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Yield of *Vigna radiata* L. and Post-harvest Soil Fertility in Response to Integrated Nutrient Management

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Abstract

Integrated Nutrient Management (INM) aims at maximizing the efficiency of plant nutrient supply to crops through the better association of organic and inorganic sources to ensure sustainable agricultural production. A field experiment was carried out in Soil Science Sub-Station of Bangladesh Agricultural Research Institute (BARI), Gazipur during the period from August 2018 to February 2019 to find out the effects of different manures along with inorganic fertilizers on the yield and yield attributes of two mungbean varieties. The experiment was laid out in randomized complete block design (RCBD) with three replications. Results revealed that most of the growth, yield and yield contributing and nutritional parameters of mungbean *i.e.*, plant height, branches plant^{-1}, pods plant^{-1}, seeds pod^{-1}, 100-seed weight, seed yield, stover yield, biological yield and post-harvest soil fertility significantly responded to the varieties and different treatments as well as combination of these factors. BARI Mung-6 significantly showed excellent results in case of number of branches plant^{-1} (5.30), number of pods plant^{-1} (34.75), pod length (8.39 cm), 100-seed weight (5.03 g), seed yield (1.75 t ha^{-1}), harvest index (35.01%), and seed and stover yield ratio (0.54) than BINA Mung-8. Among the treatments, the combination of 3 t ha^{-1} poultry manure (PM) and 70% soil test based (STB) inorganic fertilizers was superior to other treatments for plant height, branches plant^{-1}, pods plant^{-1}, seeds pod^{-1}, seed yield, stover yield and biological yield. Integrated nutrient management significantly influenced the post-harvest properties of the soils and improved significantly with the increased levels of integration of STB inorganic fertilizers and organic manures. The highest values of the soil parameters were obtained from the treatment 3 t ha^{-1} PM + 70% STB and 3 t ha^{-1} vermicompost (VC) + 70% STB and the lowest from the control. From the economic point of view, application of poultry manure @3 t ha^{-1} along with 70% STB inorganic fertilizers showed the highest cost-benefit ratio for both varieties. It can be concluded that BARI Mung-6 appeared as the better variety and poultry manure @ 3 t ha^{-1} along with 70% inorganic fertilizers should be applied for getting economically good yield and quality under the agro-climatic condition of the studied area of Bangladesh.

Keywords

Mungbean, Organic Manures, Seed, Stover, Harvest Index, Biological Yield

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1. Introduction

Increasing food production and attaining food sufficiency in Bangladesh requires sustainable growth in the agricultural sector. But the sustainable agriculture practice is being hampered persistently due to the decreased of soil fertility

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arising from the inappropriate and injudicious application of inorganic fertilizers in recent years. However, inorganic fertilizer is usually immediate and fast accessible to the plants because of containing all necessary nutrients which can be easily available to uptake. But the continuous and imbalanced use of the chemical fertilizers under intensive cropping systems has been considered to be the main cause for declining crop yield and environmental degradation [1]. Depletion of soil organic matter is considered as one of the most serious threats to the sustainability of agriculture. Organic matter content in Bangladesh soil is very low and around one percent in most and two percent in few soils; whereas it should be maintained at least three percent that is conducive to high crop productivity [2]. But the use of organic manure alone does not result in spectacular increase in crop yields; due to their low nutrient status [3]. But they perform important functions which the chemical fertilizers do not do. They increase the organic matter content and consequently the water holding capacity, improving soil structures and ultimately soil health. The use of organic fertilizers and their proper management may reduce the need for chemical fertilizers allowing the small farmers to save the cost of production.

Pulses are considered as the protein of the poor as they have lesser access to animal proteins. But the scarcity of pulses is noticeable in Bangladesh for many years. The total pulses production in Bangladesh was about 3 lakhs and 88 thousand metric tons in 2016-2017 which was very low as compared to that of many other countries [4]. Supply of pulses falls short of their total demand and therefore the demand-supply gap is met by imports. So, this crop has caught an attention as a considerable subsector of the Department of Agricultural Extension (DAE) and Ministry of Agriculture and a plan entitled “Pulses and oil crops Research and Development Vision: 2030” has set [5] due to rise the production of pulses and also for the fulfillment of scarcity of these crops in the country. Mungbean is the third most important pulse crop in Bangladesh considering both the area and production [4]. The mungbean cultivation in Bangladesh during the year 2016-2017 was about one lakh and two thousand acres and total production was about 35 thousand metric ton [4]. It is an excellent source of protein (24.5%) with high quality of lysine (460 mg g^{-1} N) and tryptophan (60 mg g^{-1} N). It also contains remarkable quantity of ascorbic acid and riboflavin (0.21 mg $100g^{-1}$) [6]. Its seed is more palatable, nutritive, digestible and non-flatulent than other pulses grown in country. Cultivation of mungbean can improve the physical, chemical and biological properties of soil which ultimately increase soil fertility status through N-fixation from atmosphere symbiotically with the help of micro-symbionts. As a whole, mungbean could be considered as an inevitable component of sustainable agriculture. As mungbean is a short duration crop, it can fit as a cash crop between major cropping patterns which can be grown three times in a year. It is being grown with less fertile soils or with lower doses of organic and chemical fertilizers in the country, which is also responsible for the deterioration of soil health and productivity [7].

Cowdung is a good source of organic matter and in addition it accelerates the development of root system which elongates both the surface level and in deep soil and produces many branches having a large active surface [8]. Poultry manure is now a days getting popularity in our country. Poultry excreta are rich in nutrients. Poultry manure plays a vital role to improve soil fertility as well as to supply primary, secondary and micronutrients for crop production [9]. Vermicompost is an excellent source of soil organic matter which is rich in macro and micronutrients. Vermicompost, which is produced by the fragmentation of organic wastes by earthworms, have a fine particulate structure and contain nutrients in forms that are readily for plant uptake. It plays a major role in improving growth and yield of different field crops [10]. By combining organic and chemical fertilizers required nutrients can be supplied keeping good soil health. Under such circumstances, there is no alternative but to add organic fertilizer in the soils to sustain crop productivity and increase fertility. Therefore, the integrated nutrient management system is a crying need for the sustainable and cost-effective management of soil fertility by the combined application of inorganic and organic materials resulting in rising soil fertility and productivity without affecting environment. The highest productivity of crops in sustainable manner without deteriorating the soil and other natural resources could be achieved by applying appropriate combination of different organic manures and inorganic fertilizers [11]. Therefore, the integrated nutrient management for mungbean cultivation would be a good option to achieve quality yield maintaining soil fertility. Keeping in view the above facts, the present investigation was carried out to study the integrated effects of manures and chemical fertilizers on the yield and yield attributes of mungbean and to find out the most economic use of fertilizers/manure for mungbean cultivation.

2. Materials and Methods

The research work relating the study of integrated nutrient management on yield and seed quality of mungbean was conducted during the *kharif*-2 season of 2018 at the Soil Science Sub-Station, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur (24°0′13″N latitude and 90°25′0″E longitude) which lies at an elevation of 8.4 m above the sea level. The crop field was medium high land with clay loam soil and it belongs to Chhiata series (Soil taxonomy: Udic Rhodustalf) under the agro-ecological zone Madhupur Tract (AEZ-28). Before land preparation, initial soil samples from 0-15 cm depth were collected from different spots of the field and was analyzed for physical and chemical properties following the standard methods [12] presented in Table 1. BARI Mung-6 and BINA Mung-8 were used as test crops. The seeds of BARI mung-6 for the experiment were collected from BARI, Joydebpur, Gazipur, and BINA Mung-8 was collected from BINA, Mymensingh, Bangladesh. The experiment was laid out following randomized complete block design (RCBD) with three replicates. The experiment consists of 8 treatments *viz.,* T_1 = control, T_2 = 100% soil test base (STB) inorganic fertilizer dose, T_3 = 2.5 t ha^{-1} cowdung (CD) + 85% STB, T_4 = 5 t ha^{-1} CD + 70% STB, T_5 = 1.5 t ha^{-1} poultry manure (PM) + 85% STB, T_6 = 3 t ha^{-1} PM + 70% STB, T_7 = 1.5 t ha^{-1} vermicompost (VC) + 85% STB, T_8 = 3 t ha^{-1} VC + 70% STB. Each plot was 12 m^2 (4 m x 3 m) in size further divided into two portions for two varieties. The distance maintained between two plots was 0.6 m and between blocks was 1.5 m.

All fertilizers was applied broadcasted and incorporated during land preparation as per treatment of the experiment. The basal dose of N, P, K, S, Zn and B @ 40, 90, 30, 40, 5 and 6 kg ha^{-1} [13] from urea, TSP, MoP, gypsum, zinc sulphate and boric acid, respectively and CD (2.5 t ha^{-1} and 5 t ha^{-1}), PM (1.5 t ha^{-1} and 3 t ha^{-1}) and VC (1.5 t ha^{-1} and 3 t ha^{-1}) was applied. In case of full dose of manures, 70% of inorganic fertilizers and for half dose, 85% of inorganic fertilizers were applied.

Table 1. Initial characteristics of the soil in experimental field.

Characteristics	Value
% Sand	26.28
% Silt	38.20
% Clay	35.52
Soil texture (0-15 cm)	Clay loam
pH	6.71
OM (%)	1.48
Ca (meq 100g^{-1})	6.1
Mg (meq 100g^{-1})	2.1
K (meq 100g^{-1})	0.16
Total N (%)	0.078
P (µg g^{-1})	6.9
S (µg g^{-1})	3.23
B (µg g^{-1})	0.3
Cu (µg g^{-1})	1.9
Fe (µg g^{-1})	22
Zn (µg g^{-1})	1.4

Mungbean seeds were sown on the 12 August, 2018 in lines following the assigned line to line distance of 30 cm and plant to plant distance of 10 cm. The seeds were sown in solid rows in the furrows having a depth of 2 - 3 cm at the rate of 30 kg ha^{-1}. The seeds were treated by Provex 200 @ 3 g kg^{-1} seed before sowing to control diseases.

Table 2. Nutrient status of different organic manure sources.

Characteristics	Organic manure sources		
	Cowdung	Poultry manure	Vermicompost
pH	6.6	6.8	6.8
OM (%)	23	20	27
Ca (%)	1.24	1.85	1.32
Mg (%)	0.40	0.94	0.46
K (%)	0.25	0.38	0.41
N (%)	1.21	1.48	1.27
P (%)	0.66	0.76	0.36
S (%)	0.32	0.36	0.38
B (%)	0.06	0.07	0.07
Cu (%)	0.003	0.005	0.006
Fe (%)	0.29	0.24	0.31
Mn (%)	0.06	0.08	0.09
Zn (%)	0.020	0.022	0.023

Different intercultural operations were done as and when necessary. The crops were harvested when 90% of the pod matured. The crop was harvested at two phases, first harvest was done on 9 October and second on 23 October, 2018. The harvested crop dried properly in the sunlight. The seed yield was adjusted at 9% moisture level. The seed and stover yield (t ha^{-1}) per plot were recorded while cleaning up and sun-drying. Seed and stover were dried and ground for chemical analysis.

Seed yield and stover yield are regarded as biological yield and was calculated according to the following formula:

Biological yield = seed yield + stover yield

The harvest index (%) is calculated by the empirical formula given below [14].

$$\text{HI} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Where, economic yield = total seed yield (t ha^{-1})

Seed and stover yield ratio was calculated using following equation

$$\text{Seed and stover yield ratio} = \frac{\text{Seed yield}}{\text{Stover yield}}$$

Cost of cultivation, gross return, net return and benefit cost ratio was worked out to evaluate the economics of each treatment, based on the existing market prices of inputs and output. The gross return from each treatment was calculated from following formula-

Gross return (ha^{-1}) = Income from seed + Income from stover

The net return from each treatment was calculated separately, by using the following formula-

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

The benefit cost ratio was calculated using the following formula-

$$\text{Benefit cost ratio} = \frac{\text{Gross return (ha}^{-1}\text{)}}{\text{Total cost of cultivation (ha}^{-1}\text{)}}$$

Data were statistically analyzed for analyses of variance (ANOVA) using the MSTATC Statistical Computer Package Programme (Michigan State University) in accordance with the principles of Randomized Completely Block Design. Duncan's Multiple Range Test (DMRT) was used to compare variations among the treatments [15].

3. Results and Discussion

3.1. Effects of Integrated Nutrient Management on the Growth and Yield Contributing Parameters of Mungbean

3.1.1. Plant Height

Plant height was significantly influenced by different integrated organic manure and inorganic fertilizer management (Figure 1). The tallest plant (74.93 cm) was recorded from T_6 which was statistically identical with T_8 (73.27 cm), T_4 (70.38 cm) and T_2 (68.60 cm), but different from T_7 (65.28 cm), T_5 (64.20 cm) and T_3 (59.37 cm). The shortest plant (54.40 cm) was recorded from T_1 which was identical to T_3 (59.37 cm). This increased plant height was obtained might be due to the increased levels of organic manures which supply higher organic matter and nutrients. A study [16] previously reported that cowdung applied at 20 t ha^{-1} and inorganic fertilizer significantly produced taller plants, more leaves and more fruits in okra. Another study [17] suggested that the application of cow dung and N:P:K @15:15:15 increased the height of *Moringa oleifera*. Scientists have also reported different levels of organic manure significantly increased plant height [18]. Again, poultry manure treated soil gave the highest mean plant height. Comparatively high N content of poultry manure increased the vegetative growth of crops. The increase in plant height with poultry manure was mainly due to the reason of more availability of nutrients by poultry manure throughout the growing season. These results are in accordance with the findings reported previously [19]. But the contrary results were found by previous reporters [20, 21, 22] who obtained the highest results from the application of vermicompost along with inorganic fertilizers.

Plant height varied significantly due to the effect of two varieties at harvest (Table 3). BINA Mung-8 showed the tallest (68.44 cm) plant compared to BARI Mung-6 (64.17 cm). BINA Mung-8 indicated 6.65% taller plant than BARI Mung-6. Similar finding was previously reported [23].

The combined effects of different levels of manures along with STB inorganic fertilizers, and variety on plant height at harvest were found non-significant (Table 4). The highest plant height was observed in V_2T_6 (76.13 cm) and lowest from V_1T_1 (51.33 cm). It seems that the combination of organic and inorganic fertilizers significantly increased the plant height than sole use of inorganic fertilizer. Actually, organic fertilizers help to increase the organic matter content of soil, thus reducing the bulk density and decreasing compaction. Thus, plants get a suitable growing environment which promotes better growth and development. The better results was found with the combination of organic and inorganic fertilizers than the sole application of inorganic fertilizers [24, 25].

Table 3. Effects of varieties on the growth and yield attributes of mungbean.

Variety	Plant height (cm)	Branches plant^{-1}	Pods plant^{-1}	Seeds pod^{-1}	Pod length (cm)	100–seed weight (g)
BARI Mung–6	64.17 b	5.30 a	34.75 a	10.42 b	8.39 a	5.03 a
BINA Mung–8	68.44 a	4.73 b	30.76 b	10.96 a	7.80 b	4.60 b
Level of sig.	**	**	**	**	**	**
LSD (0.05)	2.99	0.08	2.42	0.15	0.26	0.11
CV (%)	7.66	2.60	12.54	2.41	5.47	3.86

** = Significant at 1% level of probability

3.1.2. Branches Plant^{-1}

The data on the number of branches plant^{-1} at harvest as influenced significantly by integrated application of organic and STB inorganic fertilizers are presented in Figure 1. The maximum number of branches plant^{-1} was counted from T_6 (5.55) which was identical with T_8 (5.43) and closely followed by T_4 (5.11), T_2 (5.17), T_7 (4.87), T_5 (4.83) and T_3 (4.63). On the other hand, the minimum number of branches plant^{-1} was obtained from T_1 (4.53). The identical result was obtained from T_3 (4.63). Similar findings were previously reported [26]. It was also observed that the number of branches per plant increased significantly with increasing level of vermicompost and it was at per with the previous result [27].

Number of branches plant^{-1} was statistically different due to the effect of two varieties (Table 3). The higher number of branches plant^{-1} was counted from BARI Mung-6 (5.30) and lower number from BINA Mung-8 (4.73). BARI Mung-6 showed 12.05% higher branches plant^{-1} than BINA Mung-8.

The combined effects of different levels of manures along with inorganic fertilizers and variety were significant on number of branches plant^{-1} (Table 4). The highest number of branches plant^{-1} was obtained from V_1T_6 (5.73) which was identical with V_1T_8 (5.60) and V_1T_2 (5.60) and followed by V_1T_4 (5.47), V_2T_6 (5.37), V_2T_8 (5.27) and V_1T_5 (5.13). The lowest number of branches plant^{-1} was obtained from V_2T_1 (4.27) which were identical to V_2T_3 (4.40). The findings were in good argument with the results reported previously in case of French bean [28]. It was also observed that the number of branches per plant increased significantly with increasing level of vermicompost and it was at per with the result of other reporter [27]. Similar findings were previously reported [26]. Moreover, another report [29] showed maximum branches plant^{-1} was found from the combination of vermicompost and 100% inorganic fertilizer. So, it can be concluded that poultry manure and vermicompost more readily supply P to plants which improve the plant cell structure and increase number of branches plant^{-1}.

3.1.3. Pods Plant^{-1}

Perusal of data presented in Figure 1 clearly revealed that integrated nutrient management brought about significant variation in the number of pods plant^{-1} during the study. Maximum number of pods plant^{-1} was recorded in T_6 (38.43) which was statistically identical to T_8 (35.78) and T_2 (34.00), but significantly different from T_4, T_5, T_7 and T_3. Minimum number of pods plant^{-1} was recorded in T_1 (27.10) which were identical to T_3 (31.02). The findings were in good agreement with the result reported [30] in case of cowpea.

The main effect of variety on total number of pods per plant was significant (Table 3). The higher number of pods plant^{-1} (34.75) was recorded from the variety BARI Mung -6 and lower number of pods plant^{-1} was recorded from BINA Mung-8 (30.76). This finding was in line with a report [31] that found that BARI Mung-6 had maximum pods plant^{-1} than BARI Mung-5. Genotypic variations in effective pods plant^{-1} was observed in mungbean [32].

The combined effects of different levels of manures along with inorganic fertilizers and variety showed no significant effect (Table 4). The maximum number was found from V_1T_6 (40.87) and V_2T_1 (28.20) showed the lowest number of pods plant^{-1}. Another report [19] indicated the results that application of 100% NPK+ poultry manure @ 5 t ha^{-1} suitable for maximum no of pods per plant of mungbean. This report was in conformity with the previous report [33].

Table 4. Interaction of varieties and different levels of manures along with inorganic fertilizers on the growth and yield attributes of mungbean.

Treatment	Plant height (cm)	Branches plant^{-1}	Pods plant^{-1}	Seeds pod^{-1}	Pod length (cm)	100–seed weight (g)
V_1T_1	51.33	4.80 e	28.20	9.60 h	7.87	4.62 ef
V_1T_2	68.33	5.60 ab	36.53	10.60 def	8.54	5.28 ab
V_1T_3	55.23	4.87 e	32.77	10.01 gh	8.24	4.70 de
V_1T_4	68.93	5.47 bc	35.47	10.60 def	8.41	4.98 bcd
V_1T_5	56.60	5.13 d	35.47	10.47 ef	8.05	5.09 bc
V_1T_6	73.73	5.73 a	40.87	11.00 bcd	8.75	5.43 a
V_1T_7	66.60	5.20 d	31.73	9.80 gh	8.25	4.99 bcd
V_1T_8	72.60	5.60 ab	36.97	11.32 ab	9.03	5.13 ab
V_2T_1	57.47	4.27 h	26.00	10.13 fg	7.33	4.24 g
V_2T_2	68.87	4.73 ef	31.47	11.07 bcd	7.90	4.70 de
V_2T_3	63.50	4.40 gh	29.27	10.80 cde	7.69	4.32 fg
V_2T_4	71.83	4.76 ef	30.60	11.07 bcd	7.89	4.75 cde
V_2T_5	71.80	4.53 fg	30.00	11.00 bcd	7.64	4.30 g
V_2T_6	76.13	5.37 bcd	36.00	11.67 a	7.97	4.75 cde
V_2T_7	63.97	4.53 fg	28.13	10.80 cde	7.86	4.64 de
V_2T_8	73.93	5.27 cd	34.60	11.15 bc	8.10	5.07 bc
Level of sig.	ns	*	ns	*	ns	*
LSD (0.05)	-	0.22	-	0.43	-	0.31
CV (%)	7.66	2.6	12.54	2.41	5.47	3.86

* = Significant at 5% level of probability, ns = non-significant.
Legend: V_1 = BARI Mung-6, V_2 = BINA Mung-8. T_1 = Native (Control), T_2 = 100% STB dose [13], T_3 = 2.5 t ha^{-1} CD + IPNS (Inorganic), T_4 = 5 t ha^{-1} CD + IPNS (Inorganic), T_5 = 1.5 t ha^{-1} PM + IPNS (Inorganic), T_6 = 3 t ha^{-1} PM + IPNS (Inorganic), T_7 = 1.5 t ha^{-1} VC+ IPNS (Inorganic), T_8 = 3 t ha^{-1} VC + IPNS (Inorganic).

3.1.4. Seeds Pod^{-1}

The data pertaining to number of seeds pod^{-1} of mungbean as influenced by integrated nutrient management have been presented in Figure 1. Number of seeds pod^{-1} was significantly affected by integrated nutrient management. Maximum number of seeds pod^{-1} was counted from T_6 (11.33) which was identical with the number of seeds pod^{-1} from T_8 (11.23) but statistically different from others treatments (T_2, T_4, T_5, T_7 and T_3). On the other hand, minimum number of seeds pod^{-1} was obtained from T_1 (9.87). This result is in agreement with previous report [34].

Variety had a significant influence on number of seeds pod^{-1}

(Table 3). BINA Mung-8 produced the higher number of seeds pod^{-1} (10.96) compared to BARI Mung-6 (10.42). Similar finding was reported previously [23]. Genotypic variations in seeds pod^{-1} was also observed in mungbean [35].

Interaction between varieties and different levels of manures along with inorganic fertilizers had significant influence on number of seeds pod^{-1} (Table 4). BINA Mung-8 produced the highest number of seeds per pod (11.67) under the treatment (V_2T_6) identical to the combination of V_1T_8 (11.32). The lowest number of seeds per pod (9.60) was recorded from V_1T_1 treatment. Similar findings were previously reported [33]. 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 seeds pod^{-1} [36].

3.1.5. Pod Length

The mean data on pod length (cm) as influenced by integrated nutrient management in Figure 1. The data revealed that integrated use of manures and inorganic fertilizers significantly affected the pod length of mungbean at 5% level of probability. The recorded higher value was T_8 (8.57cm) and identical with T_6, T_2, T_4 and T_7. The lowest pod length was recorded on T_1 (7.60 cm) and identical with T_4, T_7, T_3 and T_5. This result is in agreement with previous report [30].

A significant variation was found on pod length (cm) due to the effects of variety of mungbean (Table 3). BARI Mung-6 (8.39 cm) showed longer pod size than BINA Mung-8 (7.80 cm). BARI Mung-6 gave 7.56% higher pod length than BINA Mung-8.

These results have the agreement with the previous study [37] in where it was observed that pod length differed from varieties to varieties. The probable reason of this difference could be the genetic make-up of the varieties.

The mean data on pod length (cm) as influenced by integrated nutrient management in Table 4. The data revealed that integrated use of manures and inorganic fertilizers significantly affected the pod length of mungbean at 5% level of probability. The highest pod length was showed in V_1T_8 (9.03 cm) and V_2T_1 (7.33 cm) gave the lowest result.

3.1.6. Hundred Seed Weight

The data on 100-seed weight (g) are presented in Figure 1. The 100-seed weight (g) responded significantly due to the effects of integrated nutrient management. Hundred seed weight ranged from 5.10 g to 4.43 g. The maximum 100-seed weight was observed in T_8 (5.10 g) which was identical with T_6, T_2 and T_4.

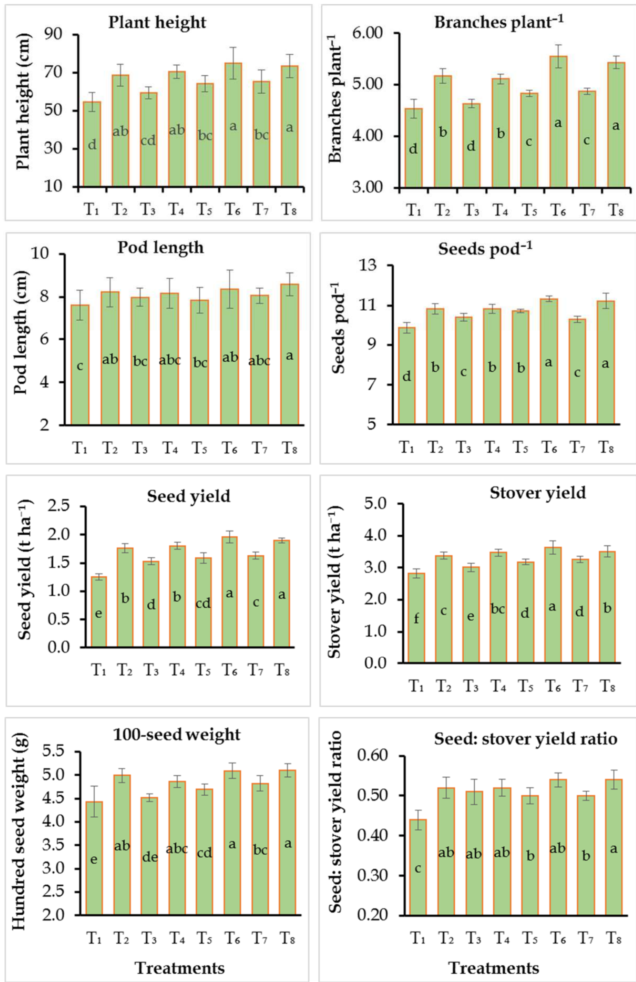

Figure 1. Effects of different treatments on the growth and yield of mungbean.

The minimum 100-seed weight was found from T_1 (4.43 g) and identical to T_3 (4.51 g). Similar findings were previously reported [30].

Variety had a significant influence on 100-seed weight (g). The maximum 100-seed weight (5.03 g) was found from the variety BARI Mung-6 (V_1). Significantly minimum (4.60 g) 100-seed weight was found in BINA Mung-8 (Table 3). BARI Mung-6 showed 9.35% higher hundred seed weight than BINA Mung-8.

The combined effect of variety and different levels of manures along with inorganic fertilizers on 100-seed weight was significant (Table 4). Significantly the highest (5.43 g) 100-seed weight was recorded from the variety V_1 (BARI Mung-6) under the treatment T_6 and identical with following treatments (V_1T_2, V_1T_8). Significantly the lowest (4.24 g) seed weight was found in the treatment combination of V_2T_1 (BINA Mung-8) under the controlled treatment which was identical to V_2T_3 (4.32 g). This may be because organic fertilizers are known to contain plant nutrients, growth promoting substances and beneficial microflora which in combination with inorganic fertilizers provide favorable soil conditions to enhance nutrient use efficiency. Similar results were reported in groundnut [24] and in green gram [25]. This finding was also in line with a study which reported that application of full dose of fertilizer + 5 t ha^{-1} poultry manure recorded the maximum test weight of field pea [38].

3.1.7. Seed Yield

Integrated nutrient management significantly influenced on seed yield (Figure 1). It appeared that seed yield varied from 1.96 to 1.25 t ha^{-1} due to different treatments. All the fertilizer treatments gave significantly higher seed yield over control. The highest amount of seed (1.96 t ha^{-1}) was obtained in T_6, which was statistically identical to T_8. The lowest grain yield (1.25 t ha^{-1}) was recorded from T_1. These results are in accordance with the previous findings [34, 39]. Seed yield varied significantly due to the effect of two varieties at harvest (Figure 2). BARI Mung-6 showed higher seed yield (1.73 t ha^{-1}) compared to BINA Mung-8 (1.63 t ha^{-1}). BARI Mung-6 showed 6.13% higher seed yield than BINA Mung-8. Genotypic variation in seed yield was also observed in another report [40].

The combined effects of variety and different levels of manures with inorganic fertilizers had significant influenced on seed yield of mungbean (Table 7). The highest seed yield (2.11 t ha^{-1}) showed the combination of V_1T_6 and followed by V_1T_8, V_2T_8 and V_1T_4. Combination of V_2T_1 showed the lowest yield (1.21 t ha^{-1}) which was identical to V_1T_1. It was revealed from the result that combination of organic and inorganic fertilizers increased the seed yield plant^{-1} than use of inorganic fertilizer alone. This may be due to higher branches plant^{-1}, pods plant^{-1}, seeds pod^{-1}. Previous study [41] supported the results for increasing of yield. This finding was in line with the study [42] suggested that the application of 2.5 t ha^{-1} poultry manure for growth and economic yield of soybean.

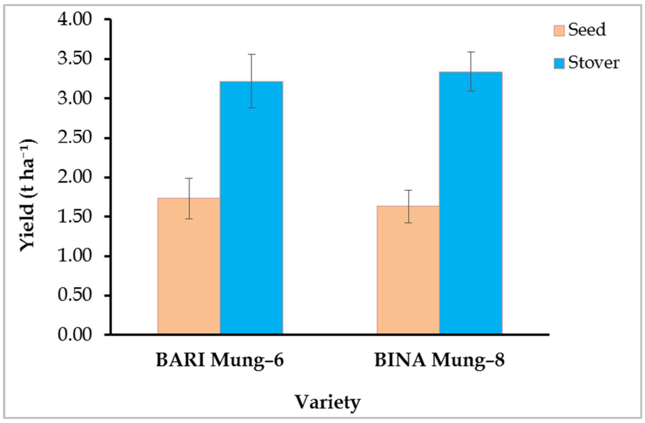

Figure 2. Effects of variety on seed and stover yield of mungbean.

3.1.8. Stover Yield

The data pertaining to stover yield as influenced by integrated nutrient management has been presented in Figure 1. Stover yield responded significantly due to the integrated nutrient management. All the fertilizer treatments gave significantly higher stover yield over control. Among the treatments T_6 recorded the highest yield (3.63 t ha^{-1}) and second highest was T_8 (3.51 t ha^{-1}) which was identical to T_4 (3.47 t ha^{-1}). The lowest stover yield was obtained from T_1 (2.82 t ha^{-1}). The result was in conformity with the report [34].

A significant variation was found on stover yield due to the effects of variety (Figure 2). The higher stover yield (3.34 t ha^{-1}) was observed from the variety BINA Mung-8 and the lower stover yield (3.22 t ha^{-1}) was recorded from the variety BARI mung-6. BINA Mung-8 showed 3.73% higher yield than BARI mung-6.

Stover yield of mungbean was significantly influenced by the combination of variety and different levels of manures with inorganic fertilizers (Table 7). Similar to seed yield, all the fertilizer treatment gave significant higher stover yield over control (Figure 2). The yield due to different treatments ranged from 3.74 to 2.72 t ha^{-1}. The highest stover yield was obtained from V_1T_6 (3.74 t ha^{-1}). Statistically identical result showed the V_2T_8 (3.64 t ha^{-1}) treatment. The lowest yield was obtained from V_1T_1 (2.72 t ha^{-1}). A previous report [41] supported the results for increasing of yield. Similar findings were also reported previously [29].

3.1.9. Biological Yield and Harvest Index

The data pertaining to the biological yield of mungbean as influenced by different treatments have been presented in Figure 3. The highest biological yield (5.59 t ha^{-1}) and lowest (4.07 t ha^{-1}) biological yield was found in treatment T_6 and T_1, respectively. A non-significant effect was shown on the biological yield due to the effect of varieties. Because, each variety produced almost same (V_1 = 4.95 t ha^{-1}, V_2 = 4.97 t ha^{-1}) biological yield (Table 6).

Table 5. Effects of integrated nutrient management on the yield and yield attributes of mungbean.

Treatment	Biological yield (t ha^{-1})	Harvest index (%)	Seed: Stover yield ratio
T_1	4.07 h	30.69 c	0.44 c
T_2	5.14 d	34.29 ab	0.52 ab
T_3	4.54 g	33.66 b	0.51 ab
T_4	5.27 c	34.20 ab	0.52 ab
T_5	4.77 f	33.29 b	0.50 b
T_6	5.59 a	35.09 a	0.54 ab
T_7	4.89 e	33.37 b	0.50 b
T_8	5.41 b	35.16 a	0.54 a
Level of sig.	**	**	**
LSD (0.05)	0.11	1.17	0.04
CV (%)	1.81	2.94	4.42

** = Significant at 1% level of probability

Legend: T_1 = Native (Control), T_2 = 100% STB dose [13], T_3 = 2.5 t ha^{-1} CD + IPNS (Inorganic), T_4 = 5 t ha^{-1} CD + IPNS (Inorganic), T_5 = 1.5 t ha^{-1} PM + IPNS (Inorganic), T_6 = 3 t ha^{-1} PM + IPNS (Inorganic), T_7 = 1.5 t ha^{-1} VC+ IPNS (Inorganic), T_8 = 3 t ha^{-1} VC + IPNS (Inorganic).

Interaction between varieties and different levels of manures with inorganic fertilizers had significant influence on biological yield (Table 7). All the treatment showed significantly higher yield over control. The highest biological yield gave the treatment V_1T_6 (5.85 t ha^{-1}) and the lowest came from V_1T_1 (4.00 t ha^{-1}) which was identical to V_2T_1. High yield in plants is determined by physiological processes leading to a high net accumulation of photosynthates and its partitioning into seeds [43]. In the study application of poultry manure had accumulated high photosynthates in the plants i.e. biological yield, which was translocated efficiently to the grains resulting high yield in mungbean [43].

Harvest index of mungbean as influenced by different treatments are presented in Table 5. Application of inorganic and different doses of organic fertilizers showed significant influence on harvest index. The highest result was observed in T_8 (35.16%) which was identical to T_6, T_2 and T_4. The lowest result was obtained from the control (30.69%). In a previous study [44], it was observed that application of 75% RDF + 2.5 t ha^{-1} VC + *Rh* + PSB significantly improved seed, straw, biological yield and harvest index of mungbean.

Table 6. Effects of varieties on the yield and yield attributes of mungbean.

Variety	Biological yield (t ha^{-1})	Harvest index (%)	Seed: Stover yield ratio
BARI Mung–6	4.95	34.84 a	0.54 a
BINA Mung–8	4.97	32.60 b	0.49 b
Level of sig.	ns	**	**
LSD (0.05)	-	0.58	0.02
CV (%)	1.81	2.94	4.42

** = Significant at 1% level of probability, ns = non-significant.

Variety had a significant influence on harvest index (Table 6). BARI Mung-6 (34.84%) was superior to BINA Mung-8 (32.60%). BARI Mung-6 had 6.87% more harvest index compared to BINA Mung-8.

In the combined effect of varieties and different levels of manures with inorganic fertilizers on harvest index showed no significant differences for statistically same results (Table 7). The highest result was obtained from V_1T_8 (36.26%) and lowest was obtained from V_2T_1 (29.38). Previous report [45] indicated that the highest harvest index 25.7% was recorded with vermicompost treatment as compared to no compost (23.29%).

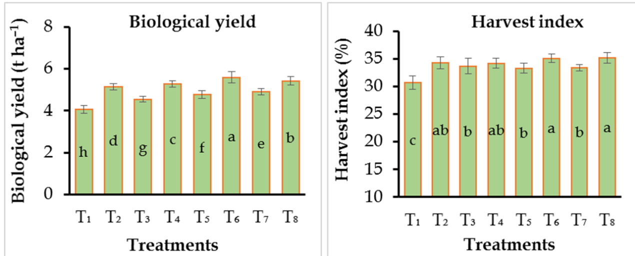

Figure 3. Effects of integrated nutrient management on biological yield and harvest index of mungbean.

3.1.10. Seed and Stover Yield Ratio

Due to the effects of different levels of manures and inorganic fertilizers, seed and stover yield ratio showed significant variation (Figure 1) where the maximum ratio (0.54) was found in T_8 treatment which was identical to T_6, T_2, T_4 and T_3. Minimum ratio was observed in control (0.44). Seed and stover yield ratio varied significantly due to the effect of two varieties (Table 6). BARI Mung-6 showed the higher ratio (0.54) compared to BINA Mung-8 (0.49). A non-significant effect was shown on seed and stover yield ratio due to the effect of variety and different levels of manures with inorganic fertilizers (Table 7). The highest result was obtained from V_1T_8 (0.57) and V_2T_1 (0.42) showed the lowest result.

Table 7. Interaction of varieties and different levels of manures along with inorganic fertilizers on the yield and yield attributes of mungbean.

Treatment	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)	Seed: Stover yield ratio
V_1T_1	1.28 j	2.72 g	4.00 i	32.00	0.47
V_1T_2	1.82 cd	3.31 cd	5.13 e	35.48	0.55
V_1T_3	1.55 hi	2.91 f	4.46 h	34.73	0.53
V_1T_4	1.87 bc	3.43 bc	5.30 cd	35.24	0.55
V_1T_5	1.62 fgh	3.01 ef	4.63 g	34.96	0.54
V_1T_6	2.11 a	3.74 a	5.85 a	36.02	0.56
V_1T_7	1.67 efg	3.25 d	4.92 f	34.00	0.52
V_1T_8	1.92 b	3.38 bcd	5.30 cd	36.26	0.57
V_2T_1	1.21 j	2.92 f	4.13 i	29.38	0.42
V_2T_2	1.71 ef	3.45 bc	5.16 de	33.09	0.50
V_2T_3	1.50 i	3.11 e	4.61 g	32.59	0.48
V_2T_4	1.74 de	3.50 b	5.24 cde	33.15	0.50
V_2T_5	1.55 hi	3.35 cd	4.90 f	31.62	0.46
V_2T_6	1.82 cd	3.51 b	5.33 c	34.16	0.52
V_2T_7	1.59 ghi	3.26 d	4.85 f	32.73	0.49
V_2T_8	1.88 bc	3.64 a	5.52 b	34.07	0.52
Level of sig.	**	**	**	ns	ns
LSD (0.05)	0.09	0.13	0.15	-	-
CV (%)	3.48	2.27	1.81	2.94	4.42

** = Significant at 1% level of probability, ns = non-significant.
Legend: V_1 = BARI Mung-6, V_2 = BINA Mung-8. T_1 = Native (Control), T_2 = 100% STB dose [13], T_3 = 2.5 t ha^{-1} CD + IPNS (Inorganic), T_4 = 5 t ha^{-1} CD + IPNS (Inorganic), T_5 = 1.5 t ha^{-1} PM + IPNS (Inorganic), T_6 = 3 t ha^{-1} PM + IPNS (Inorganic), T_7 = 1.5 t ha^{-1} VC+ IPNS (Inorganic), T_8 = 3 t ha^{-1} VC + IPNS (Inorganic).

3.2. Effects of Integrated Nutrient Management on Fertility Status of Post-harvest Soil

Integrated nutrient management significantly influenced the post-harvest properties of the soils (Tables 8 and 9). The data revealed that all the parameters were significantly increased with the increased levels of organic manures (CD, PM and VC). It can be seen from the results that all the parameters were significantly influenced by the addition of different organic manures. The acidity of the soil decreased with organic manure application. The pH of both varieties ranged from 6.64 to 6.89 in BARI Mung-6 and 6.6 to 6.91 in BINA Mung-8.

Table 8. Effects of integrated nutrient management on fertility status of post-harvest soil of BARI Mung-6.

Treatments	pH	OM (%)	Ca meq/100g^{-1}	Mg	K	N (%)	P µg g^{-1}	S	B	Cu	Fe	Zn
T_1	6.64	1.43 c	6.05 e	2.02 e	0.14 d	0.075 d	6.25 h	3.13 f	0.27 e	1.76 c	19.00 c	1.37 e
T_2	6.69	1.46 c	6.12 e	2.09 de	0.18 cd	0.082 cd	8.65 g	4.55 e	0.32 de	1.89 c	20.00 c	1.56 de
T_3	6.73	1.64 b	6.44 d	2.21 de	0.21 c	0.095 c	12.22 d	7.21 d	0.37 cd	2.34 b	26.33 bc	1.69 de
T_4	6.76	1.78 a	6.79 c	2.33 cde	0.23 c	0.100 c	13.60 b	8.50 c	0.41 bc	2.61 ab	32.00 ab	1.84 cd
T_5	6.80	1.57 b	6.92 bc	2.83 ab	0.37 b	0.133 b	12.84 c	7.23 d	0.430 bc	2.73 ab	23.00 c	1.75 de
T_6	6.84	1.76 a	7.36 a	3.07 a	0.39 b	0.260 a	15.31 a	9.28 b	0.590 a	2.94 a	30.67 ab	2.21 bc
T_7	6.83	1.76 a	6.82 c	2.48 bcd	0.42 ab	0.096 c	9.18 f	8.30 c	0.46 b	2.80 ab	31.00 ab	2.34 b
T_8	6.89	1.84 a	7.15 ab	2.63 bc	0.45 a	0.147 b	10.91 e	10.17 a	0.57 a	3.01 a	38.00 a	2.82 a
Level of sig.	ns	**	**	**	**	**	**	**	**	**	**	**
LSD (0.05)	-	0.110	0.287	0.379	0.055	0.018	0.489	0.443	0.078	0.432	6.89	0.371
CV (%)	1.51	3.72	2.44	8.81	10.72	10.10	2.51	3.47	10.24	9.84	14.30	10.93

** = Significant at 1% level of probability, ns = non-significant.
Legend: T_1 = Native (Control), T_2 = 100% STB dose [13], T_3 = 2.5 t ha^{-1} CD + IPNS (Inorganic), T_4 = 5 t ha^{-1} CD + IPNS (Inorganic), T_5 = 1.5 t ha^{-1} PM + IPNS (Inorganic), T_6 = 3 t ha^{-1} PM + IPNS (Inorganic), T_7 = 1.5 t ha^{-1} VC+ IPNS (Inorganic), T_8 = 3 t ha^{-1} VC + IPNS (Inorganic).

The organic matter status of soils was considerably improved due to the increased application levels of treatments. Organic matter content ranged from 1.43 to 1.84% in BARI Mung-6 and 1.41 to 1.82% in BINA Mung-8. The contents of total N, available P, exchangeable K, Ca, Mg, and available S, Zn, Fe, Cu and B were significantly increased with the increased levels of organic manures. The highest values of the parameters were obtained from treatment T_6 and T_8 and the lowest from the control. The acidity of the soil was reduced to some extent and favors the growth and yield of mungbean. Another report [46] was of the same opinion that any organic material if added to the soil that will reduce soil acidity. They reported that the addition of plant residues increased soil pH by 0.1 – 0.8 unit. This may be due to the fact that when organic residues (plant or animal) are added to the soil, they release organic anions which neutralize the hydrogen ion of the acid soil. The organic matter (OM) content of the post-harvest soils significantly increased due to the application of manures in the soil. This increasing OM content might be due to the additions of manures. Among the three organic amendments, PM and VC showed the highest results in case of most of the soil parameters.

Table 9. Effects of integrated nutrient management on fertility status of post-harvest soil of BINA Mung-8.

Treatments	pH	OM (%)	Ca meq/100g^{-1}	Mg	K	N (%)	P µg g^{-1}	S	B	Cu	Fe	Zn
T_1	6.66	1.41 d	6.08 d	2.01 e	0.13 e	0.074 e	6.48 f	3.20 g	0.25 g	1.81 f	18.00 e	1.32 e
T_2	6.68	1.44 d	6.11 d	2.08 de	0.17 de	0.088 de	8.303 e	4.70 f	0.33 f	1.87 f	21.00 de	1.64 d
T_3	6.71	1.61 c	6.51 c	2.28 cde	0.20 d	0.097 cd	10.37 c	7.26 e	0.38 ef	2.42 e	25.00 cd	1.77 d
T_4	6.77	1.74 ab	6.84 bc	2.42 cd	0.29 c	0.111 c	12.94 b	8.62 c	0.41 de	2.76 bc	32.00 ab	1.94 cd
T_5	6.82	1.59 c	7.06 ab	2.83 b	0.38 b	0.166 b	13.36 b	7.40 e	0.46 cd	2.54 de	21.67 cde	2.10 c
T_6	6.86	1.67 bc	7.33 a	3.18 a	0.41 b	0.233 a	15.62 a	9.38 b	0.55 a	2.85 ab	27.00 bcd	2.46 b
T_7	6.80	1.76 ab	6.93 ab	2.45 c	0.36 b	0.0950 cd	9.37 d	7.92 d	0.49 bc	2.64 cd	27.67 bc	2.21 bc
T_8	6.91	1.82 a	7.09 ab	2.79 b	0.48 a	0.163 b	10.55 c	10.48 a	0.53 ab	2.97 a	35.00 a	2.88 a
Level of sig.	ns	**	**	**	**	**	**	**	**	**	**	**
LSD (0.05)	-	0.123	0.383	0.336	0.055	0.018	0.460	0.411	0.055	0.175	5.902	0.303
CV (%)	1.67	4.24	3.26	7.65	10.52	7.43	2.42	3.18	6.93	3.93	13.00	8.43

** = Significant at 1% level of probability, ns = non-significant.
Legend: T_1 = Native (Control), T_2 = 100% STB dose [13] T_3 = 2.5 t ha^{-1} CD + IPNS (Inorganic), T_4 = 5 t ha^{-1} CD + IPNS (Inorganic), T_5 = 1.5 t ha^{-1} PM + IPNS (Inorganic), T_6 = 3 t ha^{-1} PM + IPNS (Inorganic), T_7 = 1.5 t ha^{-1} VC+ IPNS (Inorganic), T_8 = 3 t ha^{-1} VC + IPNS (Inorganic).

The higher nutrient content was found in PM and VC amended soil that might be due to higher nutrient contents in them as compared to other amendments. Moreover, the nutrients may be rapidly and consistently released from these manures over the growth period of mungbean. These results are similar with the findings of some earlier reports [47, 48].

3.3. Economic Analyses

3.3.1. Gross Income

Data revealed that the highest gross income of BARI Mung-6 (tk. 148635) was obtained from the treatment T_6 and the second highest gross income (tk. 135245) was obtained from treatment T_8. The lowest gross income (tk. 90280) was calculated from control. Again, in case of BINA Mung-8, the highest gross income (tk. 132510) was obtained from the treatment T_8 and the lowest gross income (tk. 85430) was found in control.

3.3.2. Net Return

Net return varied significantly among different treatment combinations (Table 10). The highest net return (tk. 88220) of BARI Mung-6 was obtained from the treatment T_6 which was followed by the treatment T_2 and T_4. In contrast, the lowest net return (tk. 39470) was obtained from control. Furthermore, the highest net return (tk. 68120) of BINA Mung-8 was obtained from the treatment T_6 which was identical to T_2 and the lowest was obtained from control (tk. 34850).

Table 10. Comparative economic per hectare profitability of BARI Mung-6 production.

Treatments	BARI Mung-6		BINA Mung-8	
	Net return (tk.)	BCR	Net return (tk.)	BCR
T_1	39470 e	1.78 d	34850 e	1.68 d
T_2	71030 b	2.24 b	63130 ab	2.10 ab
T_3	50090 d	1.85 cd	47050 d	1.80 c
T_4	70750 b	2.17 b	61650 bc	2.02 b
T_5	55430 cd	1.95 c	50650 d	1.86 c
T_6	88220 a	2.47 a	68120 a	2.13 a
T_7	51950 cd	1.79 d	45830 d	1.69 d
T_8	60350 c	1.81 cd	57610 c	1.77 cd
Level of sig.	**	**	**	**
LSD (0.05)	8124	0.14	5229	0.096
CV (%)	7.62	3.95	5.57	2.71

**= Significant at 1% level of probability

Legend: T_1 = Native (Control), T_2 = 100% STB dose [13] T_3 = 2.5 t ha^{-1} CD + IPNS (Inorganic), T_4 = 5 t ha^{-1} CD + IPNS (Inorganic), T_5 = 1.5 t ha^{-1} PM + IPNS (Inorganic), T_6 = 3 t ha^{-1} PM + IPNS (Inorganic), T_7 = 1.5 t ha^{-1} VC+ IPNS (Inorganic), T_8 = 3 t ha^{-1} VC + IPNS (Inorganic).

3.3.3. Benefit Cost Ratio (BCR)

Data in Table 10 revealed that benefit cost ratio (BCR) of mungbean increased significantly with integrated nutrient management sources over control. For both varities, treatment T_6 indicated the highest BCR (BARI Mung-6: 2.47, BINA Mung-8: 2.13). But incase of BINA Mung-8 (2.10), the treatment T_2 showed identical result. The lowest result was obtained from control in both varieties (BARI Mung-6: 1.78, BINA Mung-8: 1.68). Net returns and benefit cost ratio were significantly increased by the application of manures. The increased net returns could be explained on the basis of increased yield under the influence of sources of inorganic and organic nutrients. Further, the BCR was decreased due to the application of organic sources (vermicompost) of the higher cost involved in applying them. A previous report [49] at Jorhat observed that application of 100% fertilizer (N @15 kg ha^{-1} and P_2O_5 @35 kg ha^{-1}) significantly increased economics of mungbean over control.

4. Conclusions

Based on the findings of the present study, it was observed that different treatments influenced significantly in respect to yield, yield contributing and quality characters. The results of the experiment indicated that BARI Mung-6 performed better than BINA Mung-8 in case of most of the growth parameters and the combination of organic and inorganic fertilizers is more productive compare to sole use of inorganic fertilizers. Application of 3 t ha^{-1} poultry manures along with 70% inorganic fertilizers showed better performance on the yield, yield attributes, and post-harvest soil fertility. This treatment also showed economically better results. But the application of 3 t ha^{-1} vermicompost along with 70% inorganic fertilizers provided almost similar results with the sole application of inorganic fertilizers. Again, from economic point of view, the benefit cost ratio was decreased due to the application of vermicompost involved higher cost. So, it can be concluded that BARI Mung-6 appeared as the better variety and poultry manure @ 3 t ha^{-1} along with 70% STB inorganic fertilizers should be applied for getting economically good yield and quality mungbean.

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Conflicts of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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