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Effect of different levels of NPK fertilizer on quality parameters of potato (*Solanum tuberosum* L.)

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Abstract
The present study was conducted at Research Cum Demonstrational Farm, College of Agriculture, Indira Gandhi Krishi Vishwavidalaya, Raipur, Chhattisgarh during the year 2020-2021 and 2021-2022. The experiment was conducted using variety of Kufri Pukhraj under Randomized Block Design (RBD) with three replications comprising ten treatments of fertilizers *viz.*, T_1: 75% NPK as per recommendation, T_2: 100% NPK as per recommendation, T_3: 125% NPK as per recommendation, T_4: 75% NPK as per YT 35 t/ha,T_5: 100% NPK as per YT 35 t/ha, T_6: 125% NPK as per YT 35 t/ha, T_7: Without N fertilizer (PK), T_8: Without P fertilizer (NK), T_9: Without K fertilizer (NP) and T_{10}: Without NPK (Control). Result regarding quality parameters such as tuber dry matter content (19.39%), specific gravity (1.079), starch content (12.39%), reducing sugar (0.24%), non-reducing sugar (0.32%) and total sugar (0.56%) were found to be higher with the application of 125% NPK as per YT 35 t/ha. However, the maximum protein content in tuber (1.91%), carbohydrate (13.59%) and total soluble solid (6.04%) was recorded with application of 125% NPK as per recommendation. While, the minimum was recorded under without NPK (Control).

Keywords: Nitrogen, phosphorus, potassium, starch and carbohydrate etc.

Introduction
Potato (*Solanum tuberosum* L.) is one of the most productive vegetable crops of solanaceae family, grown for its starchy edible tubers and popularly known as 'The king of vegetables'. Mostly cultivated potato are tetraploid (2n=4x=48) and vegetatively propagated through tubers. Potato is a temperate vegetable crop but successfully grown in subtropical region of India. Origin of potato is believed to be from South America (Peru) and from there it was introduced to different parts of the world. In India, Portuguese introduced it at the beginning of 17^{th} century.

Potato is one of the prime sources of human nutrition. As for its composition, potato tuber contains 70 to 82% water, 17 to 29% dry matter, 11 to 23% carbohydrate, 0.8 to 3% protein, 0.1% fat, 0.6% fibre, 1.1% minerals and fair amount of essential amino acids such as isoleucine, leucine and tryptophan. Potatoes are emerging as a raw material for setting up agro-based processing industries for the production of chips, french fries, namkin, sweets, biscuits as well as the production of alcohol and starch. Potato has some medicinal properties also, like it has anti-scorbutic, aperients, diuretic, galacagoue, nervous sedative, stimulant to gout and antispasmodic (Rai and Yadav, 2005) [20].

Potato is fourth most important food crop in India after rice, wheat and maize. It is among the major food crops grown in more than 100 centuries in the world. It is not only a major food crop, but also an income generating vegetable crop. The major Potato producing states are Uttar Pradesh, West Bengal, Bihar, Gujarat, Madhya Pradesh, Punjab, Assam, Chhattisgarh, Jharkhand and Haryana. In India, it is cultivated about the 2173 thousand hectare area with a production of 50190 thousand MT with an average productivity of 23.09 MT per hectare (Anonymous, 2019) [2]. In Chhattisgarh, it is mainly cultivated in Surguja, Balrampur, Bilaspur, Bastar, Jashpur, Raigarh and Raipur as Rabi crop except in Mainpat and Samripat hills, where it is grown in both *Kharif* and *Rabi* season. The total area under potato cultivation is 42750 ha and annual production of 614056 MT with an average productivity of 14.36 MT/ha (Anonymous, 2021) [3].

Nitrogen is a key element for improving crop growth, development and quality of crop plants. It influences the yield mainly through leaf area expansion, crop development, crop quality and susceptibility to lodging and can also affect the behavior of other elements.

Nitrogen is an integral part of purin-pyrimidins which forms RNA and DNA and also being a component of protoplasm enhances chlorophyll synthesis. Nitrogen is desirable for vegetative growth, dry matter accumulation as well as nutrients uptake by potato plants (El-Ghamriny and Saeed, 2007) [7]. As phosphorus is a part of molecular structure of nucleic acid (DNA and RNA), the energy transfer compounds, cell membranes and phosphoproteins so it has a great importance in physiological processes inside the plant. P has a significant impact on the setting of potato tubers, especially in the early growth states (Jenkins and Ali, 2000) [13]. Potato acts as indicator crop for potassium deficiency symptoms due to its higher potassium requirement. Potassium plays an important role in photosynthesis through enzyme activation, carbohydrate metabolism, water regulation, translocation of assimilates and nitrogen uptake. Also, it has a role in physiological processes in plant respiration, transpiration, translocation of sugars and carbohydrates and enzyme transformation. It enables the plant to synthesize the organic compounds linked with the absorption of nitrogen and its efficient utilization (Kelling *et al*., 1998) [15].

The aim of present study is to determine the effect of different rates of fertilizers on quality parameters of potato variety *i.e.* Kufri Pukhraj. The result of this study would be worthwhile to improve the nutritional quality of potato by the use of suitable combination of NPK fertilizers.

Material and Methods

A field experiment was conducted at Research Cum Demonstrational Farm, College of Agriculture, Indira Gandhi Krishi Vishwavidalaya, Raipur, Chhattisgarh during the year 2020-2021 and 2021-2022. The experiment was laid in randomized block design with three replications comprising ten treatments of fertilizers *viz.*, T_1: 75% NPK as per recommendation, T_2: 100% NPK as per recommendation (150:100:100), T_3: 125% NPK as per recommendation, T_4: 75% NPK as per YT 35 t/ha,T_5: 100% NPK as per YT 35 t/ha (160:50.60), T_6: 125% NPK as per YT 35 t/ha, T_7: Without N fertilizer (PK), T_8: Without P fertilizer (NK), T_9: Without K fertilizer (NP) and T_{10}: Without NPK (Control). The soil of experimental field was clay-loam having soil pH 6.9 and EC 0.33. The nutrient analysis of soil revealed that it contains available nitrogen 272.51 kg ha^{-1}, available phosphorus, 20.70 kg ha^{-1} and available potassium 276.77 kg ha^{-1}. Healthy sprouted potato tubers were treated with fungicide and planted on a well-prepared field at 60cm X 20cm distance in ridges. All the experimental plants were provided same cultural practices *i.e.* fertilizer application, irrigation, gap filling, earthing-up, weed management, haulm cutting and plant protection measures during whole period of investigation. Under quality parameters of potato tubers, the observations *i.e.* protein content in tuber (%), tuber dry matter content (%), specific gravity, starch (%), total soluble solid (%), carbohydrate (%), reducing sugar (%), non-reducing sugar (%) and total sugar (%).

Results and Discussion

The results of trial pertaining to various aspects of quality attributing parameters of potato tubers are summarized as follows:

1. Protein content in tuber (%)

The result showed non-significant difference among all the treatments for protein content in tuber (%) during the both year and in pooled mean (Table 1).

During the first year, second year and pooled mean, the data showed that highest protein content (%) in tuber (1.76, 2.07 and 1.91, respectively) was recorded in treatment T_3 (125% NPK as per recommendation). However, the lowest protein content (%) in tuber (1.29, 1.50 and 1.39 %) was noticed in treatment T_{10} during the first year, second year and in pooled mean, respectively.

The higher protein content was obtained with increase in levels of fertilizer under this study. This might be due to the synergetic effect of N, P and K in nutrient absorption and their role in hydrolysis of polysaccharides, conversion of organic acid into amino acids and enhanced solubilization of insoluble starch which converts into amino acids which ultimately made protein. The results are matched with the findings of Mona *et al*. (2012) [18] reported that the protein content of potato tuber increased by increasing levels of N, P and K fertilizer application. Yusuf *et al.* (2017) [22] who reported that increasing of N, P and K fertilizer rate enhanced more protein accumulation in tuber. Similar findings have also been documented by Bashir and Qureshi (2014) [5] and Ozturk *et al.* (2010) [19].

2. Tuber dry matter content (%)

Tuber dry matter content (%) was recorded under different treatments are presented in Table 1. The result revealed that the data were differ non-significantly by application of different doses of fertilizer during the both year and in pooled mean.

Among the different fertilizer treatments during the first year, second year and in pooled means basis, treatment T_6 (125% NPK as per YT 35 t/ha) was recorded for maximum dry matter content (17.97%, 20.81% and 19.39%, respectively). However, the minimum dry matter content (15.38%, 16.74% and 15.81%, respectively in first year, second year and pooled mean) was observed in T_{10} *i.e.*, without NPK fertilizer.

The dry matter content of tubers showed a gradual rise in dry matter accumulation of potato with increasing fertilizer dose. It might be due to good response of fertilizer by crop resulted more vigorous growth *i.e.*, higher plant height, number of compound and total leaves $plant^{-1}$ which may improve photosynthesis activity resulting produce more photo assimilates and their accumulation to the tubers. Kavvadias *et al*. (2012) [14] also reported that the dry-matter content of potato was directly proportional to the amount of N applied to the soil. Singh and Lal (2012) [21] reported that the tuber dry matter percent increased with increasing in potassium rate up to 150 kg/ha. These results are in agreement with Banerjee *et al*. (2016) [4].

3. Specific gravity (g cm^{-2})

A perusal data presented in Table 1 revealed that the specific gravity differed non-significantly during the first year of study however, it was differed significantly during second year and pooled mean.

Among the treatments, maximum specific gravity (1.073, 1.084 and 1.079) was noticed under treatment T_6 (125% NPK as per YT 35 t/ha) during the first year, second year and pooled mean, respectively. Whereas, the treatment without NPK *i.e.*, T_{10} recorded for minimum specific gravity (1.032, 1.034 and 1.033).

The highest specific gravity was obtained under the higher levels of fertilizer application. This might be due to the higher dry matter content recorded in those fertilizer treatment, specific gravity is directly associated with dry matter content of tuber. Cucci *et al*. (2006) [6] reported that the tuber specific gravity positively correlated with dry matter percentage of tuber. These results are in agreement with El-Hadidi *et al.* (2017) [8] and AL-Moshileh and Errebi (2004) [1].

4. Starch content (%)

Data regarding to effect of different treatments on starch contents (%) of potato tuber are presented in Table 2.

It is evident from the data that there was a significant difference in starch content (%) due to fertilizer application. Among different fertilizer treatment during the first year, second year and in pooled mean basis, the treatment T_6 (125% NPK as per YT 35 t/ha) was recorded for maximum starch content (12.64%, 12.15% and 12.39%, respectively) which was followed by T_2 *i.e.,* 100% NPK as per recommendation for first year, second year as well as pooled mean. The minimum starch content was observed with treatment T_{10} (6.84, 7.22 and 7.03%, respectively in first year, second year and pooled mean).

Higher starch content obtained with application of higher dose of fertilizers (NPK) might be due to positive response of this crop to the nutrients like nitrogen, phosphorus and potash. Nutrients play a greater role in photosynthesis and translocation of photosynthates from leaves to tubers and subsequent starch synthesis by activation of starch synthase enzyme (Kumar *et al*., 2008).

The result is close conformity with the findings of Mona *et al.* (2012) [18] also reported that the content of starch significantly increases with the higher fertilizer application. Jatav *et al*. (2017) [12] reported that the increase in starch content with increasing dose of nitrogen upto 150 kg/ha. Similar results were also reported by El-Hadidi *et al.* (2017) [8], Mankotia *et al*. (2020) [17] and Gautam *et al*. (2012) [10].

5. Total soluble solid (%)

The data on total soluble solid (%) were recorded after harvesting and statistically analyzed (Table 2).

A perusal of data revealed that total soluble solid (%) was non-significantly influenced by different fertilizer treatments used in this study. Among the different treatments, the highest total soluble solid (6.01, 6.07 and 6.04%) was recorded in treatment T_3 (125% NPK as per recommendation) during the first year, second year and in pooled mean, respectively. However, the lowest total soluble solid (4.90, 4.93 and 4.92%) was recorded in T_{10} during the first year, second year and in pooled mean, respectively.

During the study it was observed that with the increase in nutrient application, total soluble solid also increases. This increase in total soluble solids may be accounted to the hydrolysis of polysaccharides, conversion of organic acid into soluble sugars and solubilization of insoluble starch which is enhanced by increased level of fertilizer. Jatav *et al.* (2017) [12] also reported that the increases in the total soluble solid of tuber with the increasing in nitrogen levels up to 150kg/ha. In conformity of this, similar observation was reported by El-Latif *et al.* (2011) [9].

6. Carbohydrate (%)

A perusal data presented in Table 2 revealed that the carbohydrate differed non-significantly during the first year of study however, it was differed significantly during second year and pooled mean.

Among the treatments, maximum carbohydrate of potato tuber (12.78, 14.40 and 13.59%) was recorded in treatment T_3 (125% NPK as per recommendation) during first year, second year and pooled mean. However, minimum carbohydrate of potato tuber (9.68, 10.76 and 9.87%) was recorded in treatment T_{10} (Control) during first year, second year and pooled mean, respectively.

The higher carbohydrate content was found under higher levels of fertilizer in this study. This might be due to plant supplied higher N, P and K nutrients, implying that these have absorbed more nutrient which played better role in carbohydrate synthesis resulted in better tuber quality. Bashir and Qureshi (2014) [5] reported that carbohydrates content in tubers significantly increased with increasing levels of nitrogen. The results are conformity with the findings of Mona *et al.* (2012) [18], AL-Moshileh and Errebi (2004) [1] and Haddad *et al.* (2016) [11].

7. Reducing sugar (%)

The data pertaining to reducing sugar (%) was recorded after harvest and statistically analyzed (Table 3).

Data analysis during the first year, second year and in pooled mean, the result showed non-significant difference under all the treatments for this trait. The highest reducing sugar (0.25, 0.23 and 0.24%) was recorded under T_6 (125% NPK as per YT 35 t/ha) during the first year, second year and in pooled mean, respectively. However, the lowest reducing sugar (0.12, 0.11 and 0.12%) was noticed in T_{10} during the first year, second year and in pooled mean, respectively.

The increase in reducing sugar content might be due to the hydrolysis of polysaccharides, conversion of organic acid into soluble sugars and enhanced solubilization of insoluble starch which converts into sugar. The process could be is enhanced by increased levels of fertilizer. Jatav *et al.* (2017) [12] observed that the reducing sugar content increases with the increasing in levels of fertilizer up to 175 kg/ha of nitrogen.

8. Non-reducing sugar (%)

The non-reducing sugar (%) influenced non-significantly by different doses of fertilizer during both the years and in pooled mean (Table 3).

During the first year, second year and in pooled mean, the differences due to the fertilizer treatments were differ non-significantly. However, the maximum reducing sugar (0.33, 0.31 and 0.32%) was noticed under the treatment T_6 (125% NPK as per YT 35 t/ha) during the first year, second year and in pooled mean, respectively. It was noticed lowest (0.18, 0.19 and 0.19%) in T_{10} (control) during the first year, second year and in pooled mean, respectively.

9. Total sugar (%)

Data of all treatments for fertilizer treatments were differ non-significantly for total sugar (%) during both the years and in pooled mean (Table 3).

Data regarding to total sugar was showed non-significant differences. The treatment T_6 (125% NPK as per YT 35 t/ha) was recorded for maximum total sugar (0.58, 0.53 and 0.56%) during the first year, second year and pooled mean, respectively. However, the lowest (0.31, 0.30 and 0.30%) was recorded for T_{10} (control) during the first year, second year and in pooled mean, respectively.

This increase in total sugar content might be due to the hydrolysis of polysaccharides, conversion of organic acid into soluble sugars and enhanced solubilization of insoluble starch which converts into sugar is enhanced by increased level of fertilizer. Jatav *et al.* (2017) [12] observed that the total sugar content was increases with increasing levels of fertilizer up to 175 kg/ha of nitrogen. In conformity of this, similar observation was reported by Mona *et al.* (2012) [18].

Table 1: Protein content in tuber (%), tuber dry matter content (%) and specific gravity (g cm^{-2}) influenced by different levels of fertilizers

Treatments	Protein content in tuber (%)			Tuber dry matter content (%)			Specific gravity (g cm^{-2})		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
T_1: 75% NPK as per recommendation.	1.66	1.93	1.79	17.78	19.13	18.46	1.067	1.073	1.070
T_2: 100% NPK as per recommendation.	1.74	1.81	1.78	17.75	18.02	17.88	1.066	1.069	1.068
T_3: 125% NPK as per recommendation.	1.76	2.07	1.91	17.88	20.15	19.02	1.067	1.076	1.072
T_4: 75% NPK as per YT 35 t/ha.	1.46	1.78	1.62	15.64	17.95	16.80	1.039	1.068	1.054
T_5: 100% NPK as per YT 35 t/ha.	1.59	1.81	1.70	17.10	17.82	17.46	1.059	1.066	1.063
T_6: 125% NPK as per YT 35 t/ha.	1.66	2.05	1.86	17.97	20.81	19.39	1.073	1.084	1.079
T_7: Without N fertilizer (PK).	1.36	1.70	1.53	15.88	17.37	16.63	1.053	1.051	1.052
T_8: Without P fertilizer (NK).	1.51	1.68	1.59	17.30	17.39	17.34	1.063	1.059	1.061
T_9: Without K fertilizer (NP).	1.41	1.71	1.56	15.83	17.37	16.60	1.053	1.051	1.052
T_{10}: Without NPK (Control).	1.29	1.50	1.39	15.38	16.74	15.81	1.032	1.034	1.033
Sem (±)	0.11	0.15	0.13	0.94	1.00	0.97	0.011	0.009	0.010
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	0.028	0.029

Table 2: Starch (%), TSS (%) and carbohydrate (%) as influenced by different levels of fertilizers

Treatments	Starch (%)			TSS (%)			Carbohydrate (%)		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
T_1: 75% NPK as per recommendation	9.26	9.16	9.21	5.31	5.94	5.63	12.66	12.88	12.77
T_2: 100% NPK as per recommendation	12.55	11.07	11.81	5.82	6.04	5.93	12.74	12.40	12.57
T_3: 125% NPK as per recommendation	10.20	9.46	9.83	6.01	6.07	6.04	12.78	14.40	13.59
T_4: 75% NPK as per YT 35 t/ha	9.50	8.69	9.10	5.41	5.71	5.56	10.92	11.92	11.42
T_5: 100% NPK as per YT 35 t/ha	10.00	9.28	9.64	5.00	5.75	5.38	12.10	11.97	12.04
T_6: 125% NPK as per YT 35 t/ha	12.64	12.15	12.39	5.55	5.89	5.72	12.46	13.70	13.08
T_7: Without N fertilizer (PK)	9.15	8.01	8.58	5.76	5.16	5.46	10.87	11.18	11.03
T_8: Without P fertilizer (NK)	7.93	7.88	7.91	5.77	5.85	5.81	11.10	11.20	11.15
T_9: Without K fertilizer (NP)	7.36	7.47	7.42	5.38	5.29	5.34	9.98	10.89	10.44
T_{10}: Without NPK (Control)	6.84	7.22	7.03	4.90	4.93	4.92	9.68	10.06	9.87
SEm (±)	0.76	0.67	0.72	0.29	0.36	0.33	0.75	0.73	0.74
CD (p=0.05)	2.25	2.00	2.05	NS	NS	NS	NS	2.17	2.12

Table 3: Effect of different levels of fertilizers on reducing sugar (%), non-reducing Sugar (%) and total Sugar (%)

Treatments	Reducing Sugar (%)			Non-Reducing Sugar (%)			Total Sugar (%)		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
T_1: 75% NPK as per recommendation	0.15	0.13	0.14	0.23	0.21	0.22	0.38	0.34	0.36
T_2: 100% NPK as per recommendation	0.20	0.17	0.19	0.21	0.27	0.24	0.41	0.45	0.43
T_3: 125% NPK as per recommendation	0.23	0.20	0.21	0.27	0.28	0.27	0.49	0.48	0.49
T_4: 75% NPK as per YT 35 t/ha	0.18	0.14	0.16	0.24	0.20	0.22	0.43	0.34	0.39
T_5: 100% NPK as per YT 35 t/ha	0.21	0.18	0.19	0.25	0.22	0.23	0.46	0.40	0.43
T_6: 125% NPK as per YT 35 t/ha	0.25	0.23	0.24	0.33	0.31	0.32	0.58	0.53	0.56
T_7: Without N fertilizer (PK)	0.14	0.12	0.13	0.25	0.20	0.22	0.39	0.32	0.36
T_8: Without P fertilizer (NK)	0.16	0.15	0.16	0.29	0.24	0.27	0.45	0.39	0.42
T_9: Without K fertilizer (NP)	0.19	0.19	0.19	0.28	0.27	0.27	0.47	0.45	0.46
T_{10}: Without NPK (Control)	0.12	0.11	0.12	0.18	0.19	0.19	0.31	0.30	0.30
SEm (±)	0.03	0.03	0.03	0.03	0.06	0.05	0.05	0.06	0.05
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

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