used for experimentation was procured from farmers of Zaheerabad, Telangana. The field experiment was conducted at Rajendranagar, is situated at an altitude of 536 m above mean sea level on 78°.40' East longitude and 17°.32' North latitude. The climate is semi-arid. The experiment was conducted in factorial randomized block design (FRBD) with three replications. The soil of the experimental site is sandy loam in texture with pH of 6.7 and drip irrigation method of irrigation was followed. Nitrogen and potassium fertilizers were applied at 21, 30 and 50 days intervals with equal amount of doses as per calculated. The data was recorded at 30, 60 and 90 days after planting for plant height and number of leaves. Fresh and dry weight of roots and haulms was recorded at harvest.

Observations recorded
Plant height (cm), number of leaves per plant, fresh weight of roots (g), dry weight of roots (g), fresh weight of haulms (g), dry weight of haulms (g) and shoot to root ratio were recorded as per the standard procedures in vogue.

Results and Discussion
Plant height (cm)
The data pertaining to plant height at 30, 60 and 90 DAP as influenced by the nitrogen and

potassium levels are presented in the table 1.
The maximum plant height (38.70, 61.89 and 66.30 cm) was observed in nitrogen level N_3 and minimum plant height (24.33, 52.51 and 54.93 cm) was recorded in nitrogen level N_1. Among different potassium levels, maximum and minimum plant height (60.76 and 56.27 cm) was observed in potassium level K_2 and K_4 at 60 DAP. Among the interactions, maximum plant height (41.71 and 66.28 cm) was recorded in N_3K_2 and N_4K_5 at 30 and 60 DAP. While lowest plant height (22.21 and 51.05 cm) was observed in N_1K_1 at 30 and 60 DAP. Increase in plant height, number of leaves and shoot with increase in nitrogen levels may be due to the fact that higher nitrogen concentration stimulated the assimilation of carbohydrates and protein, which in turn enhanced cell division and formation of more tissues that resulted in enhanced vegetative growth of the plant and also in the production of stem and axillary branches. On the contrary to the present findings have been reported by Bista *et al.* (2019) [3] and Sharma *et al.* (2019) [7].

Number of leaves
The data pertaining to number of leaves at 30, 60 and 90 DAP as influenced by the nitrogen and potassium levels are presented in the table 2.
Highest number of leaves 11.97 and 15.91 was observed in N_3 and 16.36 was in N_4 and lowest number of leaves 10.90, 14.14 and 14.13 were recorded in N_1 at 30, 60 and 90 DAP. Among the potassium levels highest and lowest number of leaves 12.34 and 10.89 were found in K_2 and K_4 at 30 DAP. Among the interactions maximum number of leaves 13.81, 16.63 and 17.47 were recorded in N_3K_2, N_3K_5 and N_3K_2 at 30, 60 and 90 DAP and minimum number of leaves 9.78, 13.15 and 13.59 were recorded in N_1K_4, N_1K_5 and N_1K_3 at 30, 60 and 90 DAP. There was an increase in the number of leaves per plant with increase in levels of N and K and as the crop growth period progressed which might be due to the increased and uninterrupted photosynthesis started from early growth stages. Similar number of leaves to nutrient management has also been found by Sahu *et al*. (2011) [6] and Singh *et al*. (2012) [8].

Fresh weight of roots (g)
The data pertaining to fresh weight of roots at harvest as influenced by the nitrogen and potassium levels are presented in the table 3.
At 90 DAP, N_3 has recorded highest fresh weight of roots (5.66 g) while lowest (4.30 g) was recorded in N_1. K_5 has recorded highest fresh weight of roots (5.85 g) while lowest fresh weight of roots (4.43 g) was recorded in K_1. Among all the interactions N_3K_5 has recorded highest fresh weight of roots (6.57 g) on 90 DAP while lowest fresh weight of roots (3.95 g) was recorded in N_1K_1.

Dry weight of roots (g)
The data pertaining to dry weight of roots at harvest as influenced by the nitrogen and potassium levels are presented in the table 3.
At 90 DAP, N_4 has recorded maximum dry weight of roots (1.13 g) while minimum (0.94 g) was recorded in N_1. K_5 has recorded highest dry weight of roots (1.14 g) while lowest dry weight of roots (1.05 g) was recorded in K_1. Among all the interactions N_3K_1 has recorded maximum dry weight of roots (1.25 g) on 90 DAP while lowest dry weight of roots (0.87 g) was recorded in N_1K_3.

Fresh weight of haulms (g)
The data pertaining to fresh weight of haulms at harvest as influenced by the nitrogen and potassium levels are presented in the table 3.
At 90 DAP, N_3 has recorded highest fresh weight of haulms (228.03 g) while lowest (191.30 g) was recorded in N_1. K_5 has recorded highest fresh weight of haulms (211.99 g) while lowest fresh weight of haulms (207.06 g) was recorded in K_3. Among all the interactions N_3K_5 has recorded highest fresh weight of haulms (230.78 g) on 90 DAP while lowest fresh weight of haulms (184.85 g) was recorded in N_1K_1. Application of higher dose of nitrogen and potassium resulted in increase in the plant height and number of leaves thereby increasing the fresh weight of shoot per plant as a result of increased production of dry matter. These findings are in accordance with those reported by Mechao and Sunita *et al*. (2018) [4].

Dry weight of haulms (g)
The data pertaining to dry weight of haulms at harvest as influenced by the nitrogen and potassium levels are presented in the table 3.
At 90 DAP, N_4 has recorded highest dry weight of haulms (28.70 g) while lowest (25.08 g) was recorded in N_1. K_5 has recorded highest dry weight of haulms (28.17 g) while lowest dry weight of haulms (26.91 g) was recorded in K_1. These findings were in agreement with the Sahu *et al*. (2011) [6] and Behera *et al*. (2019) [2].

Root to shoot ratio
The data pertaining to root to shoot ratio at harvest as influenced by the nitrogen and potassium levels are presented in the table 3.
At 90 DAP, N_4 has recorded maximum root to shoot ratio (0.47) while minimum (0.42) was recorded in N_1. Among all the interactions N_4K_5, N_4K_2, N_3K_5 and N_3K_4 has recorded maximum root to shoot ratio (0.48) on 90 DAP while minimum root to shoot ratio (0.40) was recorded in N_1K_3.

Conclusion
The results from the analysis of growth parameters revealed that highest plant height was recorded in N_4K_2 (68.26 cm), number of leaves in N_3K_2 (17.47), fresh weight of haulms in N_3K_5 (230.78 g), dry weight of haulms in N_4K_5 (29.21 g), fresh weight of roots in N_3K_5 (6.57 g), dry weight of roots in N_3K_1 (1.25 g) and root to shoot ratio in N_4K_5, N_4K_2, N_3K_5 and N_3K_4 (0.48).

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Table 1: Effect of levels of nitrogen, potassium and their interactions on plant height (cm) of potato cv. Kufri phukraj.

Factors Factor N: Nitrogen Levels	At 30 DAP	At 60 DAP	At 90 DAP (harvest)
N_1	24.33	52.51	54.93
N_2	33.75	59.26	61.84
N_3	38.70	61.89	66.30
N_4	37.31	61.16	64.24
S.E(m)±	0.68	0.77	0.87
C.D at 5%	1.97	2.21	2.51
Factor K: Potassium Levels			
K_1	32.78	57.79	59.81
K_2	33.33	60.76	63.07
K_3	34.49	58.22	62.59
K_4	32.80	56.27	60.89
K_5	34.21	60.50	62.79
S.E(m)±	0.76	0.86	0.97
C.D at 5%	NS	2.48	NS
N x K: Interaction Effect			
N_1K_1	22.21	51.05	52.28
N_1K_2	23.31	53.54	54.65
N_1K_3	24.48	52.35	58.54
N_1K_4	25.04	52.34	55.08
N_1K_5	26.63	53.30	54.10
N_2K_1	32.82	60.02	62.41
N_2K_2	32.24	58.43	61.40
N_2K_3	35.23	58.12	62.26
N_2K_4	32.41	57.02	59.18
N_2K_5	36.05	62.73	63.95
N_3K_1	41.28	60.18	61.74
N_3K_2	41.71	66.10	67.96
N_3K_3	38.95	64.04	67.92
N_3K_4	35.31	59.42	68.00
N_3K_5	36.26	59.71	65.91
N_4K_1	34.84	59.92	62.80
N_4K_2	36.06	64.96	68.26
N_4K_3	39.32	58.36	61.65
N_4K_4	38.43	56.29	61.30
N_4K_5	37.92	66.28	67.22
S.E(m)±	1.53	1.72	1.95
C.D at 5%	4.42	4.96	NS

N_1- 85 kg/ha	N_2- 115 kg/ha	N_3- 145 kg/ha	N_4- 175 kg/ha	
K_1- 60 kg/ha	K_2- 90 kg/ha	K_3- 120 kg/ha	K_4- 150 kg/ha	K_5- 180 kg/ha

Table 2: Effect of levels nitrogen, potassium and their interactions on number of leaves of potato cv. Kufri phukraj.

Factors Factor N: Nitrogen Levels	At 30 DAP	At 60 DAP	At 90 DAP
N_1	10.90	14.14	14.13
N_2	11.37	14.49	15.26
N_3	11.97	15.91	16.18
N_4	11.85	15.86	16.36
S.E(m)±	0.19	0.24	0.19
C.D at 5%	0.56	0.70	0.57
Factor K: Potassium Levels			
K_1	11.57	14.83	15.43
K_2	12.34	15.14	15.78
K_3	11.63	15.27	15.03
K_4	10.89	14.83	15.43
K_5	11.18	15.43	15.75
S.E(m)±	0.21	0.27	0.22
C.D at 5%	0.62	NS	NS
N x K: Interaction Effect			
N_1K_1	11.62	14.75	14.20
N_1K_2	11.66	15.04	15.11
N_1K_3	11.54	14.44	13.59
N_1K_4	9.78	13.31	14.09

N_1K_5	9.92	13.15	13.69
N_2K_1	11.41	13.56	15.09
N_2K_2	11.54	13.80	14.58
N_2K_3	11.16	13.88	14.61
N_2K_4	11.40	14.82	15.87
N_2K_5	11.36	16.42	16.18
N_3K_1	11.28	15.08	15.68
N_3K_2	13.81	16.43	17.47
N_3K_3	12.78	16.51	15.19
N_3K_4	11.09	14.91	15.28
N_3K_5	10.89	16.63	17.28
N_4K_1	11.98	15.93	16.77
N_4K_2	12.36	15.32	15.97
N_4K_3	11.04	16.24	16.74
N_4K_4	11.31	16.29	16.49
N_4K_5	12.56	15.52	15.84
S.E(m)±	0.43	0.55	0.44
C.D at 5%	1.25	1.58	1.27

N_1- 85 kg/ha	N_2- 115 kg/ha	N_3- 145 kg/ha	N_4- 175 kg/ha	
K_1- 60 kg/ha	K_2- 90 kg/ha	K_3- 120 kg/ha	K_4- 150 kg/ha	K_5- 180 kg/ha

Table 3: Effect of levels of nitrogen, potassium and their interactions on growth characters at 90 DAP of potato cv. Kufri Phukraj.

Factors Factor N: Nitrogen Levels	Fresh weight of roots (g)	Dry weight of roots (g)	Fresh weight of haulms (g)	Dry weight of haulms (g)	Root to Shoot ratio
N_1	4.30	0.94	191.30	25.08	0.42
N_2	5.14	1.09	214.71	27.33	0.43
N_3	5.66	1.11	228.03	28.61	0.46
N_4	5.55	1.13	206.18	28.70	0.47
S.E(m)±	0.08	0.01	1.08	0.16	0.005
C.D at 5%	0.25	0.05	3.10	0.46	0.01
Factor K: Potassium Levels					
K_1	4.43	1.05	210.31	26.91	0.44
K_2	4.87	1.06	209.36	27.06	0.44
K_3	4.95	1.05	207.06	27.51	0.44
K_4	5.71	1.05	211.55	27.51	0.45
K_5	5.85	1.14	211.99	28.17	0.46
S.E(m)±	0.09	0.02	1.20	0.18	0.005
C.D at 5%	0.28	0.06	3.47	0.52	NS
N x K: Interaction Effect					
N_1K_1	3.95	0.90	184.85	24.46	0.41
N_1K_2	4.51	0.94	184.91	24.47	0.41
N_1K_3	4.27	0.87	188.11	24.78	0.40
N_1K_4	4.35	0.99	194.05	25.35	0.43
N_1K_5	4.44	1.00	204.58	26.36	0.45
N_2K_1	4.64	1.03	209.05	26.79	0.45
N_2K_2	4.75	1.12	209.45	26.83	0.44
N_2K_3	4.52	1.13	218.58	27.71	0.44
N_2K_4	5.69	1.02	212.25	27.10	0.42
N_2K_5	6.08	1.17	224.21	28.24	0.43
N_3K_1	4.66	1.25	225.05	28.33	0.44
N_3K_2	4.93	1.04	226.45	28.46	0.45
N_3K_3	5.66	1.03	229.18	28.72	0.47
N_3K_4	6.51	1.02	228.71	28.68	0.48
N_3K_5	6.57	1.20	230.78	28.88	0.48
N_4K_1	4.50	1.01	222.31	28.06	0.45
N_4K_2	5.30	1.12	216.65	28.49	0.48
N_4K_3	5.35	1.18	192.38	28.84	0.47
N_4K_4	6.31	1.18	211.18	28.91	0.46
N_4K_5	6.32	1.19	188.38	29.21	0.48
S.E(m)±	0.19	0.04	2.41	0.36	0.01
C.D at 5%	0.57	0.12	6.95	NS	0.03

N_1- 85 kg/ha	N_2- 115 kg/ha	N_3- 145 kg/ha	N_4- 175 kg/ha	
K_1- 60 kg/ha	K_2- 90 kg/ha	K_3- 120 kg/ha	K_4- 150 kg/ha	K_5- 180 kg/ha

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