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Nutrient Management in Potato (*Solanum tuberosum* L.) through Evaluation of the Fertility Status of Soils in Satpura Zone of Madhya Pradesh

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ABSTRACT: Excessive or imbalanced fertilization has not only decreased nutrient use efficiency but also degraded arable land and posed a great threat to the environment. Potato productivity in India is static due to unbalanced use of nutrients and intensive cropping system. Nutrient use efficiency and yield can be increased by application of nutrients based on quantitative approaches. The QUEFTS basically works on the principle of NPK nutrient interactions and climate-adjusted yield potential of a region. Presented study was under taken to find out the quantitative evaluation of fertility of tropical soils (QUEFTS) model for the estimation of NPK requirements for different targeted yields of potato was conducted in 2018 to 2020. The experiment was undertaken in Randomized Block Design with three replications and three fertilizer level i.e. 75 %, 100% & 125% of recommended dose of NPK (RDF 120:100:100 kg/ha NPK) at Zonal Agriculture Research Station, Chhindwara with the target for achieving 30 t/ha yield target under QUEFTS model. On the basis of soil testing results, NPK as per QUEFT model (62.5:106.2:75 kg/ha NPK) for variety Kufri Pukhraj recorded economically maximum total yield (34.47 t/ha) along with net return Rs. 3,20,812/- and B:C ratio was recorded 3.46, plant emergence (93.25%), number of leaves/plant (130.5), Number of shoot/plant (10.5) are also recorded maximum among other nutrient levels. Whereas without QUEFT model 100% RDF of NPK (120:100:100 kg NPK/ha) recorded 32.67 t/ha yield with 3.17B:C ratio.

Keywords: NPK, QUEFT, model and Potato.

INTRODUCTION

Potato (*Solanum tuberosum*) is the most important food crop of the world. Potato is a temperate crop grown under subtropical conditions in India. The potato is a crop which has always been the ‘poor man’s friend’. Potato is being cultivated in the country for the last more than 300 years. For vegetable purposes it has become one of the most popular crops in this country. Potatoes are an economical food; they provide a source of low cost energy to the human diet. Potatoes are a rich source of starch, vitamins especially C and B1 and minerals. They contain 20.6 per cent carbohydrates, 2.1 per cent protein, 0.3 per cent fat, 1.1 per cent crude fiber and 0.9 per cent ash. They also contain a good amount of essential amino acids like leucine, tryptophan and isoleucine etc. Potato is a heavy feeder crop and hence needs heavy doses of fertilizers for its growth and yield. It also demands high level of soil nutrients due to relatively poorly developed and shallow root system in relation to yield. Potato produces much more dry matter in shorter cycle hence requires large amount of nutrients per unit time, which generally most of the soils are not able to supply. Proper nutrient management is essential to maximize potato production and sustain agricultural production while minimize negative impact on soil fertility

Plant nutrition is the practices of providing nutrition to the plant in the right amount, right place and right time (Wastermann, 2005). The QUEFTS model takes into account various factors, such as soil properties, climate conditions, crop type, and management practices, to estimate the amount of nutrients that crops will take up from the soil. It helps farmers and researchers make informed decisions about fertilizer application, irrigation, and other agricultural practices to ensure optimal plant growth and yield. QUEFTS stands for Quantitative Evaluation of the Fertility of Tropical Soils. It is a rule-based model that can be used to estimate crop yield from soil properties, the amount of fertilizer applied and an estimate of the yield that could be obtained when soil nutrients are in ample supply. It can also be used to estimate the amount of fertilizer needed to reach a particular yield. QUEFTS was first described by Janseen *et al.* (1990). In pursuit of higher yields, farmers are applying tremendous amounts of fertilizers which have led to not only lower yield but low nutrient use efficiency and environmental problems as well (Chen *et al.*, 2012; Liu *et al.*, 2014). Excessive or imbalanced fertilization has not only decreased nutrient use efficiency but also degraded arable land and posed a great threat to the environment (Xu *et al.*, 2019). The QUEFTS model has been used for rice (Xu *et al.*, 2015), wheat (Chuan *et al.*, 2013), soybean (Yang *et al*., 2017), rapeseed (*Brassica napus* L.) (Ren *et al.*, 2015), cassava (Manihot esculenta Crantz) (Byju *et al.*, 2016) and sweet potato (*Ipomoea batatas* L.). Potato productivity in India is static due to unbalanced use of nutrients and intensive cropping system. To better improve nutrient use efficiency and decrease environmental impacts, improved methods for optimum fertilizer recommendations are necessary for potato production. The traditional fertilization recommendation based on soil testing has contributed positive yield responses as well as cost of cultivation in potato-producing areas of India. Although soil testing is a more accurate method to evaluate the nutrient availability in the soil. Fundamental to any effective nutrient management program is a reliable soil analysis and soil test interpretation. Samples should be representative of the area to be fertilized and generally should be taken in the top 6-8 inches. The soil test will help to determine whether lime or nutrients are needed and if so, what rate should be applied. Nutrient use efficiency and yield can be increased by application of nutrients based on quantitative approaches. The QUEFTS basically works on the principle of NPK nutrient interactions and climate-adjusted yield potential of a region. For balance nutrient management study was under taken to find out the quantitative evaluation of fertility of tropical soils (QUEFTS) model for the estimation of NPK requirements for different targeted yields of potato. Potatoes grown for processing are valued for yield, size, and also for dry matter content (measured by specific gravity). As the specific gravity increases, the water content of the potato decreases, improving the frying properties and flavor. Management factors, including fertility decisions, will influence potato yield, quality, and storage properties. Fertilizer recommendations thus need to be adjusted more accurately to reflect site characteristics (Rajsic and Weersink 2008). Potato plant has relatively shallow root systems and is grown widely in India.

MATERIAL AND METHODS

The present study conducted for the estimation of NPK requirements and fertilizers recommendations for different target yields of potato in Satpura zone of Madhya Pradesh. The study was conducted during 2018 to 2020 under all India coordinated Research Project on Poatato at Zonal Agriculture Research Station, Chhindwara (Madhya Pradesh). Chhindwara is situated at a height of 682 m above mean sea level with a latitude range of 21º 28′N and longitude range 78º 10′ E. Experiment was laid out in Randomized Block Design with three replications & six treatment i.e. T_1 : 100% NPK as per recommendation, T_2 : 75% NPK as per recommendation,T_3 : 125% NPK as per recommendation planting, T_4 : 100% NPK as per QEFTS model T_5 : 75% NPK as per QEFTS model, T_6: 125% NPK as per QEFTS model. Crop was planted in 60 x 20cm (row to row and plant to plant) spacing in first week of November with variety Kufri Pukhraj.

Table 1: Initial Soil fertility status of Soil.

Soil texture	**Clay Loam**	**Av S (ppm)**	19.84
EC ds/m	0.31	**Av Zn (ppm)**	0.185
OC %	1.10	**Av Fe (ppm)**	3.317
pH	6.77	**Av B (ppm)**	1.22
Av N (Kg/ha)	332	**Av Mn (ppm)**	16.22
Av P (Kg/ha)	35	**Av Cu (ppm)**	0.579
Av K (Kg/ha)	157		

The QUEFTS Model. The QUEFTS model was used to simulate optimal nutrient uptake and used a to evaluate relationship between tuber yield and nutrient uptake. The balanced nutrient uptake from QUEFTS model was used to balance soil and plant based P and K nutrient maintenance in Nutrient Expert system. The Nutrient Expert system is a nutrient decision support system based on SSNM and a modified QUEFTS model developed by the IPNI (Chuan *et al.*, 2013a). In the Nutrient Expert, the fertilizer recommendation for N was determined by the yield response and agronomic efficiency of N fertilizer application. The P and K rates were determined by yield response and plant-soil nutrient balance of P and K uptake for different target yield, and simulated nutrient uptake from the QUEFTS model was used to balance soil and plant maintenance of P and K for certain tuber yield targets.

Prior to planting of potato tuber, soil sample was taken in the experiment plot and after analysis, on the basis of soil testing value we decided the quantity of NPK kg/ha for the QUEFT model. After soil analysis each experimental field was uniformly fertilized with Nitrogen, phosphate and potassium according to the treatments. Weed-, disease- and pest-control measures were applied as per recommendation of this area.

After the analysis of soil fixed the NPK doses for different targeted per hectare yield of Potato. Based on soil testing value of NPK, 50:85:60 kg/ha NPK in the 100% NPK, 37.5:63.75:45 kg/ha NPK in the 75 % NPK and 62.5:106.2:75 kg/ha NPK in 125% NPK applied as per Quefts model and three levels of recommended dose of NPK i.e. 100 %, 75 % and 125 %. Nitrogen was applied in two split dose after 30 & 45 days after planting as per treatment. Haulms were cut 100 days after planting (DAP) and harvesting was done 15 days after cutting of haulms. Date were collected on initial and final soil status, percent emergence percent at 30 days after planting, height, number of shoots per plant at 50 days after planting, number of compound leaves/plant at 50 days, as well as number and grade wise total yield & graded tuber at harvesting. The average of three year data was analyzed statically by applying the technique of analysis of variance (ANOVA).

Table 2: NPK kg/ha applied in different treatment.

Treatments Symb.	Treatment detail	N	P	K
T_1	100% NPK as per recommendation	120	100	100
T_2	75% NPK as per recommendation	90	75	75
T_3	125% NPK as per recommendation	150	125	125
T_4	100% NPK as per QEFTS model	50	85	60
T_5	75% NPK as per QEFTS model	37.5	63.75	45
T_6	125% NPK as per QEFTS model	62.5	106.2	75

RESULT AND DISCUSSION

The targeted yield of potato was 30 t/ha in 75, 100 and 125 % application of NPK as per QUEFT model. The initial soil fertility is soil texture is clay loam, 6.77 pH, 1.10% organic matter, 332 kg Nitrogen, 35 kg Phosphorus & 157 kg/ha Potassium was recorded. Plant height, number of compound leaves and all other morphological characters significantly affected with fertilizer application except plant emergence. Among all the treatment combination, application of 125% NPK as per QUEFT (62.5:106.2:75 Kg NPK/ha) was observed maximum emergence percent (93.25 %), plant height (64.50 cm), total tuber yield (34.48 t/ha), number of tubers (555.60 000' ha), tuber dry matter content (20.40 %), haulm dry matter content (7.45 %) and maximum benefit cost ratio (3.46) whereas the maximum number of leaves/plant (132.50) were observed in 125 % RDF of NPK (150:125:125 kg NPK/ha.). Maximum of shoot/plant (10.50) was recorded in 125 % RDF of NPK as per QUEFT model and without QUEFT.

Percent emergence of potato crop at 30 days after planting (DAP) ranged from 91.50 to 94.17 and showed non-significant difference among different treatments. Similar result was observed by Singh and Lal (2012) reported that the emergence of seed tubers in potato ranged from 90 to 98%, however, there was no effect of fertilizer treatments on the emergence of seed tubers. Except plant emergence all morphological characters respond to higher doses of fertilizer. A higher dose of Nitrogen favors luxurious plant growth in reference to plant height, leaves and number of shoots.

Nitrogen fertilizer increased the leaf area which increases the amount of solar radiation intercepted and consequent, increases vegetative growth and dry matter production of different plant parts. Similarly, the potato crop requires high amounts of nitrogen for optimum yields. Phosphorus is a part of the nucleic acid which is very important for seed and fruit formation and root growth. Phosphorus also is responsible in increasing the number of leaves in the early stages of plant growth. Potassium increases yield and improves tuber quality. It also promotes large size of tubers by the increasing water accumulation in tubers resulting in higher tuber yield. Potassium is essential for carbohydrate synthesis and in translocation and movement of starch from leaves to tubers. It increases both the rate and duration of bulking and also allowing the crops to adopt to environmental stress and promoting plant tolerance to insect infection and resistance to fungal disease.

Kumar *et al*. (2008) also reported that the application of 150% of RDF increased the number of shoots per plant. Number of leaves per plant is influenced positively due to increasing level of nitrogen (Pandey *et al*., 2007).

Application of 125% RDF of NPK as per QUEFT model or soil test value (NPK) for variety Kufri Pukhraj recorded economically highest total tuber yield 34.48 t/ha along with maximum net return of Rs. 3, 20,812/- and BC ratio was calculated 3.46, whereas without QUEFT model 100% RDF of NPK i.e. (120:100:100 kg NPK/ha) recorded yield 32.68 t/ha with 3.17BC ratio. Total tuber yield of without QUEFT model 100% RDF of NPK (120:100:100 kg NPK/ha) and with 100 % RDF as per QUEFT (50:85:60 kg NPK/ha) at par. The yield response to increasing levels of fertilizer was generally positively up to particular level, above which the response became negative (Sahota *et al.,* 1979).

However, it can be seen that as the dose increases, the results decrease. This is in accordance with Liebig's Minimum Law where the addition of elements made above the point limit cannot help because other elements become limiting factors. In addition, another possibility is that a higher dose of fertilizer, indicating a decrease in yield, it is because the NPK compound fertilizer reacts sourly, causing a decrease in soil pH. These conditions do not support the growth of potato plants (Yusdian *et al*., 2019). Uptake of nutrients depends upon available nutrient status of soil, plants vegetative as well as reproductive health, metabolic activity of crop and fertilizer used etc. Plants need adequate nutrition for potatoes to achieve optimum yields (Fageria *et al*., 2011).

Table 3: Effect of different treatments on growth parameter, yield parameters and economics.

Treatment		Emergence (%)	Plant height (cm)	No. of leaves/ plant	No. of shoots/ plant	Total tuber yield (t/ha)	Number of tuber (000' ha)	Tuber dry matter content (%)	Haulm dry matter content (%)	Cost of cultivation (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net returns (Rs ha^{-1}	B:C ratio
T_1	100% NPK as per recommendation	92.25	63.25	109.50	9.50	32.68	531.06	19.63	5.79	93960	392040	298080	3.17
T_2	75% NPK as per recommendation	91.00	61.50	102.75	7.50	29.19	456.06	19.67	6.26	91845	350160	258315	2.81
T_3	125% NPK as per recommendation	92.25	64.25	132.50	10.50	33.31	536.39	20.27	6.85	96075	399600	303525	3.16
T_4	100% NPK as per QEFTS model	91.00	63.25	109.25	8.75	32.06	513.70	20.13	6.89	91363	384600	293237	3.21
T_5	75% NPK as per QEFTS model	91.00	61.75	99.75	7.00	28.17	452.58	20.90	7.24	89898	337920	248022	2.76
T_6	125% NPK as per QEFTS model	93.25	64.50	130.50	10.50	34.48	555.60	20.40	7.45	92828	413640	320812	3.46
SE(d)		0.58	1.24	3.00	0.67	1.05	22.59	0.64	0.24				
C.D.		1.25	NS	6.45	1.45	2.26	48.60	NS	0.55				

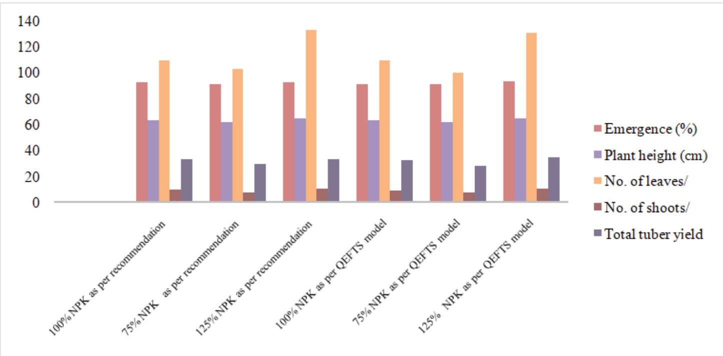

Fig. 1. Effect of NPK level on growth parameters.

CONCLUSIONS

As per QUEFT model, application of 62.5:106.2:75 kg/ha NPK for achieving 30 t/ha yield target with variety Kufri Pukhraj recorded economically highest yield (34.00 t/ha) along with net return of Rs. 3, 20,812/- and the BC ratio was recorded 3.46. At present, the soil test based recommendations are relatively on a stronger footing. This method not only indicates soil test based fertilizer dose but also the level of yield the farmer can hope to achieve if good agronomy is followed in raising the crop. It provides the scientific basis for balanced fertilization not only between the fertilizer nutrients themselves but also that with the soil available nutrients. When fertilizer availability is limited or the resources of the farmers are also' limited, planning far moderate yield targets which are, at the same time, higher than the yield levels normally obtained by the farmer provides means, far saturating mare areas with the available fertilizers and ensuring increased total production also.

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Conflict of Interest. None.

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