



# Studies on the Effect of Integrated Nutrient Management in Growth of Potato (Cv. Kufri Chandramukhi) Cultivation under Telangana Conditions

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## **Authors' contributions**

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

**Aim:** To study the effect of integrated nutrient management in growth of potato.

**Study Design:** The experiment was laid out in RBD with 13 treatments and replicated thrice.

**Place and Duration of Study:** The present investigation was carried out at Sri Konda Laxman Telangana State Horticultural University, Mulugu, Siddipet district, Telangana during the *rabi*, 2021-22 and *rabi*, 2022-23.

**Results:** Among the treatments, T<sub>12</sub> treatment (75 % Recommended dose of NPK+ Organic NPK with micronutrients + Organic NPK + Organic based micronutrients + Organic phosphorus + Organic potash) was recorded significantly highest growth parameters like plant height (53.10 cm and 71.74 cm), leaf length (24.09 cm and 25.74 cm), leaf width (16.29 cm and 21.03 cm), leaf area (119.40 cm<sup>2</sup> and 157.41 cm<sup>2</sup>), leaf area index (0.133 and 0.175), plant spreading (52.00 cm at E-W & 49.85 cm at N-S and 69.00 cm at E-W & 68.50 cm at N-S) and stem diameter (0.60 cm and 1.15 cm) at 30 and 60 DAP respectively. While number of main stems per plant was not affected by the imposed treatments during both the seasons.

**Keywords:** Growth; nitrogen; phosphorus; potassium and micronutrients.

## 1. INTRODUCTION

Potato (*Solanum tuberosum* L.) is a popular tuber crop that contributes to global food security (Karam *et al.*, 2009) and belongs to the family Solanaceae. It was originated in Peru Bolivia in the Andes (South America) with the fundamental chromosome number (x=12) (Hawkes, 1990). Potato has the highest food value in terms of dry matter and is also the most nutritious in terms of calorific value (Khurana, 1978). It also contains a high concentration of important amino acids like leucine, tryptophane and isoleucine (Khurana and Naik, 2003). The tubers are one of the richest sources of the B complex group of vitamins such as pyridoxine, thiamin, niacin, pantothenic acid and folates. Fresh potato is a good source of antioxidants and vitamin C (Gray and Hughes, 1978). In addition, it includes calcium, phosphorus and iron. Potato proteins are of equivalent quality to egg and milk proteins. Food and Agricultural Organization has selected this crop as a future food crop and based on its nutritional value and production capability declared the year 2008 as the "International Year of Potato". Potato is used to make potato flour, chips, puffs, french fries, frozen potato and raw material for alcohol production (Abdeldagir *et al.*, 2003).

The entire area under cultivation in India is 2.208 million hectare with a production of 53.603 million metric tonnes (NHB, 2021-22). The leading

states in term of production are Uttar Pradesh, West Bengal, Bihar, Gujarat, Madhya Pradesh and Punjab. In Telangana State, the production of potato is 38.99 thousand tonnes from 1.63 thousand hectare area (Anonymous, 2021-22). Potato production in Telangana is limited to the erstwhile district of Medak, Sangareddy, Siddipet and Vikarabad.

Potato necessitates a high quantity of soil nutrients due to its underdeveloped and shallow root system in proportion to yield (Perrenoud, 1983). Because of the fast rate of dry matter generation, substantial amount of soil nutrients are consumed per unit time, which most soils are unable to replenish. As a result, nutrition application from external sources such as fertilizers becomes critical. The indiscriminate applications of chemical fertilizers had a number of negative consequences, including a decrease in soil microbial activity, a decrease in soil humus and increased contamination of soil, water and air. Because of these problems, integrated nutrient management strategy used to improve potato yield in which organic and inorganic fertilizers are utilized to keep soil healthy by lowering farmer's cultivation costs (Kumar *et al.*, 2022).

Adopting organic farming practices through proteino lacto gluconate based bioavailable nutrients enhances soil fertility, soil organic carbon (SOC), prevents mineral nutrients from

forming insoluble precipitates, reduces the toxicity of some metal ions to plants, prevents nutrients from leaching, increases plant nutrient mobility and suppresses the growth of plant pathogens (Kumar *et al.*, 2021). These products are made from natural ingredients with microbial actions through fermentation. These formulations are ideal substitutes for inorganic nutrients in organic farming. These nutrients increase the enzymatic activity like urease, phosphatase and dehydrogenase in soil resulting in more microbial activity and greater uptake of nutrients from the soil (Reddy and Reddy, 2011). Keeping this in mind the current research work has been formulated with studies on the effect of integrated nutrient management on growth of potato (Cv. Kufri Chandramukhi) cultivation under Telangana conditions".

## 2. MATERIALS AND METHODS

The present experiment was conducted for two cropping seasons during *rabi*, 2021-22 and *rabi*, 2022-23 at the PG research farm, Sri Konda Laxman Telangana State Horticultural University, Mulugu, Siddipet district, Telangana. The experimental site is located at a latitude of 17°43'02" N and a longitude of 78°37'34" E. The soil of the experimental site was sandy loam in texture having organic carbon (0.87 and 0.89 %), PH (7.73 and 7.85), Electrical conductivity (0.16 and 0.20 Ds/m), available nitrogen (136.67 and 143.26 kg/ha), available phosphorus (14.49 and 16.00 kg/ha) and available potassium (181.31 and 265 kg/ha) during *rabi*, 2021-22 and *rabi*, 2022-23 respectively. The experiment was laid out in RBD with 13 treatments *i.e.*, T<sub>1</sub>: 50 % Recommended dose of NPK + Organic NPK with micronutrients, T<sub>2</sub>: 50 % Recommended dose of NPK + Organic NPK, T<sub>3</sub>: 50 % Recommended dose of NPK + Organic based micronutrients, T<sub>4</sub>: 50 % Recommended dose of NPK + Organic phosphorus, T<sub>5</sub>: 50 % Recommended dose of NPK + Organic potash, T<sub>6</sub>: 75 % Recommended dose of NPK + Organic NPK with micronutrients, T<sub>7</sub>: 75 % Recommended dose of NPK + Organic NPK, T<sub>8</sub>: 75 % Recommended dose of NPK + Organic based micronutrients, T<sub>9</sub>: 75 % Recommended dose of NPK+ Organic phosphorus, T<sub>10</sub>: 75 % Recommended dose of NPK + Organic potash, T<sub>11</sub>: 50 % Recommended dose of NPK+ Organic NPK with micronutrients + Organic NPK + Organic based micronutrients + Organic phosphorus + Organic potash, T<sub>12</sub>: 75 % Recommended dose of NPK+ Organic NPK with micronutrients + Organic NPK + Organic based micronutrients + Organic phosphorus + Organic

potash and T<sub>13</sub>: 100 % Recommended dose of NPK (120:240:120 kg NPK/ha) and replicated thrice.

The data on the growth parameters of the crop were recorded at different intervals at 30, 60 DAP and at harvest. The plant height was measured from ground level to the tip of the main shoot with the help of a scale. The number of main stems per plant was recorded in selected five tagged plants in each plot. The leaf length, leaf width and leaf area was measured with the help of a leaf area meter in five randomly selected plants. The data on the leaf area index was calculated using the formula given by Williams (1946).

$$\text{Leaf Area Index (LAI)} = \frac{\text{Total leaf area (cm}^2\text{)}}{\text{Ground area (cm}^2\text{)}}$$

The plant spreading was measured in the North-South and East-West directions with the help of scale. The stem diameter was measured with the help of vernier callipers in each tagged five plants. The data pertaining to all characters like plant height, number of main stems per plant, leaf length, leaf width, leaf area, leaf area index and plant spreading studied were subjected to statistical analysis by using Analysis of Variance (ANOVA) technique as described by Panse and Sukhatme (2000).

## 3. RESULTS AND DISCUSSION

The experimental results revealed that a significant difference observed in all growth parameters at all stages of crop growth in both the seasons due to integrated nutrient management. Obtained results revealed that a rapid increase in growth was observed up to 60 DAP and recorded maximum value at 60 DAP in both the seasons, while due to senescence the crop was completely ceased at harvest.

The results related to pooled data of two seasons on growth parameters revealed that among the treatments, T<sub>12</sub> recorded highest values for plant height (53.10 cm and 71.74 cm), leaf length (24.09 cm and 25.74 cm), leaf width (16.29 cm and 21.03 cm), leaf area (119.40 cm<sup>2</sup> and 157.41 cm<sup>2</sup>), leaf area index (0.133 and 0.175), plant spreading (52.00 cm at E-W & 49.85 cm at N-S and 69.00 cm at E-W & 68.50 cm at N-S) and stem diameter (0.60 cm and 1.15 cm) at 30 and 60 DAP respectively.

**Table 1. Effect of integrated nutrient management on plant height (cm) and number of main stems per plant of potato Cv. Kufri Chandramukhi**

Treatments	Plant height (cm)						Number of main stems		
	30 DAT			60 DAT			At harvest		per plant
	2021-22 (Rabi)	2022-23 (Rabi)	Pooled	2021-22 (Rabi)	2022-23 (Rabi)	Pooled	2021-22 (Rabi)	2022-23 (Rabi)	
T <sub>1</sub>	44.59	47.50	46.04	62.06	66.19	64.12	Dried	7.07	7.07
T <sub>2</sub>	43.54	46.89	45.22	61.30	65.46	63.38	Dried	6.87	7.27
T <sub>3</sub>	37.79	38.35	38.07	54.09	54.93	54.51	Dried	6.20	7.47
T <sub>4</sub>	39.38	41.56	40.47	56.15	57.71	56.93	Dried	6.20	6.50
T <sub>5</sub>	39.78	41.79	40.79	57.69	60.23	58.96	Dried	6.53	6.83
sT <sub>6</sub>	49.24	52.45	50.84	67.52	71.55	69.54	Dried	7.40	7.60
T <sub>7</sub>	46.80	50.07	48.44	65.60	68.01	66.81	Dried	7.27	7.43
T <sub>8</sub>	41.59	45.94	43.77	60.56	63.04	61.80	Dried	6.67	6.83
T <sub>9</sub>	40.47	45.10	42.78	59.33	61.65	60.49	Dried	5.73	6.53
T <sub>10</sub>	45.75	48.80	47.28	63.93	67.45	65.69	Dried	6.40	6.93
T <sub>11</sub>	49.18	52.13	50.66	66.64	71.20	68.92	Dried	6.93	7.13
T <sub>12</sub>	52.53	53.67	53.10	69.30	74.18	71.74	Dried	6.60	7.40
T <sub>13</sub>	48.91	51.75	50.33	66.19	69.89	68.04	Dried	7.07	7.07
CD (P=0.05) for Treatments	3.81	4.10	2.73	5.35	5.54	3.75	-	NS	0.28
CD (P=0.05) for Years			1.07			1.47			
SEm ± for Treatments	1.31	1.40	0.96	1.83	1.90	1.32	-	0.73	0.10
SEm ± for Years			0.38			0.52			
CV	5.08	5.13	5.11	5.09	5.02	5.05	-		

**Table 2. Effect of integrated nutrient management on leaf length (cm) at different growth stages of potato Cv. Kufri Chandramukhi**

Treatments	Leaf length (cm)							
	30 DAP			60 DAP			At harvest	
	2021-22 (Rabi)	2022-23 (Rabi)	Pooled	2021-22 (Rabi)	2022-23 (Rabi)	Pooled	2021-22 (Rabi)	2022-23 (Rabi)
T <sub>1</sub>	16.86	18.13	17.50	20.47	21.01	20.74	Dried	Dried
T <sub>2</sub>	16.13	17.51	16.82	20.03	20.12	20.07	Dried	Dried
T <sub>3</sub>	11.69	12.51	12.10	13.17	14.12	13.64	Dried	Dried
T <sub>4</sub>	11.96	14.07	13.01	15.87	16.36	16.11	Dried	Dried
T <sub>5</sub>	12.70	14.83	13.77	16.70	16.94	16.82	Dried	Dried
T <sub>6</sub>	22.25	23.90	23.08	23.90	24.90	24.40	Dried	Dried
T <sub>7</sub>	19.00	20.53	19.77	21.93	22.15	22.04	Dried	Dried
T <sub>8</sub>	15.78	16.93	16.36	18.17	18.29	18.23	Dried	Dried
T <sub>9</sub>	14.84	16.11	15.48	17.34	17.79	17.56	Dried	Dried
T <sub>10</sub>	18.33	19.77	19.05	21.28	21.39	21.34	Dried	Dried
T <sub>11</sub>	21.99	23.53	22.76	23.30	24.02	23.66	Dried	Dried
T <sub>12</sub>	23.32	24.85	24.09	25.10	26.38	25.74	Dried	Dried
T <sub>13</sub>	21.61	23.38	22.50	22.60	23.76	23.18	Dried	Dried
CD (P=0.05) for Treatments	1.66	1.78	1.19	1.75	1.98	1.29	-	-
CD (P=0.05) for Years			0.47			0.50		
SEm ± for Treatments	0.57	0.61	0.42	0.60	0.68	0.45	-	-
SEm ± for Years			0.16			0.18		
CV	5.64	5.59	5.62	5.19	5.71	5.46	-	-

**Table 3. Effect of integrated nutrient management on leaf width (cm) at different growth stages of potato Cv. Kufri Chandramukhi**

Treatments	Leaf width (cm)							
	30 DAP			60 DAP			At harvest	
	2021-22 (Rabi)	2022-23 (Rabi)	Pooled	2021-22 (Rabi)	2022-23 (Rabi)	Pooled	2021-22 (Rabi)	2022-23 (Rabi)
T <sub>1</sub>	12.20	14.19	13.20	16.75	18.65	17.70	Dried	Dried
T <sub>2</sub>	12.02	13.88	12.95	16.41	18.28	17.35	Dried	Dried
T <sub>3</sub>	9.43	11.16	10.30	13.01	15.85	14.43	Dried	Dried
T <sub>4</sub>	10.07	12.09	11.08	13.98	16.34	15.16	Dried	Dried
T <sub>5</sub>	10.28	12.24	11.26	14.95	16.81	15.88	Dried	Dried
T <sub>6</sub>	14.16	16.11	15.14	19.50	21.37	20.43	Dried	Dried
T <sub>7</sub>	13.53	15.12	14.32	17.61	20.02	18.81	Dried	Dried
T <sub>8</sub>	11.80	13.40	12.60	15.88	17.86	16.87	Dried	Dried
T <sub>9</sub>	10.98	12.85	11.92	15.56	17.48	16.52	Dried	Dried
T <sub>10</sub>	12.84	14.81	13.82	17.43	19.69	18.56	Dried	Dried
T <sub>11</sub>	14.09	15.94	15.01	19.03	20.93	19.98	Dried	Dried
T <sub>12</sub>	15.47	17.12	16.29	20.10	21.95	21.03	Dried	Dried
T <sub>13</sub>	13.99	15.93	14.96	18.89	20.86	19.88	Dried	Dried
CD (P=0.05) for Treatments	1.24	1.68	1.02	1.61	1.64	1.12	-	-
CD (P=0.05) for Years			0.40			0.44		
SEm ± for Treatments	0.43	0.57	0.36	0.55	0.56	0.39	-	-
SEm ± for Years			0.14			0.15		
CV	5.96	7.00	6.59	5.68	5.13	5.39	-	-

**Table 4. Effect of integrated nutrient management on leaf area (cm<sup>2</sup>) at different growth stages of potato Cv. Kufri Chandramukhi**

Treatments	Leaf area (cm <sup>2</sup> )							
	30 DAP			60 DAP			At harvest	
	2021-22 (Rabi)	2022-23 (Rabi)	Pooled	2021-22 (Rabi)	2022-23 (Rabi)	Pooled	2021-22 (Rabi)	2022-23 (Rabi)
T <sub>1</sub>	104.40	107.59	105.99	139.35	148.33	143.84	Dried	Dried
T <sub>2</sub>	101.93	105.19	103.56	136.85	147.08	141.97	Dried	Dried
T <sub>3</sub>	83.52	91.17	87.35	122.53	132.40	127.46	Dried	Dried
T <sub>4</sub>	86.33	94.57	90.45	124.85	136.86	130.86	Dried	Dried
T <sub>5</sub>	90.95	96.73	93.84	129.61	139.57	134.59	Dried	Dried
T <sub>6</sub>	114.05	117.33	115.69	149.45	160.60	155.03	Dried	Dried
T <sub>7</sub>	110.55	112.30	111.43	144.01	154.39	149.20	Dried	Dried
T <sub>8</sub>	98.80	102.44	100.62	133.08	144.62	138.85	Dried	Dried
T <sub>9</sub>	97.29	99.77	98.53	131.44	141.97	136.71	Dried	Dried
T <sub>10</sub>	107.76	109.88	108.82	140.74	151.52	146.13	Dried	Dried
T <sub>11</sub>	113.46	116.90	115.18	148.16	158.91	153.54	Dried	Dried
T <sub>12</sub>	117.92	120.88	119.40	151.27	163.56	157.41	Dried	Dried
T <sub>13</sub>	112.40	113.33	112.87	147.39	157.87	152.63	Dried	Dried
CD (P=0.05) for Treatments	8.79	9.04	6.14	11.71	13.07	8.55	-	-
CD (P=0.05) for Years			2.41			3.35		
SEm ± for Treatments	3.01	3.10	2.16	4.01	4.48	3.01	-	-
SEm ± for Years			0.85			1.18		
CV	5.06	5.02	5.04	5.02	5.20	5.12	-	-

**Table 5. Effect of integrated nutrient management on Leaf Area Index (LAI) at different growth stages of potato Cv. Kufri Chandramukhi**

Treatments	Leaf area index (LAI)							
	30 DAP			60 DAP			At harvest	
	2021-22 (Rabi)	2022-23 (Rabi)	Pooled	2021-22 (Rabi)	2022-23 (Rabi)	Pooled	2021-22 (Rabi)	2022-23 (Rabi)
T <sub>1</sub>	0.116	0.120	0.118	0.155	0.165	0.160	Dried	Dried
T <sub>2</sub>	0.113	0.117	0.115	0.152	0.163	0.158	Dried	Dried
T <sub>3</sub>	0.093	0.101	0.097	0.136	0.147	0.142	Dried	Dried
T <sub>4</sub>	0.096	0.105	0.101	0.139	0.152	0.146	Dried	Dried
T <sub>5</sub>	0.101	0.108	0.104	0.144	0.155	0.150	Dried	Dried
T <sub>6</sub>	0.127	0.130	0.129	0.166	0.178	0.172	Dried	Dried
T <sub>7</sub>	0.123	0.125	0.124	0.160	0.171	0.166	Dried	Dried
T <sub>8</sub>	0.110	0.114	0.112	0.148	0.160	0.154	Dried	Dried
T <sub>9</sub>	0.108	0.111	0.110	0.146	0.158	0.152	Dried	Dried
T <sub>10</sub>	0.120	0.122	0.121	0.156	0.168	0.162	Dried	Dried
T <sub>11</sub>	0.126	0.130	0.128	0.164	0.177	0.171	Dried	Dried
T <sub>12</sub>	0.131	0.134	0.133	0.168	0.182	0.175	Dried	Dried
T <sub>13</sub>	0.125	0.126	0.126	0.164	0.175	0.170	Dried	Dried
CD (P=0.05) for Treatments	0.010	0.010	0.007	0.013	0.015	0.010	-	-
CD (P=0.05) for Years			0.003			0.004		
SEm ± for Treatments	0.003	0.004	0.002	0.005	0.005	0.003	-	-
SEm ± for Years			0.001			0.001		
CV	5.13	5.12	5.13	5.07	5.21	5.15	-	-



**Table 6. Effect of integrated nutrient management on plant spreading (cm) at different growth stages of potato Cv. Kufri Chandramukhi**

Treatments	Plant spreading (cm)												
	30 DAP						60 DAP						At
	2021-22		2022-23		Pooled		2021-22		2022-23		Pooled		harvest
	(Rabi)		(Rabi)				(Rabi)		(Rabi)				Dried
	E-W	N-S	E-W	N-S	E-W	N-S	E-W	N-S	E-W	N-S	E-W	N-S	
T <sub>1</sub>	39.00	39.00	44.00	43.00	41.50	41.00	57.00	57.00	61.09	62.00	59.05	59.50	Dried
T <sub>2</sub>	38.60	38.60	42.00	42.00	40.30	40.30	56.34	56.03	59.23	61.00	57.78	58.51	Dried
T <sub>3</sub>	30.00	30.00	35.50	35.00	32.75	32.50	49.62	49.00	51.02	50.00	50.32	49.50	Dried
T <sub>4</sub>	32.00	32.00	37.00	37.53	34.50	34.77	52.00	51.00	54.12	53.00	53.06	52.00	Dried
T <sub>5</sub>	34.00	34.00	38.00	39.00	36.00	36.50	54.00	51.89	56.09	54.93	55.05	53.41	Dried
T <sub>6</sub>	46.70	43.28	50.22	52.00	48.46	47.64	66.00	64.00	69.00	70.00	67.50	67.00	Dried
T <sub>7</sub>	41.60	40.00	45.00	46.53	43.30	43.26	59.00	60.00	65.00	65.00	62.00	62.50	Dried
T <sub>8</sub>	36.45	36.45	39.50	40.21	37.97	38.33	55.00	52.00	57.00	57.04	56.00	54.52	Dried
T <sub>9</sub>	37.00	37.00	39.99	41.00	38.50	39.00	55.69	55.21	58.03	59.01	56.85	57.11	Dried
T <sub>10</sub>	40.00	40.00	44.60	45.67	42.30	42.84	59.50	59.86	62.89	63.00	61.19	61.43	Dried
T <sub>11</sub>	45.00	42.00	48.47	51.00	46.73	46.50	62.00	63.21	68.00	68.03	65.00	65.62	Dried
T <sub>12</sub>	48.00	45.70	56.00	54.00	52.00	49.85	68.00	66.00	70.00	71.00	69.00	68.50	Dried
T <sub>13</sub>	42.00	41.00	46.00	49.00	44.00	45.00	60.00	62.00	67.23	67.00	63.62	64.50	-
CD (P=0.05) for Treatments	3.47	3.45	3.94	3.90	2.56	2.54	5.35	5.22	5.28	5.25	3.66	3.61	
CD (P=0.05) for Years					1.00	1.00					1.44	1.41	-
SEm ± for Treatments	1.19	1.18	1.35	1.34	0.90	0.89	1.83	1.79	1.81	1.80	1.29	1.27	
SEm ± for Years					0.35	0.35					0.51	0.50	-
CV	5.25	5.34	5.37	5.23	5.32	5.29	5.47	5.39	5.10	5.05	5.28	5.22	

**Table 7. Effect of integrated nutrient management on stem diameter (cm) at different growth stages of potato Cv. Kufri Chandramukhi**

Treatments	Stem diameter (cm)						
	30 DAP			60 DAP			At harvest
	2021-22 (Rabi)	2022-23 (Rabi)	Pooled	2021-22 (Rabi)	2022-23 (Rabi)	Pooled	2021-22 (Rabi)
T <sub>1</sub>	0.44	0.55	0.49	0.86	1.09	0.98	Dried
T <sub>2</sub>	0.42	0.54	0.48	0.85	1.06	0.95	Dried
T <sub>3</sub>	0.31	0.39	0.35	0.70	0.83	0.76	Dried
T <sub>4</sub>	0.33	0.41	0.37	0.72	0.85	0.79	Dried
T <sub>5</sub>	0.37	0.46	0.42	0.78	0.90	0.84	Dried
T <sub>6</sub>	0.51	0.63	0.57	0.97	1.27	1.12	Dried
T <sub>7</sub>	0.46	0.58	0.52	0.93	1.18	1.05	Dried
T <sub>8</sub>	0.40	0.50	0.45	0.83	0.98	0.91	Dried
T <sub>9</sub>	0.39	0.48	0.43	0.81	0.95	0.88	Dried
T <sub>10</sub>	0.45	0.57	0.51	0.91	1.14	1.02	Dried
T <sub>11</sub>	0.50	0.61	0.56	0.96	1.24	1.10	Dried
T <sub>12</sub>	0.55	0.65	0.60	1.02	1.28	1.15	Dried
T <sub>13</sub>	0.47	0.60	0.53	0.95	1.23	1.09	Dried
CD (P=0.05) for Treatments	0.05	0.07	0.04	0.10	0.12	0.08	-
CD (P=0.05) for Years			0.02			0.03	
SEm ± for Treatments	0.02	0.02	0.02	0.04	0.04	0.03	-
SEm ± for Years			0.01			0.01	

Plant height is an important growth index to study the accumulation of dry matter by the plant. The highest plant height (Table 1) was recorded in T<sub>12</sub> treatment at all the growth stages might be attributable to the spraying potato plants with organic compounds which can be readily absorbed by the leaves and not lost through fixation, decomposition or leaching as well as these bio-available organic fertilizers secreted microorganisms, which releases organic acids which are precursors of enzymes that help in the mineralization of vastly available NPK nutrients in soil thus encourage the capability of plants to produce vigorous vegetative growth characters by activating the photosynthesis process (Ahmed *et al.*, 2002). This finding was in close conformity with the results of Najm *et al.* (2013) and Al-Hisnawy (2011) in potato.

Number of stems per plant is important because it influences the number and size of tubers at harvest. The results (Table 1) revealed that inorganic fertilizers and organic fertilizers had a non significant effect on the number of main stems per plant at all growth stages of potato it could be attributed to the inherent genetic variation in the number of eyes on seed tubers and also it depends upon the uptake of nutrients by the plant at early stages of crop growth (Ghiyal and Bhatia, 2018). Muleta and Aga (2019) reported that the absence of close relationships between mineral nutrition and the number of stems per plant, the yield difference due to nitrogen treatment was not attributed to its effect on stem density as the number of stems was not significantly influenced by nitrogen nutrition.

The highest leaf length and leaf width (Tables 2 & T3) in T<sub>12</sub> treatment at all the growth stages might be due to organic fertilizers integrated with inorganic fertilizers which play a major role in many physiological and biochemical processes such as cell division and elongation, enzyme activation, stabilization of the native conformation of enzymes and metabolism of carbohydrates and protein compounds led to increased leaf length and width (Medani *et al.*, 2000). The obtained results are supported by those of Gunadi (2009) in potato.

Leaf area is required for maximum light interception which results in synthesizing photosynthetic and an increase in the weight of the tuber (Gangele, 2017). The data showed (Tables 4 & 5) that T<sub>12</sub> treatment was recorded significantly highest value of leaf area and leaf

area index at all the growth stages could be attributed to the presence of balanced macro and micronutrients in INM could be sufficient at the beginning of growth season which has a synergistic effect in promoting cell division, cell growth and proliferation of leaves and auxillary branches which might be caused by the extension of the leaf surface and the increase of photosynthetic efficiency resulting in higher leaf area index as reported by Abou-Hussain *et al.* (2003). Present results are in close conformity with Chopra *et al.* (2006) who stated that there was an increase in leaf area index with increasing fertilizer levels in potato.

Plant spreading indicates the size of the photosynthetic system is therefore an indication of intercepted radiation. The (Table 6) highest plant spreading was recorded in T<sub>12</sub> treatment that could be attributed to higher nutrient availability induced by the maximum vegetative growth in terms of plant height, number of main stems, increased leaf length and leaf width led to more canopy development (Neogi and Das, 2022). This result is in accordance with the finding of Shubha *et al.* (2019) in potato. Stem diameter is one of the most important parameters for the transportation of water, nutrients and other internal fluids from roots to the leaves and the flow of photosynthates from the source (leaves) to sink *i.e.*, tubers (Wien, 1997). The highest stem diameter (Table 7) was recorded in T<sub>12</sub> treatment might be due to the higher availability of nutrients, thus might increased photosynthesis and consequently increased the synthesis of carbohydrates within the plants which helped in increased stem diameter (Marton, 2001 and Saha *et al.*, 2001).

#### 4. CONCLUSION

The present investigation revealed that application of 75 % Recommended dose of NPK+ Organic NPK with micronutrients + Organic NPK + Organic based micronutrients + Organic phosphorus + Organic potash recorded significantly highest growth in terms of plant height, leaf area, leaf area index, plant spreading and stem diameter. It could be concluded that effect of bio available nutrients on growth of potato is significant.

#### DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image

generators have been used during writing or editing of this manuscript.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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