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Effect of different levels of NPK fertilizer on economics 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 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). The economics studies indicated that the highest gross return (510330.04 Rs ha^{-1}), net return (409882.54 Rs ha^{-1}) and benefit: cost ratio (4.08) were recorded under 125% NPK as per YT 35 t/ha application. While, the minimum was recorded under without NPK (Control).

Keywords: Nitrogen, phosphorus, potassium, net return, benefit: cost ratio 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 17th 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) [8].

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) [1]. 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) [1].

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) [3]. 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) [4]. 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) [5].

Balanced application of nutrients is an important aspect that significantly influences on the crop yield of potato. Optimizing fertilizer application in crop production is not only important for maximizing crop yield but also for the co-benefits of mitigating climate change and improving human health (West *et al*., 2013) [11]. On the other hand, the imbalanced use of fertilizer has a negative impact on soil fertility, reduces the profit of farmers ultimately increasing cost of cultivation. Keeping the above facts in view, the present investigation was carried out to study the economics of potato cultivation influenced by different doses of fertilizer.

Materials and Methods

A field experiment was conducted at Research Cum Demonstrational Farm, College of Agriculture, Indira Gandhi Krishi Gandhi Krishi Vishwavidalaya, Raipur, Chhattisgarh during the year 2020-2021 and 2021-2022. The experiment was laid in Randomized Block Design (RBD) with three replications. In each replication 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 schedules of various cultural operations were carried out during course of investigation according to need and time of operation.

Studies on the economy of production were carried out by recording the work done, number of workers employed, electricity used and inputs. The standard cultivation cost was calculated according to the rate fixed by the government and IGKV. Gross returns hectare^{-1}, Net return hectare^{-1} and Benefit: Cost ratio were calculated according to the following formula:

1. Cost of cultivation (ha^{-1})

The total cost of cultivation included labor cost, field preparation cost, value of seed, manures, fertilizers and irrigation charges.

2. Gross return (ha^{-1})

It is total monetary value of the produce (tuber) obtained from the crop raised. It is calculated by multiplying the yields with the prevailing market prices and expressed as:

Gross return = Yield (t ha^{-1}) X Price of yield (t^{-1})

3. Net return (ha^{-1})

It is also referred to as net profit and represents the actual income to the farmer. It is calculated as follow:

Net return (ha^{-1}) = Gross return (Rs ha^{-1}) – Cost of cultivation (Rs ha^{-1})

4. Benefit: Cost ratio

This index provides an estimate of the benefit derived for the expenditure incurred in adopting a particular practice. It is calculated by the following formula.

$$\text{Benefit: Cost ratio} = \frac{\text{Gross return (Rs/ ha)}}{\text{Cost of cultivation (Rs/ha)}}$$

Result and Discussions

Data on cost of cultivation, gross returns, net returns and benefit: cost ratios as influenced by different levels of fertilizer. The economics of potato cultivation under the present investigation were calculated using the prevailing cost of inputs and market rate of the produce during the respective years are shown in Table 1 (a, b & c).

1. Cost of cultivation (Rs ha^{-1})

The perusal of detail cost of cultivation presented in Table 1 (a, b & c). The data revealed that maximum cost of cultivation (102295, 102956 and 102625 Rs/ha) were calculated for treatment T_3 (125% NPK as per recommendation) during the first year, second year and pooled mean, respectively. Minimum cost of cultivation was observed under treatment T_{10} (87774, 88444 and 88109 Rs/ha) during the first year, second year and in pooled mean, respectively.

The cost of cultivation was increased with increasing levels of fertilizer of NPK. It was due to higher fertilizer application which increases the cost of input. Yadav *et al.* (2020) [12] recorded highest cost of cultivation with the application of 150% RDF of NPK. Singh *et al.* (2018) [9] also reported the highest cost of cultivation increases with increasing in fertilizer dose up to 100% RDF of NPK.

2. Gross return (Rs ha^{-1})

The gross return of each treatment per hectare workout and it is given in Table 1 (a, b & c). The maximum gross returns (532598.89, 488061.18 and 510330.04 Rs/ha) was obtained with treatment T_6 (125% NPK as per YT 35 t/ha) followed by T_3 (513668.56, 457109.21 and 485388.88 Rs/ha) during the first year, second year and pooled data, respectively. However, minimum gross return (279325.93, 215086.67 and 247206.30 Rs/ha) was recorded under treatment T_{10} during the first year, second year and in pooled data, respectively.

3. Net return (Rs ha^{-1})

A perusal data present in Table 1 (a, b & c) revealed that the maximum net returns (432484.89, 387280.18 and 409882.54 Rs/ha) was recorded with treatment T_6 (125% NPK as per YT 35 t/ha) during the first year, second year and in pooled mean, respectively. However, minimum net return (191551.93, 126642.67 and 159097.30 Rs/ha) was recorded under treatment T_{10} during the first year, second year and in pooled

mean, respectively.

4. B:C Ratio

The recorded data given in Table 1 (a, b & c) showed that the maximum B:C ratio (4.32, 3.84 and 4.08) was recorded with treatment T_6 (125% NPK as per YT 35 t/ha) during the first year, second year and in pooled mean, respectively. However, minimum was recorded (2.18, 1.43 and 1.81) under treatment T_{10} during the first year, second year and pooled mean, respectively.

The highest gross return, net return as well as the maximum benefit cost ratio (B:C ratio) found in treatment T_6 (125% NPK as per YT 35 t/ha) under this investigation. It might be due to higher application of nutrient in the soil which increases nutrient availability to the plant resulted more vigorous plant growth and development, which ultimately leads to produced higher tuber yield.

Singh and Lal (2012) [10] observed the highest gross return, net return and benefit cost ratio was obtained with application of 225 kg/ha nitrogen. Raghuwanshi *et al.* (2021) [7] reported the maximum gross return, net return and benefit cost ratio was found under the application of 150% RDF of NPK. Similar results had also been reported by Mankotia and Sharma (2020) [6], Yadav *et al.* (2020) [12] and Singh *et al.* (2018) [9].

Table 1(a): Effect of different levels of fertilizers on economics of potato (during the year 2020-21)

Treatments	Cost of cultivation (Rs/ha)			Cost (Rs/ha)		Net returns (Rs/ha)	B:C ratio
	Seed	Fertilizers	Cultivation	Inputs	Produce		
T_1: 75% NPK as per recommendation	40000	6894	47774	94668	413266.39	318598.39	3.37
T_2: 100% NPK as per recommendation	40000	9192	47774	96966	464203.70	367237.70	3.79
T_3: 125% NPK as per recommendation	40000	14521	47774	102295	513668.56	411373.56	4.02
T_4: 75% NPK as per YT 35 t/ha	40000	4504	47774	92278	447307.78	355029.78	3.85
T_5: 100% NPK as per YT 35 t/ha	40000	7009	47774	94783	493725.56	398942.56	4.21
T_6: 125% NPK as per YT 35 t/ha	40000	12340	47774	100114	532598.89	432484.89	4.32
T_7: Without N fertilizer (PK)	40000	7261	47774	95035	319705.56	224670.56	2.36
T_8: Without P fertilizer (NK)	40000	5080	47774	92854	391543.31	298689.31	3.22
T_9: Without K fertilizer (NP)	40000	6042	47774	93816	379687.78	285871.78	3.05
T_{10}: Without NPK (Control)	40000	0	47774	87774	279325.93	191551.93	2.18

Table 1(b): Effect of different levels of fertilizers on economics of potato (during the year 2021-22)

Treatments	Cost of cultivation (Rs/ha)			Cost (Rs/ha)		Net returns (Rs/ha)	B:C ratio
	Seed	Fertilizers	Cultivation	Inputs	Produce		
T_1: 75% NPK as per recommendation	40000	6893	48444	95337	362172.73	266835.73	2.80
T_2: 100% NPK as per recommendation	40000	9191	48444	97635	401864.99	304229.99	3.12
T_3: 125% NPK as per recommendation	40000	14512	48444	102956	457109.21	354153.21	3.44
T_4: 75% NPK as per YT 35 t/ha	40000	4503	48444	92947	386459.87	293512.87	3.16
T_5: 100% NPK as per YT 35 t/ha	40000	7004	48444	95448	450468.42	355020.42	3.72
T_6: 125% NPK as per YT 35 t/ha	40000	12337	48444	100781	488061.18	387280.18	3.84
T_7: Without N fertilizer (PK)	40000	7261	48444	95705	254760.60	159055.60	1.66
T_8: Without P fertilizer (NK)	40000	5080	48444	93524	323151.83	229627.83	2.46
T_9: Without K fertilizer (NP)	40000	6041	48444	94485	302745.91	208260.91	2.20
T_{10}: Without NPK (Control)	40000	0	48444	88444	215086.67	126642.67	1.43

Table 1(c): Effect of different levels of fertilizers on economics of potato (Pooled mean basis)

Treatments	Cost of cultivation (Rs/ha)			Cost (Rs/ha)		Net returns (Rs/ha)	B:C ratio
	Seed	Fertilizers	Cultivation	Inputs	Produce		
T_1: 75% NPK as per recommendation	40000	6894	48109	95003	387719.56	292717.06	3.08
T_2: 100% NPK as per recommendation	40000	9192	48109	97301	433034.34	335733.84	3.45
T_3: 125% NPK as per recommendation	40000	14517	48109	102626	485388.88	382763.38	3.73
T_4: 75% NPK as per YT 35 t/ha	40000	4504	48109	92613	416883.82	324271.32	3.50
T_5: 100% NPK as per YT 35 t/ha	40000	7007	48109	95116	472096.99	376981.49	3.96
T_6: 125% NPK as per YT 35 t/ha	40000	12339	48109	100448	510330.04	409882.54	4.08
T_7: Without N fertilizer (PK)	40000	7261	48109	95370	287233.08	191863.08	2.01
T_8: Without P fertilizer (NK)	40000	5080	48109	93189	357347.57	264158.57	2.84
T_9: Without K fertilizer (NP)	40000	6042	48109	94151	341216.84	247066.34	2.63
T_{10}: Without NPK (Control)	40000	0	48109	88109	247206.30	159097.30	1.81

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