Plant growth pattern, tiller dynamics and dry matter accumulation of wetland rice (*Oryza sativa* L.) as influenced by application of different manures

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Abstract: To observe the comparative performance of different organic manures with inorganic fertilizers on the growth rate, tillering and dry matter accumulation of rice an experiment was conducted in the Research Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during June to November, 2008. The 10 treatments comprised viz. T_1 (Control), T_2 (Green manure @ 15 t ha^{-1}), T_3 (Green manure @ 15 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ i.e.50% NPK), T_4 (Poultry manure @ 4 t ha^{-1}), T_5 (Poultry manure @ 4 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ i.e. 50% NPK), T_6 (Cowdung @ 12 t ha^{-1}), T_7 (Cowdung @ 12 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ i.e. 50% NPK), T_8 (Vermicompost @ 8 t ha^{-1}), T_9 (Vermiconpost @ 8 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ i.e. 50% NPK) and T_{10} ($N_{80}P_{12}K_{72}S_{10}$ i.e.100% NPK). Plant height, number of tillers hill^{-1}, total dry weight of plants, crop growth rate and relative growth rate were significantly influenced by different treatments. Except plant height and total tiller per hill all the parameters were found to be the highest with the treatment T_5 (Poultry manure @ 4 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ i.e. 50% NPK). The dry matter production showed a significant relationship with grain yield of rice.

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Key words: Rice, Organic manures, CGR, RGR, Dry matter partitioning, Yield

1. Introduction

After the industrial revolution widespread introduction of inorganic fertilizers led to a decline in the use of organic material in the cropping systems (Rosegrant and Roumasset, 1987). The impact of increased fertilizer use on crop production has been large and important (Hossain and Singh, 2000). More recently, attention is focused on the global environmental problems. The world elite society is giving emphasize on utilization of organic wastes, FYM, compost, vermicompost and poultry manures as the most effective measure to save the environment to some extent. Organic materials are the safer sources of plant nutrient which have no detrimental effect to crops and soil. Cowdung, farm yard manure, poultry manure and also green manure are excellent sources of organic matter as well as primary plant nutrients (Pieters, 2005).

Rice production in Asia increased upto 25% between 1965 and 1980 due to fertilizer use (Barker et al., 1985). In recent years there has been serious concern about long-term adverse effect of continuous and indiscriminate use of inorganic fertilizers on deterioration of soil structure, soil health and environmental pollution (Ghosh and Bhat, 1998; Shukla et al., 1998; Singh, 2000). In contrast to inorganic fertilizer the use of green manures and other organic matter can improve soil structure, improve nutrient exchange and maintain soil health and that is why interests have been raising in organic farming (Ayoub, 1999; Becker et al., 1995). Poultry manure is an excellent organic fertilizer, as it contains high nitrogen, phosphorus, potassium and other essential nutrients. Poultry manure supplies phosphorus more readily to plants than other organic manure sources (Garg and Bahla, 2008). Vermicompost has been shown to have high levels of total and available nitrogen, phosphorous, potassium (NPK) and micro nutrients, microbial and enzyme activities and growth regulators (Parthasarathi and Ranganathan 1999; Chaoui et al., 2003) and continuous and adequate use with proper management can increase soil organic carbon, soil water retention and transmission and improvement in other physical properties of soil like bulk density, penetration resistance and aggregation (Zebarth et al., 1999) as well as beneficial effect on the growth of a variety of plants (Atiyeh et al., 2002).

Most of the cultivated soils of Bangladesh have less than 1.5% organic matter while a good agricultural soil should contain at least 2% organic matter. In last 20 years in the content of organic matter decreased by 15 to 30% (Miah, 1994). The reasons for declining organic matters with time is intensive cropping and use of higher dose of chemical fertilizers with little or no addition of organic manure.

Rice is the staple food of Bangladesh and majority of food grain comes from rice. About 80% of cropped area of this country is used for rice production, with annual production of 4,37,29,000 metric tons (IRRI, 2006) in total acreage of 1,10,59,000 ha. The average yield of rice in Bangladesh is 3.90 t ha^{-1} (BRRI, 2007) which is almost less than 50% of the world average yield. Due to declining factor of productivity under increased intensification the production level of rice is maintaining the same level for years. Therefore, farmers are compelled to apply increasing rates of fertilizers to maintain current yield levels (Pagiola, 1995). But it is more detrimental for the soil health. The reasons for low yield of rice are manifold; some are varietals, others are technological and rests are climatic. The yield can be increased by using improved cultural practices like use of quality seed, high yielding varieties, adopting plant protection measures, judicious application of fertilizers, etc. Among them integrated nutrient management can be one of the most effective means to increase the productivity of rice.

Guowei et al. (1998) reported that rice (*Oryza sativa* L.) crop functions as a population of tillers produced at different times and possessing specific growth characteristics. They showed significant contribution of cultivar tillering ability to dry matter accumulation, yield components, and grain yield. Singh et al. (2003) reported that crop growth rate and relative growth rate was significantly influenced by NPK. The tiller number and total dry matter production are closely correlated with yield depending on the rice cultivar (Tanaka, 1968) which can be greatly enhanced by applying proper nutrient. Prasad (1981) observed the increase of TDM due to increased N application.

A good amount of plant nutrients are supplied by organic manure that contribute to crop growth and yields. To maintain the present levels of crop productivity of high yielding varieties the use of organic manures single-handedly, as a substitute to chemical inorganic fertilizer is not economic and sufficient (Garrity and Flinn, 1988). Therefore, integrated nutrient management in which both organic manures and inorganic fertilizers are used simultaneously is probably the most effective method to maintain healthy sustainable soil system while increasing crop productivity (Janssen, 1993). Organic manures and chemical fertilizers should be used combined to get higher yield, to maintain soil health as well as a cost effective production system. Thus it is necessary to carry out studies by using fertilizers and manures in an integrated way to find out the appropriate dose or proportion of chemical fertilizers and manures use to maintain a desirable yield level. Considering these facts the present study was undertaken to determine the suitable manure and fertilizer combination for optimum growth, tillering and dry matter production of transplanted rice.

2. Materials and Methods

2.1 Experimental site:

The experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during June to November, 2008. Geographically, the experimental area is located at 23^0 77′ N latitude and 90^0 33′ E longitude at the elevation of above 18 m of the sea level. The soil of the experimental field belongs to the Shallow Red Brown Terrace Soils. Physical and chemical properties of initial soil is presented in Table 1.

Table 1. Physical and chemical characteristics of the initial soil (0-15 cm depth)

Characteristics	Value
Mechanical fractions:	
% Sand (0.2-0.02 mm)	22.26
% Silt (0.02-0.002 mm)	56.72
% Clay (<0.002 mm)	20.72
Textural class	Silt Loam
pH (1: 2.5 soil: water)	6.2
CEC (cmol kg^{-1})	17.9
Organic C (%)	0.686
Organic Matter (%)	1.187
Total N (%)	0.032
Exchangeable K (cmol kg^{-1})	0.12
Available P (mg kg^{-1})	19.85
Available S (mg kg^{-1})	14.40

2.2 Experimental treatments and design:

The experiment was carried out with 10 different treatments were as follows:

T_1= Control

T_2= Green manure @ 15 t ha^{-1}

T_3= Green manure @ 15 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ (50% NPK)
T_4= Poultry manure @ 4 t ha^{-1}
T_5= Poultry manure @ 4 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ (50% NPK)
T_6= Cowdung @ 12 t ha^{-1}
T_7= Cowdung @ 12 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ (50% NPK)
T_8= Vermicompost @ 8 t ha^{-1}
T_9= Vermicompost @ 8 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ (50% NPK)
T_{10}= $N_{80}P_{12}K_{72}S_{10}$ (100% NPK)

The experiment was laid out in a randomized completely block design (RCBD) with 3 replications. The unit plot size was 12 m^2.

Table 2. Chemical compositions of the organic manures used for the experiment (oven dry basis)

Organic manure	**Nutrient content**				
	C (%)	**N (%)**	**P (%)**	**K (%)**	**C: N**
Cowdung	36.0	1.48	0.29	0.75	24.0
Poultry manure	29.0	2.19	1.98	0.81	8.0
Sesbania	46.0	2.95	0.26	1.56	15.0
Vermicompost	11.5	1.66	1.25	0.25	9.6

2.3 Crop establishment and application of treatments:

The experiment was carried out with rice variety 'BRRI dhan40'. A common procedure was followed in raising of seedlings in seed bed. Seedlings of 25 days old were uprooted from the nursery beds carefully. Seedlings were transplanted according to the treatments in the well-puddled experimental plots. Spacings were given as 20 cm × 15 cm. Organic manures were applied before land preparation as per treatments. The nutrient compositions of the manures used in this experiment are presented in Table 2. Thirty-days-old *Sesbania rostrata* green plants were incorporated as green manure. Others manures were used as decomposed. Chemical fertilizers were applied as per treatments during final land preparation. Urea, triple superphosphate, muriate of potash and gypsum were applied as sources of N, P, K and S. In case of N one-third urea was applied as basal dose at the time of final land preparation and incorporated well into the soil. Rest two-third of urea was applied in two equal splits at 30 and 60 days after transplanting (DAT). All intercultural operations were done carefully. The first weeding was done at 15 days after transplanting (DAT) followed by second and third weeding was done at 15 days interval after first and second weeding. Irrigation was applied by alternate wetting and drying from transplanting to maximum tillering stage. From panicle initiation (PI) to hard dough stage, a thin layer of water (2-3 cm) was kept on the plots. Water was removed from the plots during ripening stage. The crop of each plot was harvested separately on different dates when 90% of the grains become golden yellow in colour.

2.4 Data collection and analysis:

The first plant height was measured at 30 DAT and continued up to harvesting period with 20 days interval. Plant height was determined by measuring the distance from the soil surface to the tip of the leaf before heading and to the tip of the flag leaf after heading. The collected data were finally averaged. Number of tillers hill^{-1} was counted at 20 days interval starting from 30 DAT and continued up to harvest from 10 pre-selected hills and finally averaged them to have tiller number hill^{-1}. Ten hills from each plot were uprooted and oven dried at 85 ± 5^{0}C for 72 hours from which the dry matter weight was recorded at 20 days interval up to 90 days.

The dry matter accumulation of the crop per unit land area in unit of time is referred to crop growth rate (CGR), expressed as g m^{-2} d^{-1}. The mean CGR values for the crop during the sampling intervals were computed using the formula of Brown, (1984).

$$CGR = \frac{W_2 - W_1}{SA(t_2 - t_1)} \text{ g m}^{-2} \text{ d}^{-1}$$

Where,

SA= Ground area occupied by the plant at each sampling. W_1 and W_2 are the total dry matter production in grams at the time t_1 and t_2, respectively.

The relative growth rate at which a plant incorporates new material into its sink is measured by Relative Growth Rate of dry matter accumulation and is expressed in g g^{-1}d^{-1}. Relative growth rate was worked out by following the formula of Radford (1967).

$$RGR = \frac{L_n W_2 - L_n W_1}{T_2 - T_1} \quad \text{g g}^{-1} \text{ d}^{-1}$$

Where, W_1 and W_2 is initial and final dry matter weight at the time T_1 and T_2, respectively. L_n refers to Natural Logarithm.

The grain weights for each plot were recorded after proper sun drying and then converted into t ha^{-1}. The grain yield was adjusted at 12% moisture level.

The data was analyzed using CoStat software (CoHort, 2008) programme. The mean differences among the treatments were compared by multiple comparison tests using Duncan's Multiple Range Test

(DMRT). Regression analysis was done by using SPSS software package (SPSS, 2009).

3. Results and Discussion

3.1 Plant height

From the study it was observed that plant height of rice cv. BRRI dhan40 was significantly affected by the manure treatments regardless the crop duration (Fig. 1). The increase rate of plant height was more between 50 DAT and 70 DAT as it was the maximum vegetative stage in rice plant. At 110 DAT the plants were about to maturity and hence the plant height was increased further very slightly. Regarding the treatments T_{10} (full dose of NPK) produced the tallest plants in each stage of growth. At maximum vegetative stage 50% NPK and *Sesbania* green manure incorporation (T_3) also gave significantly taller plants than others manures. Significant roles of *Sesbania* green manures to plant height might be due to its high N content which influenced the vegetative growth at the earlier stage of plant growth. Any organic manure applied in combination with 50% NPK gave identical results in this study (Fig. 1). In case of rice vegetative growth is greatly mediated by N fertilizers. In this study treatment T_{10} produced the tallest plant because it provided sufficient N available for plant. The amount of N released by *Sesbania* with 50% NPK was also sufficient to supply the required amount of N. However, control treatment (without fertilizer) produced the shortest plants in this experiment. The variation in plant height due to nutrient sources was considered to be due to variation in the availability of major nutrients. Chemical fertilizer offers nutrients which are readily soluble in soil solution and thereby instantaneously available to plants. Nutrient availability from organic sources is due to microbial action and improved physical condition of soil. These results were supported by Sarker et al. (2004).

3.2 Number of tillers

Tillering is an important trait for grain production and is thereby an important aspect of rice growth improvement. Production of tillers in rice plant was also influenced by different fertilizer combination at all the growth stages (Fig. 2).

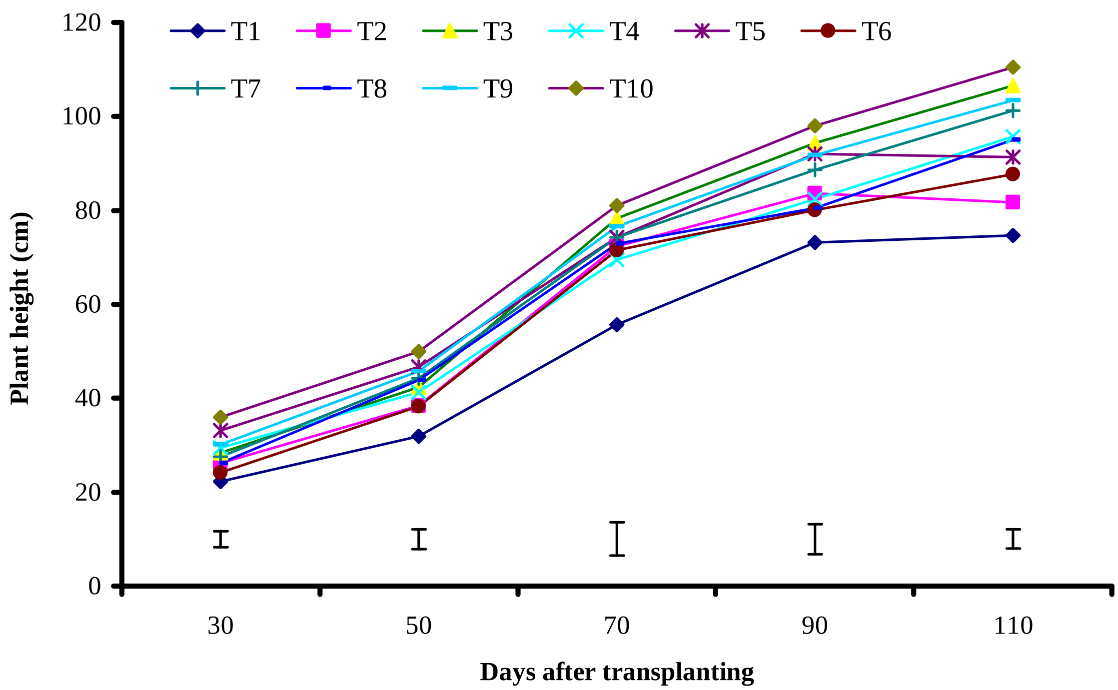

Figure 1. Plant height of transplanted rice cv. BRRI dhan40 at different days after transplanting as affected by different manuring treatments (vertical error bars represents the LSD values at $P < 0.05$)

[T_1= Control; T_2= Green manure @ 15 t ha^{-1}; T_3= Green manure @ 15 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ (50% NPK); T_4= Poultry manure @ 4 t ha^{-1}; T_5= Poultry manure @ 4 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ (50% NPK); T_6= Cowdung @ 12 t ha^{-1}; T_7= Cowdung @ 12 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ (50% NPK); T_8= Vermicompost @ 8 t ha^{-1}; T_9= Vermicompost @ 8 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ (50% NPK) and T_{10}= $N_{80}P_{12}K_{72}S_{10}$ (100% NPK)]

At initial sages tiller number was not remarkably influenced by the treatments because of the slower activity of nutrients. After 30 DAT tiller numbers were linearly increased up to 70 DAT. But after the counting from 90 DAT tiller number was found decreased. It was due to the tiller mortality and the senescence of plants. In the present study up to 50 DAT (just before maximum tillering stage) the highest number of tillers was produced by the treatment T_{10} (100% NPK) but at 70 DAT and 90 DAT T_5 (Poultry manure @ 4 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$) produced the highest number of tillers per hill which was statistically identical with T_{10}. Just before harvest (110 DAT) maximum number of tillers (13.4 per hill) was produced with T_{10} which was followed by T_5 and T_9. Tiller productions with these treatments were 90.14%, 80.28% and 70.42% higher than control (T_1) treatment. In case of control treatment there was deficiency of N and other essential nutrients which was required for tiller production while the other treatments supplied it which rendered the higher number of tillers. Similar findings were reported by Tanaka (1968). The productivity of rice plant is greatly dependent on the number of productive tiller (tillers which bears panicle) rather than the total tiller numbers. Hence we observed the maximum number of effective tillers (10.4 per hill) with T_5 which was similar to T_{10} and T9. However, application of cowdung with 50% NPK (T_7) also gave higher number of effective tillers than any organic manures alone (Table 3). The number non-effective tillers were also lower with proper fertilization. From this study it was observed that excess application of inorganic fertilizers is not necessary to produce effective tillers if we can supplement it with organic manures. However, organic sources offer more balanced nutrition to the plants, especially micro nutrients which has caused better affectivity of tiller in plants grown with poultry manure and vermicompost (Miller, 2007). This result was also supported by Rakshit et al. (2008), Ayoub (1999) and Uddin et al. (2002).

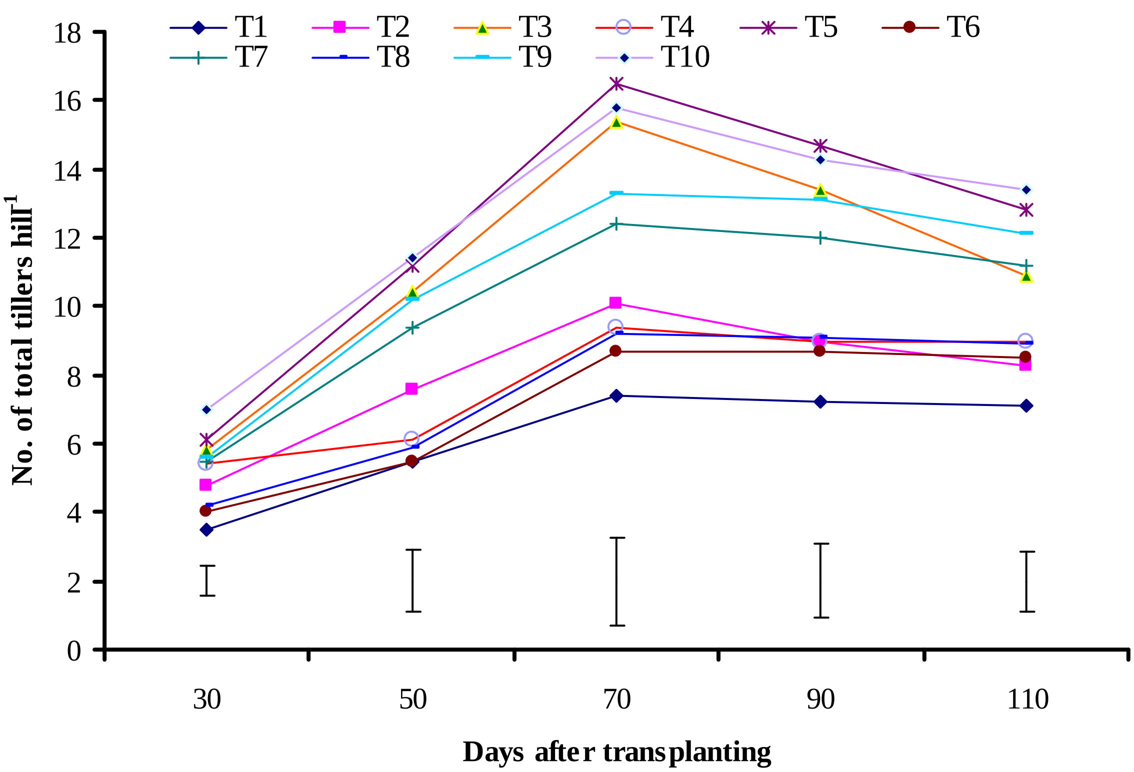

Figure 2. No. of total tillers $hill^{-1}$ of transplanted rice cv. BRRI dhan40 at different days after transplanting as affected by different manuring treatments (vertical error bars represents the LSD values at $P < 0.05$)

[T_1= Control; T_2= Green manure @ 15 t ha^{-1}; T_3= Green manure @ 15 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ (50% NPK); T_4= Poultry manure @ 4 t ha^{-1}; T_5= Poultry manure @ 4 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ (50% NPK); T_6= Cowdung @ 12 t ha^{-1}; T_7= Cowdung @ 12 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ (50% NPK); T_8= Vermicompost @ 8 t ha^{-1}; T_9= Vermicompost @ 8 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ (50% NPK) and T_{10}= $N_{80}P_{12}K_{72}S_{10}$ (100% NPK)]

Table 3. No. of total tillers hill^{-1} of transplanted rice cv. BRRI dhan40 at different days after transplanting as affected by different manuring treatments

Treatments	Effective tillers hill^{-1}	Non-effective tillers hill^{-1}
T_1	4.2	2.9
T_2	5.6	2.7
T_3	7.1	3.8
T_4	6.3	2.7
T_5	10.4	2.4
T_6	5.8	2.7
T_7	8.3	2.9
T_8	5.3	3.6
T_9	10.1	2
T_{10}	10.3	3.1
$LSD_{0.05}$	1.1	0.88

[T_1= Control; T_2= Green manure @ 15 t ha^{-1}; T_3= Green manure @ 15 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ (50% NPK); T_4= Poultry manure @ 4 t ha^{-1}; T_5= Poultry manure @ 4 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ (50% NPK); T_6= Cowdung @ 12 t ha^{-1}; T_7= Cowdung @ 12 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ (50% NPK); T_8= Vermicompost @ 8 t ha^{-1}; T_9= Vermicompost @ 8 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ (50% NPK) and T_{10}= $N_{80}P_{12}K_{72}S_{10}$ (100% NPK)]

3.3 Total dry weight:

Dry matter production is the ultimate goal of application of any inputs in crop because it is directly related to the yield. The data presented in Fig. 3 revealed a statistically significant increase due to different manures combination (Fig. 3). At initial stages the differences of dry weight of plant was not influenced greatly. However, the treatments T_5 produced the highest dry weight in rice plant compared to other treatments at any growth stages except 30 DAT. At 30 DAT the basal application of inorganic fertilizer with T_{10} made the rapid availability of NPK for plant which rendered the maximum dry matter production at initial stages. The rapid increase of dry matter was observed between 50 DAT and 70 DAT (Fig. 3). It was due to the maximum growth and tillering of plant. After 70 DAT although tillers mortality and senescence occurred but reproductive parts contributed a considerable amount of dry matter in plant. Application of poultry manure combined with half of NPK enhances the nutrient availability and suitable soil condition for proper plant growth by reducing the losses of nutrient and hence produced the maximum dry weight. The production of maximum dry matter with proper manuring might be accounted for the luxuriant growth of plant as well as higher number of tillers plant^{-1} (Rahman et al., 2007). Total dry matter production increased due to nitrogen application at active tillering stage and panicle initiation stage. This result was also supported by Zhang et al. (2009).

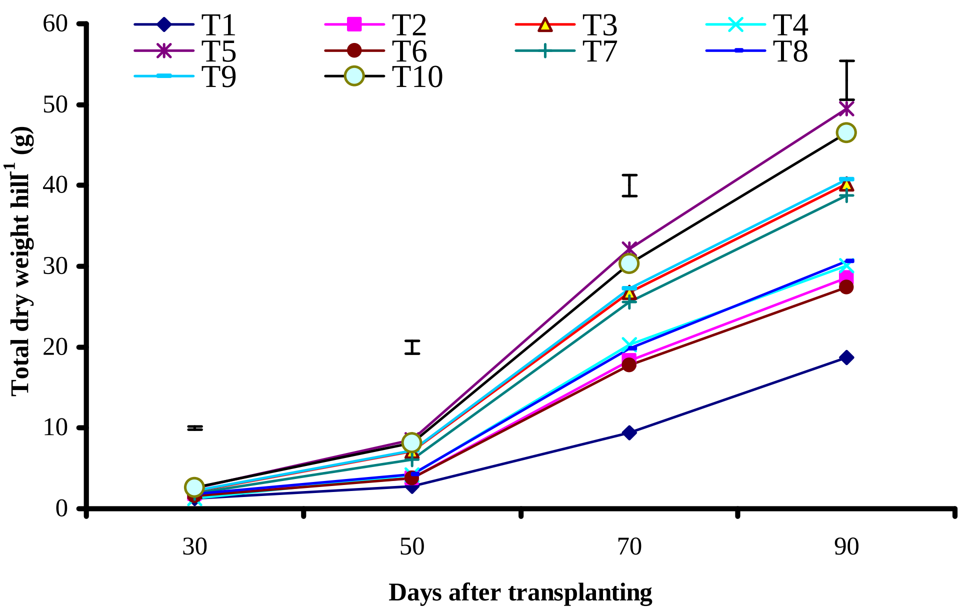

Figure 3. Dry weight of transplanted rice cv. BRRI dhan40 at different days after transplanting as affected by different manuring treatments (vertical error bars represents the LSD values at $P < 0.05$)

[T_1= Control; T_2= Green manure @ 15 t ha^{-1}; T_3= Green manure @ 15 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ (50% NPK); T_4= Poultry manure @ 4 t ha^{-1}; T_5= Poultry manure @ 4 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ (50% NPK); T_6= Cowdung @ 12 t ha^{-1}; T_7= Cowdung @ 12 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ (50% NPK); T_8= Vermicompost @ 8 t ha^{-1}; T_9= Vermicompost @ 8 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ (50% NPK) and T_{10}= $N_{80}P_{12}K_{72}S_{10}$ (100% NPK)]

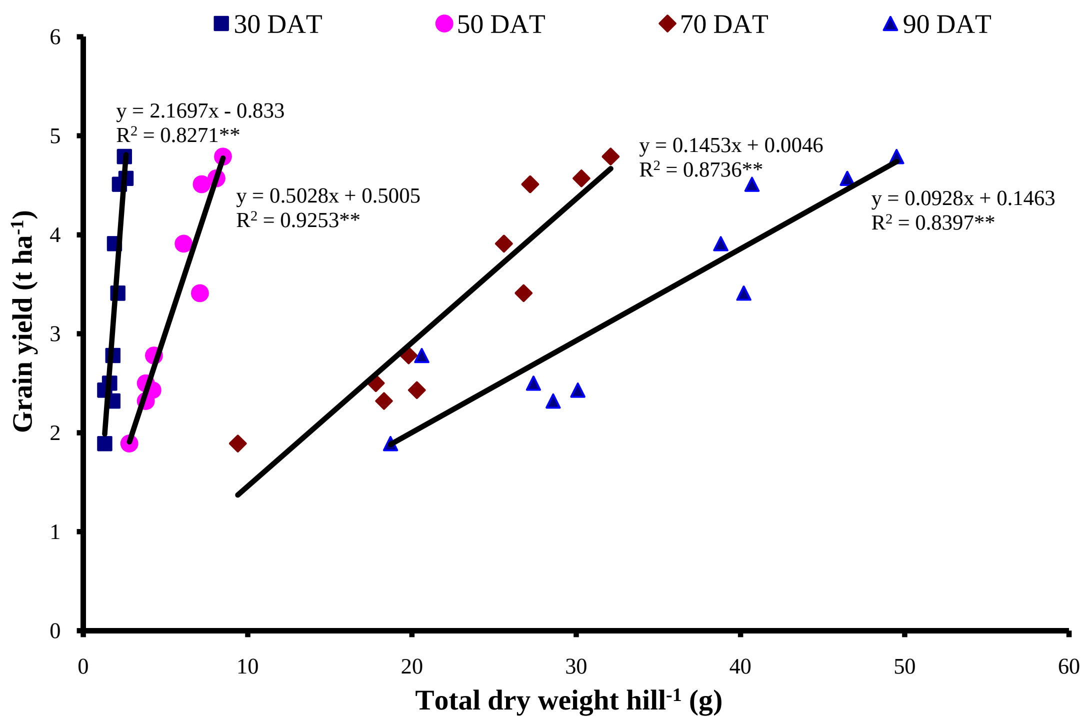

Figure 4. Relationship between dry matter production at different days after transplanting and grain yield of transplanted rice cv. BRRI dhan40 as affected by different manuring treatments (** indicates significant at $P < 0.01$)

From regression analysis we observed the contribution of the dry matter accumulation to the yield and found a very significant relationship among them (Fig. 4). Ibeawuchi et al. (2008) also showed the positive relationship between dry matter accumulation and yield in maize.

3.4 Growth rate

Crop growth rate (CGR) as well as relative growth rate (RGR) of BRRI dhan40 was significantly affected by manuring at different stages (Fig. 5 and 6). Growth rate was lowest during 30-50 DAT while the maximum growth occurred at 30-70 DAT. After maximum vegetative stage (70-90 DAT) the growth rate decreased. The treatments T_5 enhanced the highest CGR and RGR in the present study. It might be due to maximum tillering and vegetative growth facilitated by proper nutrient supply. The higher growth rate achieved by using poultry manure and NPK fertilizer treated plants which would be associated with the positive effect of nitrogen, phosphorus and potassium. Singh et al. (2003) reported that crop growth rate, averaged across treatments, was highest at 45-60 days after transplanting of rice and significantly influenced by NPK fertilizers.

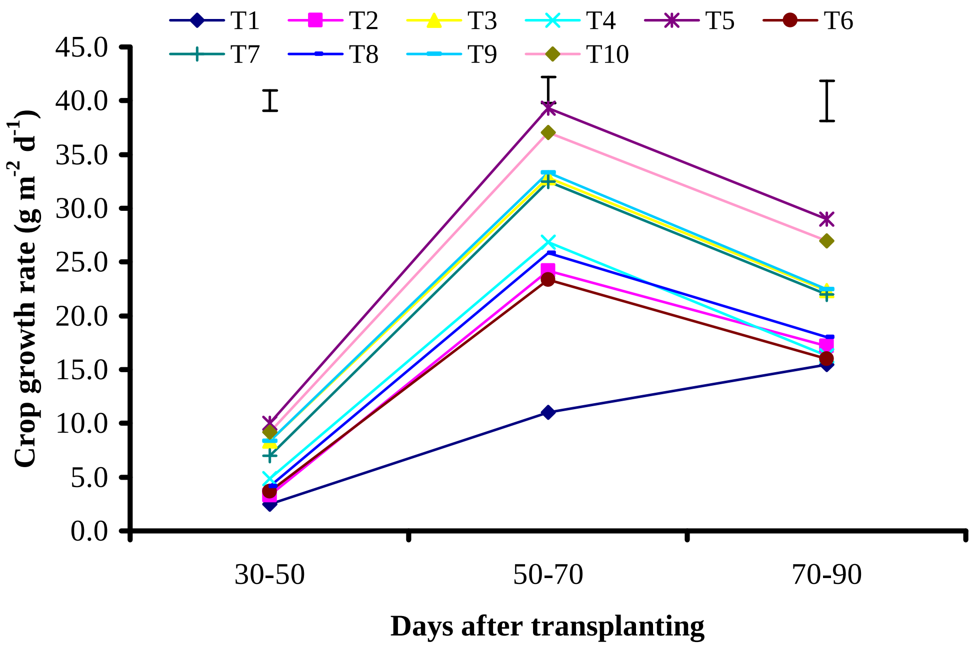

Figure 5. Crop growth rate (CGR) of transplanted rice cv. BRRI dhan40 at different days after transplanting as affected by different manuring treatments (vertical error bars represents the LSD values at P < 0.05)

[T_1= Control; T_2= Green manure @ 15 t ha^{-1}; T_3= Green manure @ 15 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ (50% NPK); T_4= Poultry manure @ 4 t ha^{-1}; T_5= Poultry manure @ 4 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ (50% NPK); T_6= Cowdung @ 12 t ha^{-1}; T_7= Cowdung @ 12 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ (50% NPK); T_8= Vermicompost @ 8 t ha^{-1}; T_9= Vermicompost @ 8 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ (50% NPK) and T_{10}= $N_{80}P_{12}K_{72}S_{10}$ (100% NPK)]

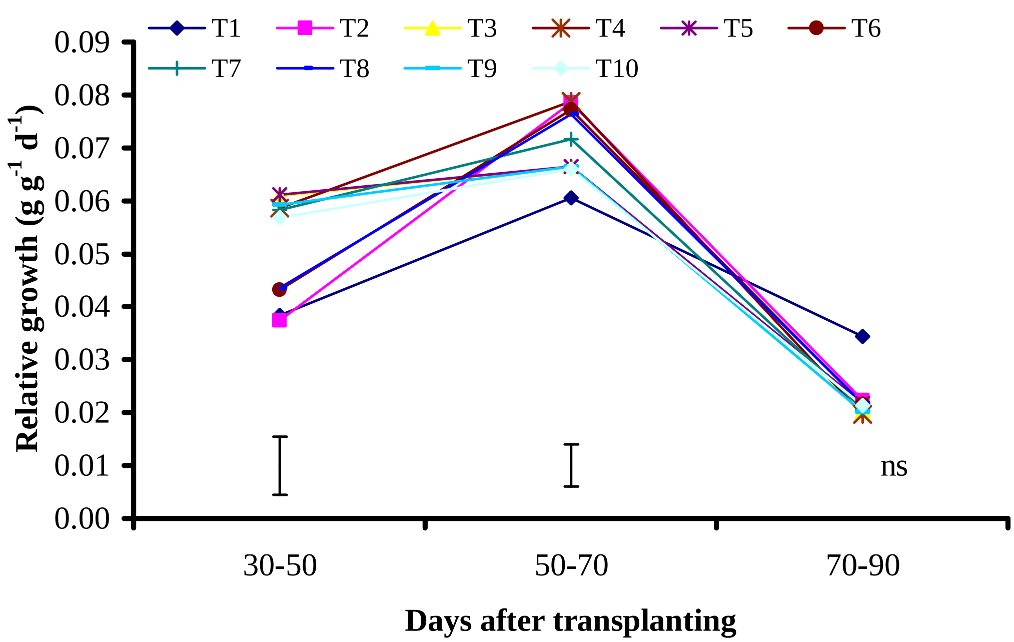

Figure 6. Relative growth rate (RGR) of transplanted rice cv. BRRI dhan40 at different days after transplanting as affected by different manuring treatments (vertical error bars represents the LSD values at P < 0.05; ns=non-significant)

[T_1= Control; T_2= Green manure @ 15 t ha^{-1}; T_3= Green manure @ 15 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ (50% NPK); T_4= Poultry manure @ 4 t ha^{-1}; T_5= Poultry manure @ 4 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ (50% NPK); T_6= Cowdung @ 12 t ha^{-1}; T_7= Cowdung @ 12 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ (50% NPK); T_8= Vermicompost @ 8 t ha^{-1}; T_9= Vermicompost @ 8 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ (50% NPK) and T_{10}= $N_{80}P_{12}K_{72}S_{10}$ (100% NPK)]

4. Conclusions

From the above discussion it is clear that organic manures have significant influence on the growth pattern and tillering of transplanted rice. Organic manure can be a better supplement of inorganic fertilizer to achieve better growth. From the present study it was observed that poultry manures combined with 50% of the recommended NPK fertilizers gave the best results compared to the other combinations. Organic manure alone could not enhance the better growth and dry matter production. For farmers practice, the full doses of commercial inorganic NPK fertilizers can be replaced with poultry manures combined with 50% NPK.

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