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Effect of integrated nutrient management on growth, yield and economics of summer mungbean (*Vigna radiata*)

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Abstract
A study was conducted in mungbean to investigate the effect of integrated nutrient management on growth, yield and economics of summer mungbean (*Vigna radiata*) at Research farm of Tirhut College of Agriculture, Dholi, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar, India during *summer,* 2020. The experiment was carried out in randomized bock design with three replications in various permissible combinations with inorganic fertilizers, rhizobium and PSB along with FYM on mungbean (*Vigna radiata*). This study revealed that 100% RDF + 5 tonnes FYM/ha + Rhizobium and PSB seed inoculation significantly increased plant height, dry weight/plant, number and dry weight of root nodules. The same treatment combination also proved most effective in improving the yield and yield attributing parameters *viz.,* number of pods/plant, number of grains/pod, pod length, test weight and harvest index. Thus, application of farm yard manure @ 5 tonnes/ha along with *Rhizobium* and PSB helped in increase in yield over control. However, application of 80% RDF along with bio-fertilizer and FYM @ 2.5 tonnes/ha significantly increase net returns and benefit: cost ratio. These results indicate that inorganic fertilizers along with bio-fertilizers and addition of organic matter proved to be useful in achieving the yields with integrated use of different sources of nutrients.

Keywords: Integrated nutrient, mungbean, growth, yield attributes, yield, economics

Introduction
Pulses are commonly known as food legumes which are in second position after cereals in production and consumption in India. Pulse is a rich source of dietary protein (25%), energy, minerals and vitamins for the vegetarian population. Mungbean is one of the most important and hardiest crops among the pulses. It has 25-26% protein, 3% vitamins and 51% carbohydrates (Mondal *et al.,* 2012) [11]. In addition to being an important source of human food and animal feed, plays an important role in sustaining soil fertility. By improving soil physical properties and fixing atmospheric nitrogen, it is a drought resistant crop suitable for dryland farming and predominantly used as an intercrop with other crops. In India, mungbean is cultivated in an area of 3.38 Mha, with a production of 1.61 million tonnes and average productivity of 474 kg/ha (CMIE, 2015) [3]. Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh, Bihar and Karnataka are the major pulses producing states in India.

In mungbean, roots have symbiotic rhizobia bacteria which help in fixing atmospheric nitrogen into the soil (Anjum *et al.,* 2006) [1]. For increasing the growth and yield of mungbean, starter dose of nitrogen is essential. Nitrogen plays a major role in synthesis of protein, chlorophyll and plant enzymes of legume. The chemical fertilizers are used in huge quantity alone hazards the soil and environment. Synthetic fertilizers have mainly macronutrients in large quantities and cemented the soil for worsening the soil and also the negative impact on crops, livestock and human being (Moller, 2009) [10]. For sustainable agriculture, emphasis should be given on the use of organic sources of nutrients for growing crops (Tejada *et al.,* 2009) [17]. Organic manures contains both macro and micronutrients and enhance soil fertility, soil porosity, infiltration rate, total carbon, water holding capacity, cation exchange capacity, reducing bulk density, check soil erosion and lead to the increasing availability of plant nutrients through mineralization process. Use of chemical fertilizers in combination with organic sources of nutrients will help to improve physico-chemical properties of the soils, efficient utilization of applied fertilizers for improving seed quality and quantity. Organic sources provide a good substrate for the growth of microorganisms and maintain a favourable nutritional balance and soil physical properties. It is recognized that combined source of organic manures, bio-fertilizers and chemical fertilizers play a key role in increasing the productivity of the soil. Farmyard manure is known to play an important role in improving the productivity of soils through its positive effects on soil physical, chemical and biological properties and balanced plant nutrition (Kumar *et al.*, 2011) [8]. The increasing cost of inorganic fertilizer, growing environmental concern and energy crisis have created considerable interest for the alternative cheap sources of plant nutrients. Considering the above facts, the present study on integrated approach of organic manures, bio-fertilizers and inorganic fertilizers was carried out to assess the productivity and profitability of mungbean cultivation.

Materials and Methods

The field research was carried out in experimental field of Tirhut College of Agriculture, Dholi, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur Bihar, India during summer season in 2020 to study the effect of integrated nutrient management on growth, yield and economics of summer mungbean (*Vigna radiata*) under different integrated approaches of nutrients. The area was situated on the southern bank of the river *Burhi Gandak* at an altitude of 52.18 meter above mean sea level and lies at $25^0$39' N latitude and $85^0$40' E longitude. The experiment was comprised of eleven treatments *viz.*, T_1 – control, T_2 - 100% RDF, T_3 - 100% RDF + Seed treatment (Rhizobium and PSB), T_4 - 100% RDF + Seed treatment (Rhizobium and PSB) + 2.5 t FYM/ha, T_5 - 100% RDF + Seed treatment (Rhizobium and PSB) + 5.0 t FYM/ha, T_6 - 80% RDF + Seed treatment (Rhizobium and PSB), T_7 - 80% RDF + Seed treatment (Rhizobium and PSB) + 2.5 t FYM/ha, T_8 - 80% RDF + Seed treatment (Rhizobium and PSB) + 5.0 t FYM/ha, T_9 - 60% RDF + Seed treatment (Rhizobium and PSB), T_{10} - 60% RDF + Seed treatment (Rhizobium and PSB) + 2.5 t FYM/ha and T_{11} - 60% RDF + Seed treatment (Rhizobium and PSB) + 5.0 t FYM/ha. The experiment was laid out in randomized block design with three replications. The soil of the experimental plot was alluvial and calcareous in nature. The soil of the experimental plot was low in organic carbon, available nitrogen, available P_2O_5 and medium in available K_2O which indicate that the soil was low in fertility. The land was primarily ploughed followed by two harrowings. The field was given a pre-sowing irrigation before field preparation to obtained proper germination and establishment of the crop. Mungbean variety 'HUM-16' was sown after pre-sowing irrigation using 25 kg/ha seed rate. A basal dose of 20 kg N, 40 kg P_2O_5 was applied per hectare as recommended dose of fertilizer. FYM was applied in the field as per the treatment details before sowing and mixed in soil. Accordingly, seeds were inoculated with rhizobium and PSB.

Plant height (cm) and dry weight/plant (g) was measured at harvest. The height of five randomly selected and tagged plants in second row of each plot was measured from ground surface to apex leaf and then average was taken. The samples so obtained were sun dried and then oven-dried at 70 °C temperature till constant weight was obtained. Thereafter, final dry weight was recorded. Five plants were randomly selected from each plot at 20 and 40 DAS and uprooted carefully such that nodules were not lost by detaching in the soil. After washing the roots carefully, total number of nodules present on the roots were detached from the roots and counted and then averaged. The nodules so detached were freshly weighed in the weighing balance after which the nodules were dried in sun for 2 days and then dried in oven at 70°C temperature. After complete drying of the nodules, dry weight was taken. Length of pods in cm in sampled five plants were recorded from base of pod to the tip of the pod with the help of metre scale and then averaged out. Number of pods in sampled five plants were counted. The average number were computed and expressed as number of pods per plant. A representative sample of 1000-grains of mungbean was sundried at 15% moisture level from each plot and weighed in gram. Grain yield after threshing, cleaning and sun drying were taken and finally recorded in quintal per hectare. After picking the pods, the remaining portion of the plant was harvested. The stover yield was calculated after the plant was completely dried. For obtaining the final stover yield, weight of stover of the observational plants were also added in the corresponding figures. The yield was then converted into quintal per hectare. The harvest index was calculated as the ratio of economic yield (grain) to biological yield (grain + stover). Its value was expressed in percentage, using the following formula:

$$\text{H.I }(\%) = \frac{\text{Grain yield (kg/ ha)}}{\text{Grain + Stover yield (kg/ ha)}} \times 100$$

Total uptake of nitrogen, phosphorus and potassium were calculated for each effect separately using the following formula –

Nutrient uptake = (%) nutrient concentration x biomass (kg/ ha)/100

Economic indices were calculated based on the prevailing market prices. Cost of cultivation was worked out by taking into consideration all the expenses incurred during raising the crop. Total gross return (Rs/ha) was worked out by multiplying the yield (grain + stover) per hectare under various treatments with prevailing market rate. Net return (Rs/ha) was obtained by subtracting the cost of cultivation from gross return of the individual treatments. Benefit: Cost ratio was calculated by the following formula:

$$\text{Benefit : Cost ratio} = \frac{\text{Net profit (Rs/ha)}}{\text{cost of cultivation(Rs/ha)}}$$

For statistical analysis "Analysis of variance" technique was applied to the data recorded for each character. Overall differences were tested by "F" test of significance at 5 percent level of significance as suggested by Cochran and Cox (1959). Critical differences at 5 percent level of probability were worked out for comparing treatment.

Results and Discussion

Effect on growth parameters

The data revealed from Table 1 that recommended dose of fertilizer along with seed inoculation with rhizobium and PSB and farm yard manure application @ 5.0 t/ha (T_5) have significantly superior effect on plant height and dry weight/plant at harvest and statistically at par with 100% RDF + Seed treatment (Rhizobium and PSB) + 2.5 t FYM/ha, 80% RDF + Seed treatment (Rhizobium and PSB) + 2.5 t FYM/ha and 80% RDF + Seed treatment (Rhizobium and PSB) + 5.0 t FYM/ha. The maximum plant height was recorded in case of treatment T_5 (45.23 cm) and minimum was in the treatment T_1 (31.47 cm).The results also corroborated the finding of Kumar and Singh (2010) [7]. Further, the effect observed with the dual inoculation of both the bio-inoculants alongwith inorganic fertilizers might be due to the provision of fixation of nitrogen by Rhizobium and possible solubilization of fixed P (as alumina and iron phosphates) as well as applied P besides synthesis of growth promoting substances like auxins and gibbrellins and produced vitamins which augmented plant growth by phosphorus solubilizing species, might have improved vigour and resulted in recording higher values of morphological parameters which increased photosynthetic capacity of plant thereby increasing the biological yield in terms of dry matter production/plant. The increase in various growth parameters due to balanced nutrition in mungbean were also reported by Rudreshapa and Halikatti (2002) [13] and Das *et al.* (2002) [4].

Number of nodules/plant and dry weight of nodules/plant at 20 and 40 days after sowing also produced significantly higher in full dose of recommended dose of fertilizer along with seed inoculation with rhizobium and PSB and farm yard manure application @ 5.0 t/ha (T_5) than rest of the treatments. Application of 100% RDF, FYM and bio-fertilizer in combination significantly increased the number of nodules as compared to control. The maximum number of root-nodules/plant were recorded in case of treatment T_5 (12.27 & 25.64) which was found statistically at par with treatment T_4, T_7, T_8, T_{10} & T_{11} at 20 days after sowing and with T_4, T_7 & T_8 at 40 days after sowing. Root characterization is reported by Singh *et al.* (2000) [14]. Increase in nodules count might be due to increased infection and rhizobial colonization in rhizosphere because of increased availability of micronutrient (Meena *et al*, 2012) [9].

Effect on yield and yield attributes

The effect of treatments on number of pod/plant were recorded and presented in Table 2. The yield attributing characters namely number of pods/plant, pod length, number of grains/pod and test weight increased with addition of organic manures in RDF and recorded maximum with 100% RDF + Seed treatment (Rhizobium and PSB) + 5.0 t FYM/ha. This might be due to combination of organic and inorganic nutrition provides better soil environment for root growth, nodule formation, availability and absorption of nutrient from soil. Seed inoculation resulted in greater number of pods/plant, pod length, number of grains/pod and test weight. This may be attributed to increased nodulation and nitrogen ixation, more solublization of native P and production of secondary metabolites by the bacteria. Treatment T_5 (18.10) registered significantly superior number of pods/plant as compared to all the other treatments. The increased yield with inorganic fertilizers and FYM application might be due to increased availability absorption and translocation of nutrient under NPK and FYM treated plots Rajkhowa *et al*. (2000) [12]. The maximum number of grains per pod (7.12) was recorded in 100% RDF + Seed treatment (Rhizobium and PSB) + 5.0 t FYM/ha. Similar results were also reported by Sivakumar *et al.* (2013) [16] in mungbean. The overall improvement in growth and yield components may be due to synergistic effect of combined use of organic and inorganic manures. Test weight and harvest index were not significantly affected by different treatment combinations. However, maximum data of test weight and harvest index was observed in T_5 as 36.12 g and 36.21%, respectively.

The statistical analysis of data showed that there were significant differences between treatments and grain yield. Significantly maximum grain yield was recorded on treatment 100% RDF + rhizobium & PSB inoculation + FYM @ 5 t/ha as compared to the all other treatments (Table 3). Significantly increased grain yield in mungbean because application of organic manures, inorganic fertilizers and bio-fertilizers could be ascribed to their direct influence on dry matter production at successive stages by virtue of increased photosynthetic efficiency. While indirect influence seems to be due to increase in plant height. The profound influence of nutrient application on biological yield seems to be an account of its influence on vegetative (stover) and reproductive growth (grain). An enhancement in seed yield is also attributed to cumulative effect of number of pods/plant, pod length, number of grain/pod and seed weight. This result is also in close conformity with the findings of Singh *et al* (2010) [15] and Tiwari *et al* (2011) [18].

Effect on economics and nutrient uptake

A close perusal of data indicated that the highest gross returns was obtained under treatment 100% RDF + rhizobium & PSB inoculation + FYM @ 5 t/ha (Rs. 1,03,742/ha) which was significantly higher over rest of the treatments except T_4, T_7 & T_8. Net returns and benefit: cost ratio was also significantly affected by different treatment combinations. Maximum net returns of Rs. 63,453/ha and benefit: cost ratio of 1.77 was obtained in treatment 80% RDF + rhizobium & PSB seed inoculation + FYM @ 2.5 t/ha which was statistically at par with T_4, T_5 & T_8 while benefit: cost ratio was statistically at par with T_4.

Nitrogen, phosphorus, potassium uptake by crop was also relatively higher with 100% RDF + seed inoculation with rhizobium & PSB + FYM @ 5 t/ha (Table 4). This was mainly due to higher biological production under these fertility levels. The increased uptake with the application of bio-fertilizers and micronutrients might be due to enhanced effect of Rhizobium in nitrogen supply (Bhattacharyya and Pal, 2001) [2]. The increased uptake of P by phosphobacteria (Bacillus) could be attributed to its greater P-solubilization potentiality in the presence of organic matter. Organic fertilizer provides significant cation exchange capacity to hold cations such as K+. The change in cation exchange capacity of organics by acidification might have enhanced K availability (Kumar *et al*, 2009 and Jat *et al*, 2011) [6, 5].

Table 1: Effect of Integrated Nutrient Management on growth of summer mungbean

Treatment	Plant height at harvest (cm)	Dry weight/ plant at harvest (g)	No of nodules per plant		Dry weight of nodules per plant (g)	
			20 DAS	40 DAS	20 DAS	40 DAS
T_1	31.47	6.23	8.03	14.29	15.98	42.01
T_2	38.19	9.52	8.41	18.65	19.12	54.83
T_3	38.24	10.17	10.19	19.61	23.16	57.65
T_4	44.92	12.55	12.10	24.86	27.50	73.09
T_5	45.23	12.97	12.27	25.64	27.89	75.38
T_6	36.28	8.91	9.95	19.43	22.62	57.12

T_7	44.28	12.49	12.06	23.78	27.41	69.91
T_8	45.06	12.64	12.21	24.14	27.75	70.97
T_9	35.95	7.91	9.83	19.27	22.34	56.65
T_{10}	37.94	8.99	11.16	20.95	25.37	61.59
T_{11}	38.27	9.65	11.24	21.26	25.55	62.50
S.Em ±	2.034	0.563	0.565	1.001	1.282	2.944
CD (P=0.05)	6.110	1.692	1.698	3.008	3.850	8.844

Table 2: Effect of Integrated Nutrient Management on yield attributes of summer mungbean

Treatment	No. of pods/plant	No. of grains/pod	Length of pod (cm)	Test weight (g)	Harvest Index (%)
T_1	13.26	5.63	5.14	33.85	33.78
T_2	15.04	6.22	7.11	35.74	35.17
T_3	15.15	6.46	7.29	35.83	35.26
T_4	17.82	7.01	7.92	36.01	36.19
T_5	18.10	7.12	8.05	36.12	36.21
T_6	14.87	6.19	7.03	34.94	35.06
T_7	17.73	6.94	7.87	35.92	35.95
T_8	17.95	7.06	7.98	36.08	36.1
T_9	14.46	6.02	6.85	34.61	34.87
T_{10}	14.69	6.13	6.92	34.87	34.96
T_{11}	14.98	6.24	7.10	35.12	35.08
S.Em ±	0.852	0.282	0.301	0.620	0.616
CD (P=0.05)	2.558	0.848	0.904	NS	NS

Table 3: Effect of Integrated Nutrient Management on yield and economics of summer mungbean

Treatment	Seed yield (q/ha)	Stover yield (q/ha)	Biological yield (q/ha)	Gross Return (Rs/ha)	Net Return (Rs/ha)	B:C ratio
T_1	6.26	12.27	18.53	47201	20201	0.75
T_2	10.15	18.71	28.86	76235	46733	1.58
T_3	10.58	19.43	30.01	79445	49843	1.68
T_4	13.28	23.42	36.70	99478	63264	1.75
T_5	13.85	24.40	38.25	103742	61278	1.44
T_6	9.30	17.23	26.53	69871	40697	1.39
T_7	13.24	23.59	36.83	99239	63453	1.77
T_8	13.58	24.04	37.62	101748	59712	1.42
T_9	8.43	15.75	24.18	63368	34622	1.20
T_{10}	9.35	17.39	26.74	70266	34908	0.99
T_{11}	10.17	18.82	28.99	76404	34796	0.84
S.Em ±	0.615	1.078	1.722	3859	2235	0.025
CD (P=0.05)	1.848	3.239	5.173	11591	6713	0.075

Table 4: Effect of Integrated Nutrient Management on total nutrient uptake (kg/ha) of summer mungbean

Treatment	Total nutrient uptake (kg/ha)		
	N	P	K
T_1	52.56	5.03	32.90
T_2	84.63	9.97	55.97
T_3	88.03	10.37	58.17
T_4	108.50	13.15	71.12
T_5	113.10	13.72	74.13
T_6	77.04	8.63	50.78
T_7	107.56	12.45	70.51
T_8	110.18	12.73	71.96
T_9	69.83	7.37	45.69
T_{10}	77.37	8.42	50.79
T_{11}	83.92	9.14	55.01
S.Em ±	3.931	0.483	2.574
CD (P = 0.05)	11.807	1.450	7.730

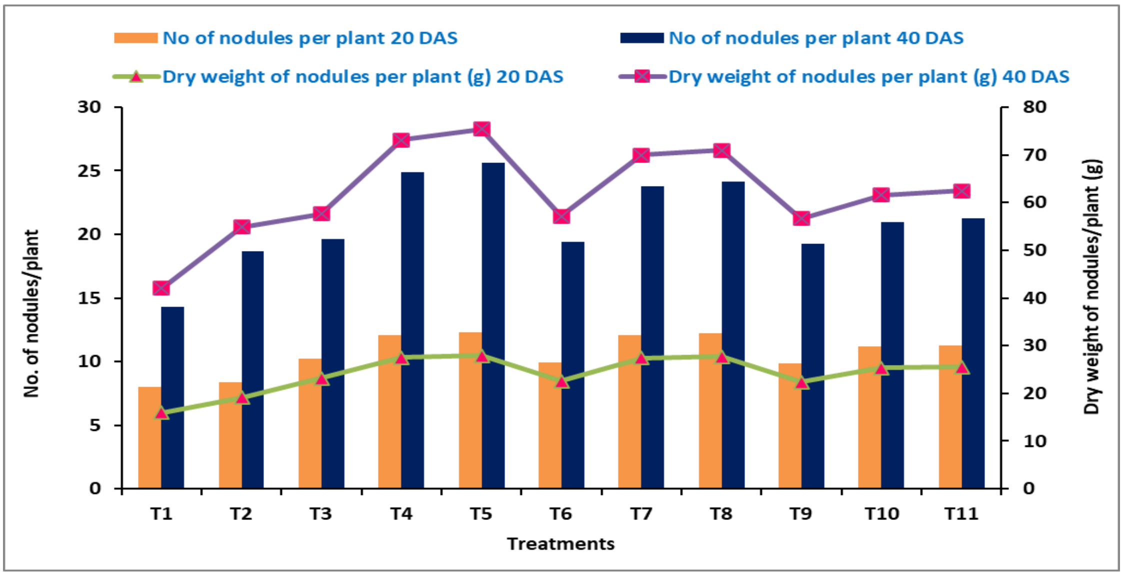

Fig 1: Effect of Integrated Nutrient Management on no. of nodules and dry weight of nodules in summer mungbean at 20 & 40 DAS

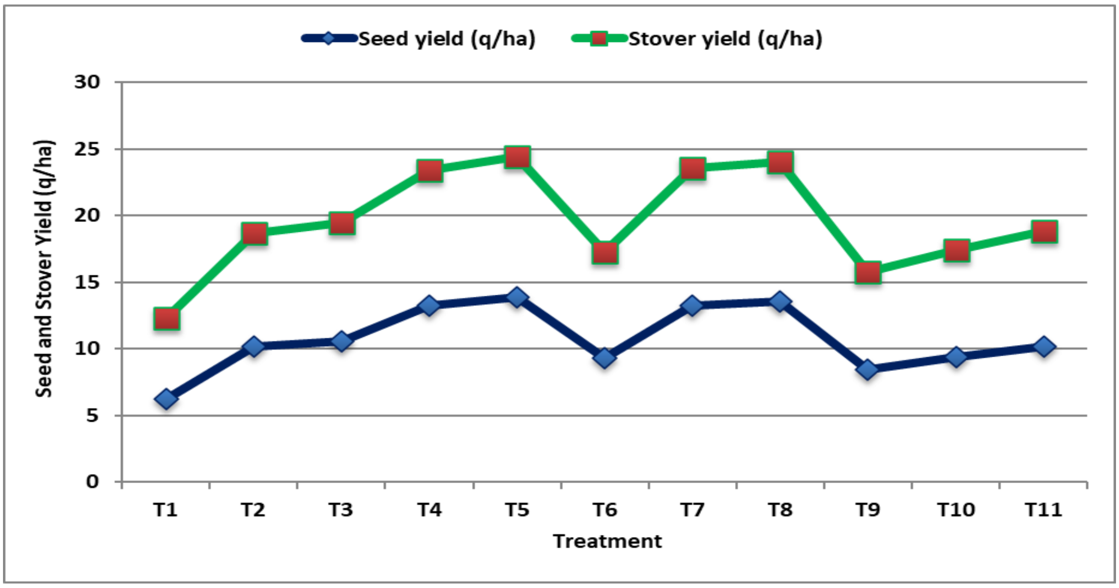

Fig 2: Effect of Integrated Nutrient Management on seed and stover yield (q/ha) in summer mungbean

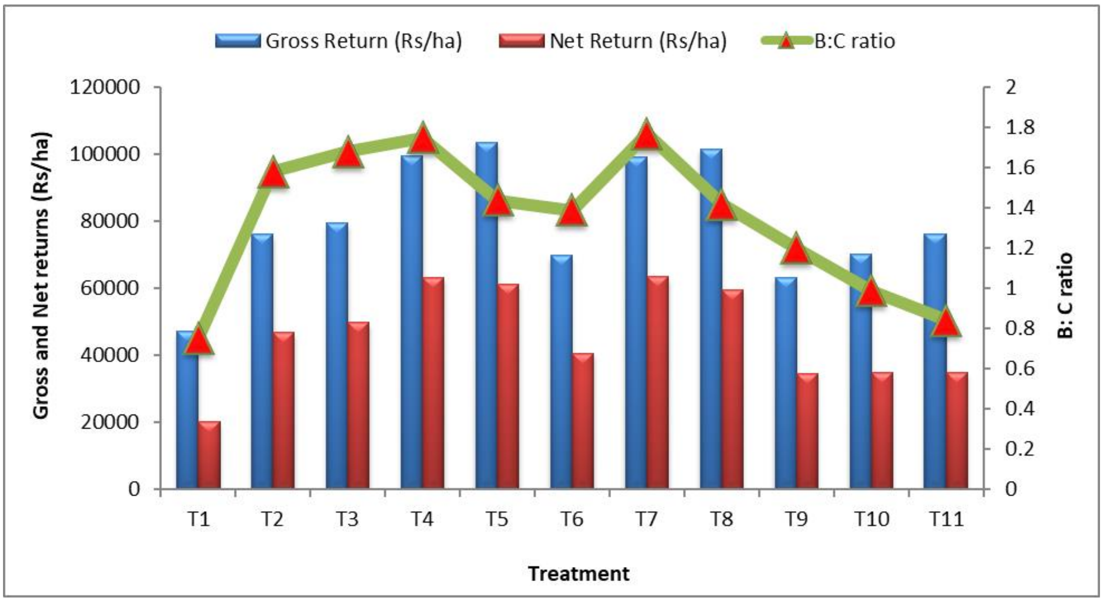

Fig 3: Effect of Integrated Nutrient Management on economic indices in summer mungbean

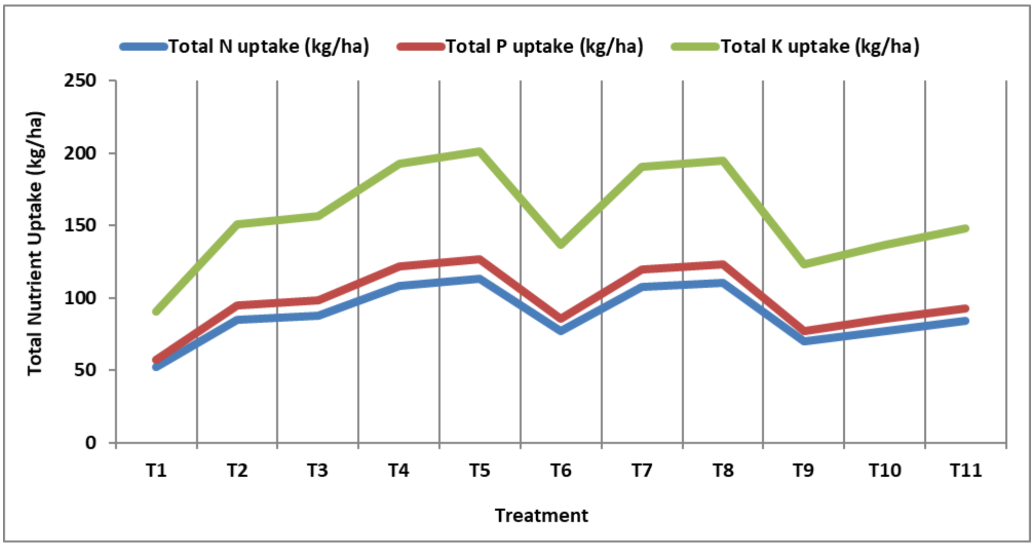

Fig 4: Effect of Integrated Nutrient Management on total N, P & K uptake (kg/ha) in summer mungbean

Conclusions

Thus, from the experiment it can be concluded that integrated application of 100% recommended dose of fertilizer with rhizobium and phosphate solubilising bacteria and farm yard manure @ 5 t/ha was found to be the best treatment for enhancing the productivity and obtaining more net returns and benefit: cost ratio in mungbean cultivation.

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