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Original Research Article

Biofertilizer Alternative for Potato Production in the Northern Plains of India

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A B S T R A C T

Eight nutrient management options were studied for quality parameters, nutrient uptake and economics of potato during two consecutive *Rabi* seasons of 2004-05 and 2005-06. The pooled results of two years revealed that among the quality parameters, specific gravity and dry matter contents were statistically higher under 75 % of fertility level alone, ascorbic acid under 100 % fertility level + tuber soaks with 1% each of urea and $NaHCO_3$, starch and protein content under 100 % fertility level + tuber soaks with 1% each of urea and $NaHCO_3$ + tuber treatment with biofertilizers (*Azotobacter +PSB*), however, the protein content did not touch the level of significance. Tuber soaks with 1% each of urea and $NaHCO_3$ + tuber treatment with biofertilizers (*Azotobacter +PSB*) under 75 % NP fertility level gave at par yield (282.80 q/ha) and uptake of nutrients (88.14 kg N/ha and 11.62 kg P/ha) to 100 % fertility level.

Keywords

Integrated; Biofertilizers; Sodium bicarbonate; Yield; Quality

Introduction

Potato is the world's fourth most important food crop after maize, wheat and rice with an annual production approaching 373.15 million tonnes from an area of 19.18 million hectares (FAOSTAT, 2011). It is an important crop and can supplement the food needs of the country in a substantial way as it produces more dry-matter, balanced protein and more calories from unit area of land and time than other major food crops. Potato relatively demands higher level of soil nutrients due to poorly developed and shallow root system in relation to yield (Perrenoud, 1993). Compared to cereal crops, potato produces much more dry matter in a shorter cycle (Singh and Trehan, 1998). This high rate of dry matter production results in large amounts of nutrients removed per unit time, which generally most of the soils are not able to supply. Hence, nutrient application through fertilizers becomes essential.

Nitrogen, phosphorus and potassium are the most limiting nutrients in potato production that greatly influence the growth, yield and quality. Being a shallow rooted crop, the use efficiency of N, P and K has been estimated to 40 – 50, 10 – 15 and 50 – 60 per cent, respectively. A mature crop of potato yielding 25 - 30 t/ha tubers removes about 120-140 kg N/ha (Sud and Jatav, 2008). The continuous and excessive uses of chemical fertilizers are causing ecological and health hazards as well as deteriorating the soil health resulting in decline in crop yield. The basic concept underlying the principle of integrated nutrient management is to maintain or adjust plant nutrient supply to achieve a given level of crop production by optimizing the benefits from all possible sources of plant nutrients. The basic objectives of integrated plant nutrition systems are to reduce the inorganic fertilizer requirement, to restore organic matter in soil, to enhance nutrient use efficiency and to maintain soil quality in terms of physical, chemical and biological properties. Bulky organic manures may not be able to supply adequate amount of nutrients, nevertheless their role becomes important in meeting the above objectives (Subbarao and Sammireddy, 2008).

Inorganic fertilizers becoming very costly and their imbalanced use deteriorate soil physico-chemical environment. At the same time large quantities of random organic sources of nutrients are not exploited in crop productions. These organic sources of nutrients are cheaper, ecofriendly, improve soil properties and can substitute nutrient requirement of crops partially. Thus, we can sustain balanced nutrient supply to the crop, improve productivity and soil health with low investment cost.

The biological sources of nutrients i.e. *Azotobacter, phosphobacteria and Bacillus* have been recognized as cheapest fertilizer input for improving soil health and fertility for optimum crop production. However, their effects vary with the crops, soil and environmental conditions. However, all these works were very much restricted to northern plains of India. The present investigation communicates the effect of seed soaking and biofertilizers in combination with chemical fertilizers on potato under field conditions.

Materials and Methods

Field experiments were conducted at the main experiment station, ND. University of Agriculture & Technology, Kumarganj, Faizabad, U.P. (India) during 2004-05 and 2005-06 on sandy loam soil. Eight treatments i.e. T_1 (100 % NP), T_2 (T_1 + tuber soaking with 1% each of urea and $NaHCO_3$), T_3 ($T_{2\ +}$ tuber treatment with biofertilizers (*Azotobacter +PSB*), T_4 (T_1 + *Bacillus cereus*), T_5 (75 % NP), T_6 (T_5 + tuber soaking with 1% each of urea and $NaHCO_3$), T_7 ($T_{6\ +}$ tuber treatment with biofertilizers (*Azotobacter +PSB*) and T_8 (T_5 + *Bacillus cereus*) were arranged in randomized block design replicated thrice. The field was fertilized with 150 kg N, 100 kg P and 120 kg K/ha, respectively through urea, single super phosphate and muriate of potash keeping potassium as a common dose. Half of nitrogen and full of phosphorus (as per treatment) and potassium were placed in bands below the seed tubers at the time of planting, and remaining half dose of N was applied at hilling (25 days after planting).

Seed tubers were soaked with one per cent solution of each of urea and sodium bicarbonate ($NaHCO_3$) for 5 minutes. For inoculation of *Azotobacter and PSB*, 100g jaggery solution was prepared in a litre of water, boiled and thoroughly mixed 200g each of inoculants after it get cooled. The slurry of biofertilizers was poured on to the tubers first treated with urea and $NaHCO_3$ in order to obtain uniform coating of biofertilizers. For *Bacillus cereus* treatment, half kg of culture was suspended in 40 litres of water and slurry prepared by 2 kg jaggery in one litre of water was added into suspension. The tubers were dipped in the solution for 30 minutes. The treated tubers were dried in shade and used for the planting on same date. All the recommended package of practices was followed for the healthy crop. Dehaulming was done manually at full maturity (90 days after planting) and harvesting was made two weeks later after peel setting.

Observations regarding yield attributes and total tubers yield were recorded at harvest. Uptake of nitrogen and phosphorus was estimated following the standard procedures (Jackson, 1973). Post harvest quality of tubers like specific gravity, dry matter content in tubers, ascorbic acid, starch and protein contents were estimated scientifically. The economic feasibility of various treatments was also worked out. The two years data were pooled and statistically analyzed following the standard techniques (Gomez & Gomez, 1984) and results were evaluated at 5% level of significance to draw the valid conclusion.

Results and Discussion

Pooled analysis for two years data revealed that all the quality parameters i.e. specific gravity, dry matter, ascorbic acid and starch content varied significantly except protein content in tubers, which showed insignificant variation (Table 1, Figure 1 & 2). The maximum specific gravity (1.086) and dry matter (22.18 %) were observed with application of 75 % NP (T_5), however, the maximum ascorbic acid (18.83 mg/100g) was estimated with 100% NP and starch contents (17.18 %) with 100% NP+ tuber soaking with 1% each of urea and $NaHCO_3$ + tuber treatment with biofertilizers (*Azotobacter +PSB*) i.e. T_3 treatment.

The maximum tuber yield (286.19 q/ha) was recorded (Table 1 & Figure 4) with the treatment T_3, which was at par with treatment T_7 *i.e.* 75 % NP + tuber soaking with 1% each of urea and $NaHCO_3$ + tuber treatment with biofertilizers (*Azotobacter +PSB*). The increase in the yield parameters may be attributed to better supply of plant nutrients, especially N and P in biofertilizers inoculated treatment possibly due to enhanced biological nitrogen fixation, solublization of phosphorus, better development of root systems and secretion of plant hormones (Kushwah and Banafar, 2003; Baishya *et al.*, 2005; Raghav and Chanda, 2005).

The maximum uptake of nitrogen to the tune of 100.94 kg/ha and phosphorus to the tune of 18.69 kg/ha (Table 1 & Figure 3) were obtained with treatment T_3 (100 % NP + tuber soaking with 1% each of urea and $NaHCO_3$ + tuber treatment with biofertilizers (*Azotobacter +PSB*). It may be attributed to the fact that use of biofertilizers under favourable environment might have provided better circumstances for adequate nutrient availability and the better growth that had increased the nutrient uptake (Mahendran *et al.*, 1996).

In addition, release of organic acids would have added in the solublization of minerals and change over non changeable to exchangeable form of nutrients, which lead to the direct and early absorption of nitrogen and phosphorus resulting in better nutrient uptake (Bhattacharya *et al.*, 2000). Application of 100 % NP + tuber soaking with 1% each of urea and $NaHCO_3$ + tuber treatment with biofertilizers (*Azotobacter +PSB*) i.e. T_3 treatment involved maximum cost of production and incurred highest gross and net return, however, incorporation of 75 % NP + tuber soaking with 1% each of urea and $NaHCO_3$ + tuber treatment with biofertilizers (*Azotobacter +PSB*) i.e. T_7 treatment resulted in the highest B: C ratio (1.48) followed by T_3 and T_8 (Table 1 & Figure 5).

Table.1 Quality parameters, nutrient uptake and economic feasibility of treatments in potato cv. Kufri Jawahar as influenced by nutrient management options

Treatment	Quality parameters					NU(kg/ha)		TY (q/ha)	CC (Rs/ha)	GI (Rs/ha)	NR (Rs/ha)	B:C ratio
	SG	DM (%)	AA (mg/100g)	S (%)	PN (%)	N	P					
T_1	1.009	21.23	13.70	16.45	1.72	79.26	12.09	247.88	43755	99152	55397	1.27
T_2	1.031	20.02	18.83	16.28	1.88	85.39	14.23	265.73	46218	106290	60073	1.30
T_3	1.044	19.13	15.08	17.18	2.21	100.94	18.69	286.19	46514	114474	67960	1.46
T_4	1.039	19.36	14.38	16.95	2.17	97.45	16.66	266.36	44051	106546	62495	1.42
T_5	1.086	22.18	13.60	15.29	1.77	67.45	7.41	236.79	42808	94714	51906	1.21
T_6	1.066	20.98	13.72	15.05	1.89	74.40	9.26	255.33	45271	102170	56899	1.26
T_7	1.043	19.88	14.90	16.13	1.97	88.14	11.62	282.82	45567	113129	67562	1.48
T_8	1.049	20.12	13.95	15.66	1.91	82.22	10.79	260.28	43101	104110	61009	1.42
CD (P=0.05)	0.05	1.37	0.63	0.72	NS	16.81	6.10	18.30				

T_1= 100% NP

T_2= T_1 + tuber soaking with 1% each of urea and $NaHCO_3$

T_3= T_2 + tuber treatment with biofertilizers (*Azotobacter* + *PSB*)

T_4=T_1 + tuber treatment with *Bacillus cereus*

T_5= 75% NP

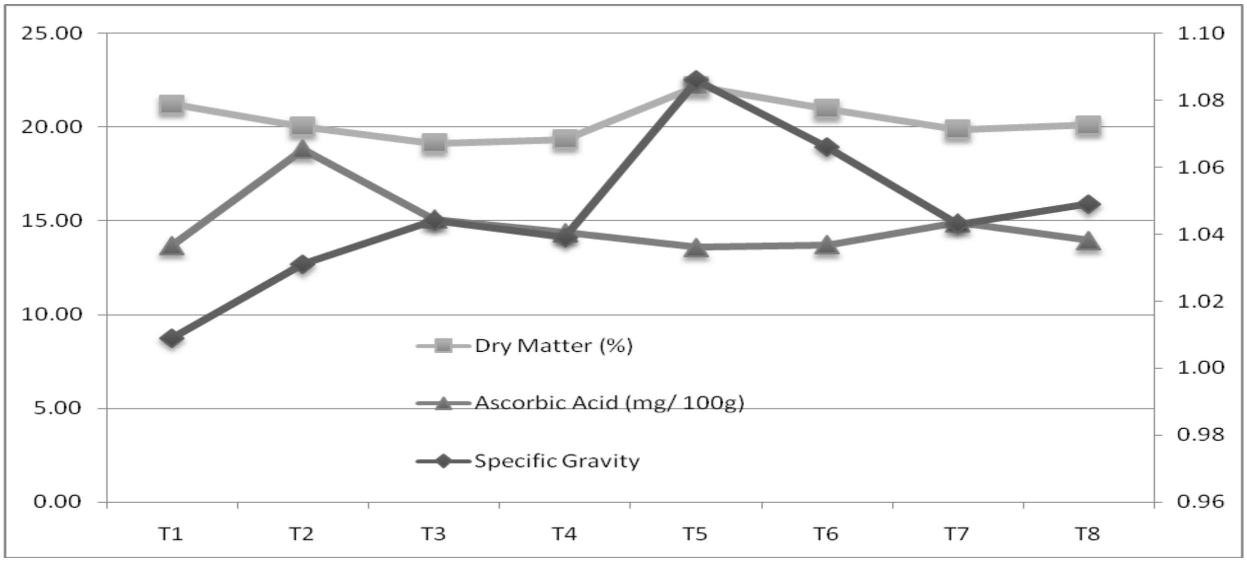
T_6=T_5 + tuber soaking with 1% each of urea and $NaHCO_3$

T_7= T_6 + tuber treatment with biofertilizers (*Azotobacter* + *PSB*)

T_8: T_5 + tuber treatment with *Bacillus cereus*

SG= Specific Gravity, DM= Dry Matter, AA= Ascorbic Acid, S= Starch, PN= Protein, N= Nitrogen, P= Phosphorus, TY= Tuber Yield, NU= Nutrient Uptake, CC= Cultivation Cost, GI= Gross Income, NR= Net Return

Fig.1 Effect on dry matter, ascorbic acid and specific gravity in potato cv. Kufri Jawahar as influenced by nutrient management options



Where,
T_1= 100% NP
T_2= T_1 + tuber soaking with 1% each of urea and $NaHCO_3$
T_3= T_2 + tuber treatment with biofertilizers (*Azotobacter* + *PSB*)
T_4=T_1 + tuber treatment with *Bacillus cereus*
T_5= 75% NP
T_6=T_5 + tuber soaking with 1% each of urea and $NaHCO_3$
T_7= T_6 + tuber treatment with biofertilizers (*Azotobacter* + *PSB*)
T_8: T_5 + tuber treatment with *Bacillus cereus*

Fig.2 Effect on protein and starch content in potato cv. Kufri Jawahar as influenced by nutrient management options

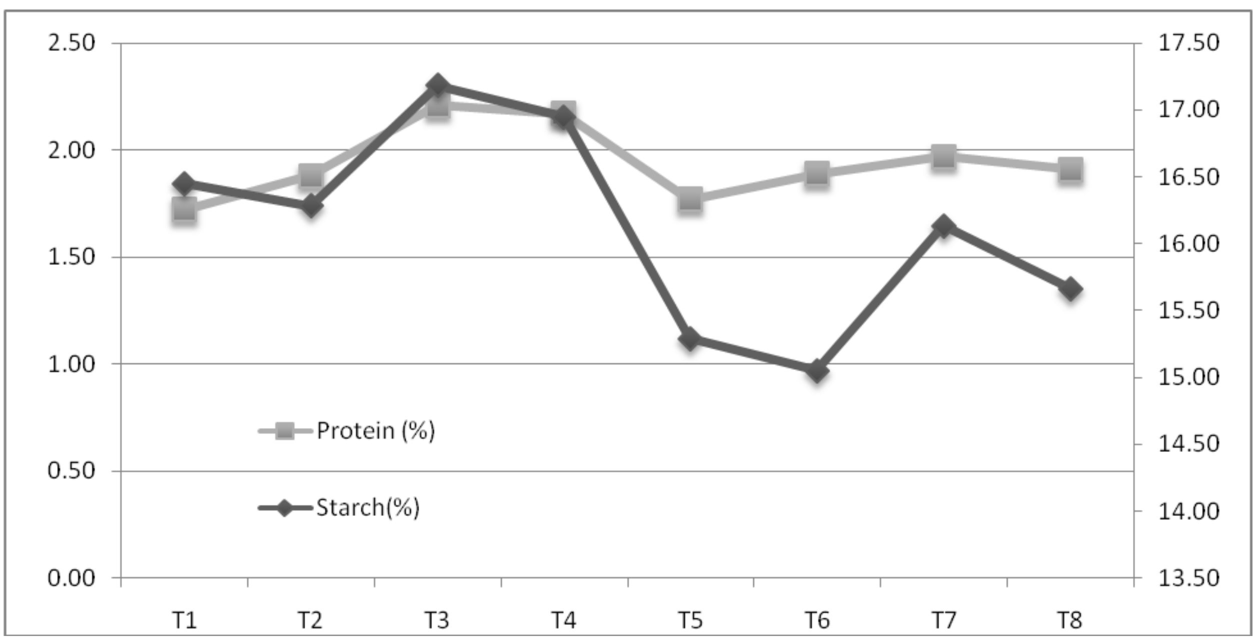


Fig.3 Effect on uptake of nitrogen and phosphorus in potato cv. Kufri Jawahar as influenced by nutrient management options

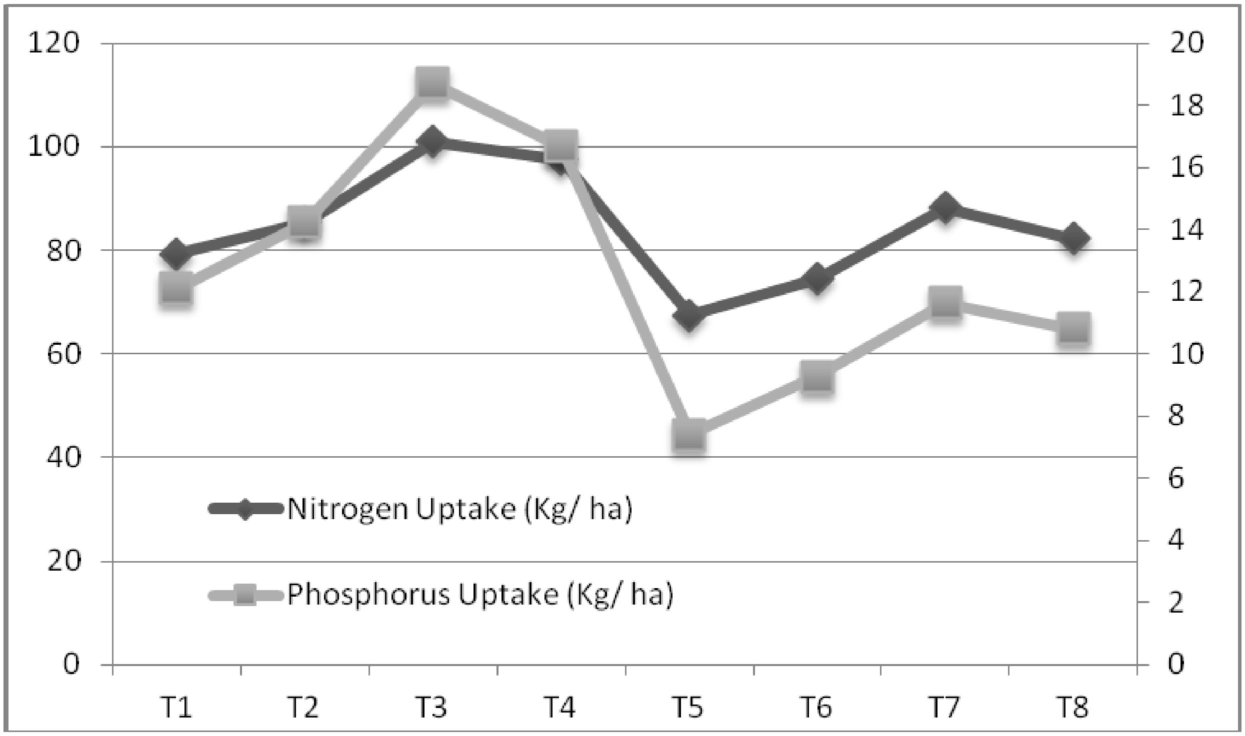


Fig.4 Effect on tuber yield in potato cv. Kufri Jawahar as influenced by nutrient management options

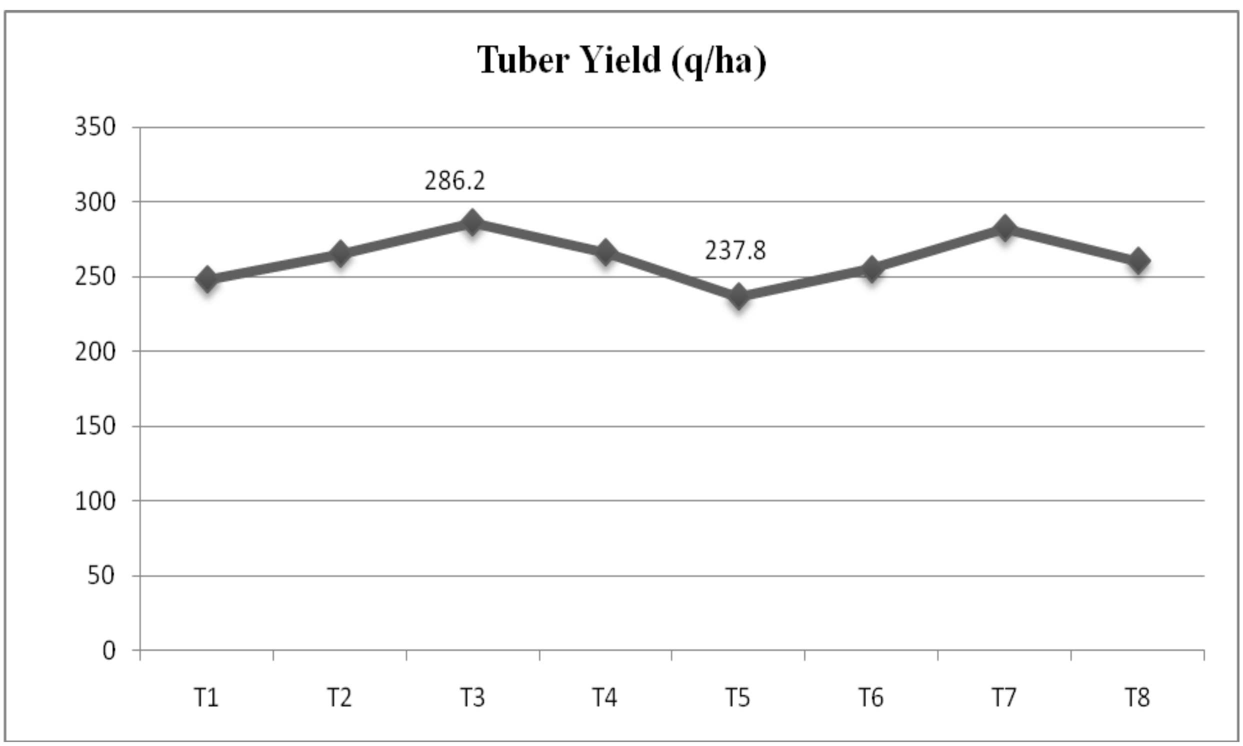
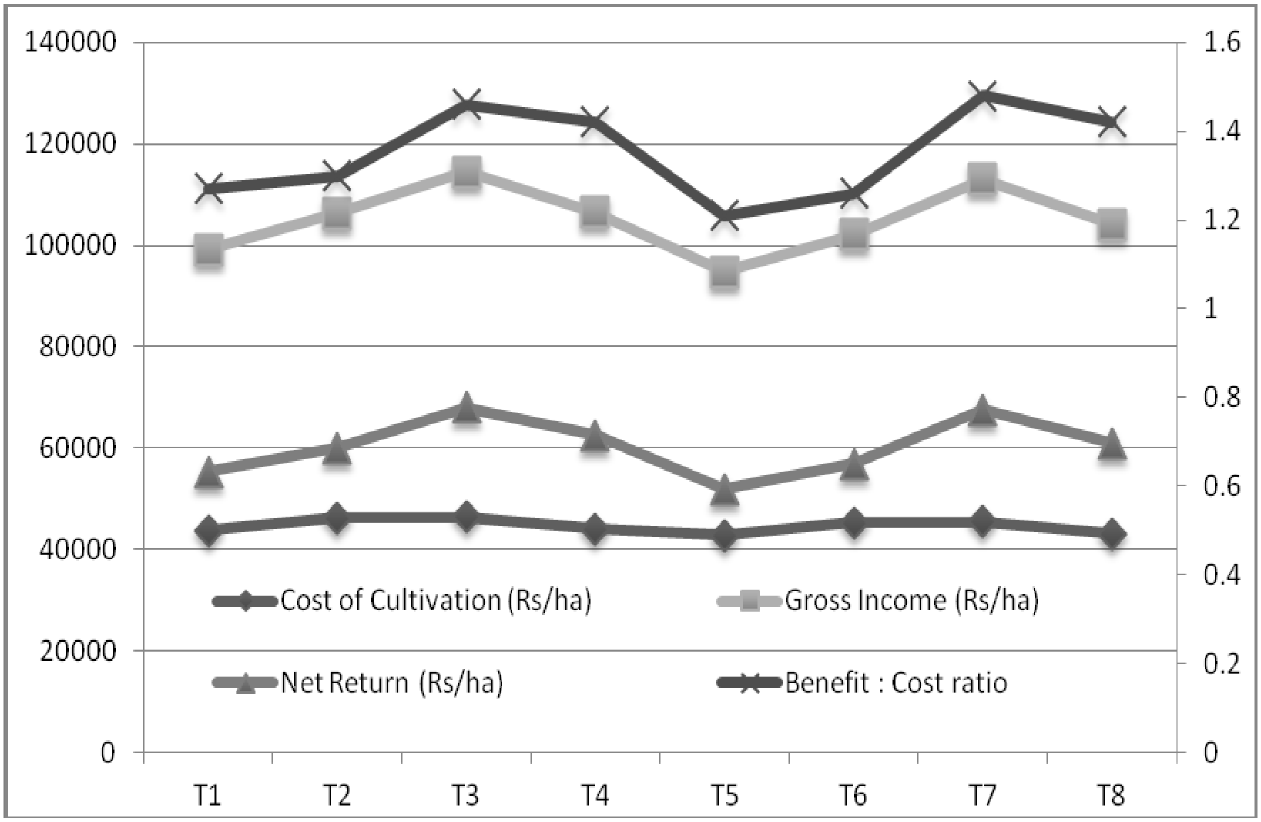


Fig.5 Economics in potato cv. Kufri Jawahar as influenced by nutrient management options



It may be attributed to the fact that biofertilizers inoculation might have resulted in better growth and yield of tubers with comparatively lower input involved in production (Vendan & Niranjan, 1998; Raghav and Chanda, 2005).

On the basis of above findings it may be concluded that specific gravity (1.086) and dry matter contents (22.18%) were statistically higher under 75 % of fertility level alone, ascorbic acid (18.33) under 100 % fertility level + tuber soaks with 1% each of urea and $NaHCO_3$ and starch (17.18%) under100 % fertility level + tuber soaks with 1% each of urea and $NaHCO_3$ + tuber treatment with biofertilizers (*Azotobacter +PSB*). Tuber soaks with 1% each of urea and $NaHCO_3$ + tuber treatment with biofertilizers (*Azotobacter +PSB*) under 75 % NP fertility level gave at par yield (282.80 q/ha) and uptake of nutrients (88.14 kg N/ha and 11.62 kg P/ha) to 100 % fertility level along with maximum (1.48) net return per rupee investment.

It may be inferred that the 25 % of fertilizer cost (N and P) in potato production can be reduced with the supplementation of 75 % NP fertilizers along with seed soaking with 1% each of urea and $NaHCO_3$ + tuber treatment with *Azotobacter* and *PSB*.

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