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Plant growth characters and productivity of wetland rice (*Oryza sativa* L.) as affected by application of different manures

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Abstract: The experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh (90°33′ E longitude and $23^0$77′ N latitude) during June to November, 2008 with a view to observe the comparative performance of different organic manures and inorganic fertilizers on the growth and productivity of transplanted rice. The experiment comprises of 10 treatments 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 (Vermicompost @ 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 characters, yield attributes and yield were significantly influenced by different treatments. Except plant height, total tiller per hills and biological yield all the parameters were found to be highest with the treatment T_5 (Poultry manure @ 4 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ i.e. 50% NPK). From our study we observed that among the treatments T_5 (Poultry manure @ 4 t ha^{-1} + 50% of recommended NPK) produced the highest grain yield (4.79 t ha^{-1}) of rice which was statistically identical to T_{10} (100% of recommended NPK) and T_9 (Vermicompost @ 8 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$) which resulted grain yield of 4.57 t ha^{-1} and 4.51 t ha^{-1}, respectively. Vermicompost was found as the best manures when it was applied alone. The economic analysis also showed that the application of T_5 maximized the profit and benefit-cost ratio (BCR) was the height (1.75) in the treatment which was almost similar to T_{10}. The lowest BCR (1.07) was obtained from control treatment (T_1).

Keywords: Organic farming, paddy, vermicompost, poultry manure, yield, economic benefit

تأثير إضافة أسمدة مختلفة على خصائص النمو والإنتاج لمحصول الأرز (*Oryza sativa* L.)

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الملخص: أجريت تجربة حقلية في جامعة شير ايد بنغال الزراعية، دكا – 1207، بنغلاديش ($90^0$33′ شرقا و′77 23^0 شمال) خلال شهر يونيو إلى نوفمبر من عام 2008 لدراسة تأثير اضافة أسمدة عضوية وأسمدة غير عضوية على نمو وإنتاجية الأرز. ضمت التجربة 10 معاملات مختلفة: المعاملة الاولى (شاهد) ، المعاملة الثانية (السماد الأخضر @ 15 طن $هكتار^{-1}$) ، المعاملة الثالثة (السماد الأخضر @ 15 طن $هكتار^{-1}$ + $N_{40}P_6K_{36}S_{10}$ i.e.50% NPK)، المعاملة الرابعة (سماد دواجن @ 4 طن $هكتار^{-1}$) ، المعاملة الخامسة (سماد دواجن @ 4 طن $هكتار^{-1}$ + $N_{40}P_6K_{36}S_{10}$ i.e. 50% NPK)، المعاملة السادسة (سماد بقر @ 12 طن $هكتار^{-1}$)، المعاملة السابعة (12 طن $هكتار^{-1}$ + $N_{40}P_6K_{36}S_{10}$ i.e. 50% NPK)، المعاملة الثامنة (فيرموكمبوست @ 8 طن $هكتار^{-1}$)، المعاملة التاسعة (فيرموكمبوست @ 8 طن $هكتار^{-1}$ + $N_{40}P_6K_{36}S_{10}$ i.e. 50% NPK)، المعاملة العاشرة ($N_{80}P_{12}K_{72}S_{10}$ i.e.100% NPK). مؤشرات النمو والإنتاج تأثروا بشكل معنوي بمعاملات التسميد المختلفة. جميع مؤشرات النمو والإنتاج باستثناء ارتفاع النبات وعدد الاشطاء والوزن البيولوجي

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كانت أعلى في المعاملة الخامسة (سماد دواجن @ 4 طن هكتار$^{-1}$ + $N_{40}P_6K_{36}S_{10}$ i.e. 50% NPK). لوحظ من الدراسة بان المعاملة الخامسة أنتجت أعلى محصول من الحبوب (4.79 طن هكتار$^{-1}$) والتي تعتبر إحصائيا مطابقة للمعاملة العاشرة ($N_{80}P_{12}K_{72}S_{10}$ i.e.100% NPK) والمعاملة التاسعة (فيرموكمبوست @ 8 طن هكتار$^{-1}$+ $N_{40}P_6K_{36}S_{10}$ i.e. 50% NPK) واللاتي انتجتن محصول من الحبوب مقداره 4.57 طن هكتار$^{-1}$ و 4.51 طن هكتار$^{-1}$ على التوالي. وجد بان سماد الفيرموكمبوست كان الأفضل في حالة إضافته منفردا. أظهر التحليل الاقتصادي أن المعاملة الخامسة كانت الأعلى من ناحية تعظيم الأرباح ومعدل المنفعة والتكاليف ومقداره 1.75 وهو نفس المقدار تقريبا للمعاملة العاشرة. بينما كانت المعاملة الأولى (الشاهد) هي الأقل 1.07.

Introduction

Due to the extensive and improper use of chemical fertilizers in the soil, our soil is degrading to an alarming level, causing an imbalance in the ecosystem and environmental pollution as well. More recently, attention is being focused on the global environmental problems; utilization of organic wastes, FYM, compost, vermicompost and poultry manures as the most effective measure for the purpose. Organic materials are the safer sources of plant nutrient without any 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, 2004).

However, 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, 1988). The impact of increased fertilizer use on crop production has been large and important (Hossain and Singh, 2000). It has been estimated that fertilizer use growth contributed to about 25% of the total increase in rice production in Asia between 1965 and 1980 (Barker et al., 1985). However, 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). The fact that use of green manures and other organic matter can improve soil structure, improve nutrient exchange and maintain soil health has again raised interest 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. It was also indicated that poultry manure more readily supplies P 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).

In Bangladesh, most of the cultivated soils have less then 1.5% organic matter while a good agricultural soil should contain at least 2% organic matter. Evidences from different AEZ of the country have shown a decrease in the content of organic matter by the range of 15 to 30% over the last 20 years (Miah, 1994). Moreover, this important component of soil is declining with time due to intensive cropping and use of higher dose of chemical fertilizers with little or no addition of organic manure.

Majority of food grain of Bangladesh come from rice. About 80% of cropped area of this country is used for rice production, with annual production of 43.72 million metric tons (IRRI, 2006) in total acreage of 11.59 million ha. The average yield of rice in Bangladesh is 2.52 t ha^{-1} (MoA, 2006). This is almost less than 50% of the world average yield. The yield of rice has reached a plateau due to declining factor productivity under increasing intensification. Therefore, farmers are compelled to apply increasing rates of fertilizers to maintain current yield levels (Pagiola, 1995).The reasons for low yield of rice are manifold; some are varietals, others are technological and rests are climatic. Undoubtedly, with the introduction of high yielding varieties the yield of rice has been increased, but the trend of increase is not linear. 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. Integrated nutrient management for rice can increase the productivity of rice.

The long-term research of BARI revealed that the application of cowdung @ 5 t ha^{-1} $year^{-1}$ improved rice productivity as well as prevented the soil resources from degradation (Bhuiyan, 1994). Poultry manure is another good source of nutrients in soil. Meelu and Singh (1991) showed that 4 t ha^{-1} poultry manure along with 60 kg N ha^{-1} as urea produce grain yield of crop similar to that with 120 kg N ha^{-1} as urea alone. Use of organic manures alone, as a substitute to chemical inorganic fertilizer is not profitable and will not be enough to maintain the present levels of crop productivity of high yielding varieties (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). Combined applications of both chemical and organic fertilizers need to be applied for the improvement of soil physical properties and supply of essential plant nutrients for high yield. However, it is necessary to carry out studies by using fertilizers and manures in an integrated way in order to obtain sustainable crop yield without affecting soil fertility.

Materials and Methods

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 24^0 75′ N and 90^0 50′ E longitude at the elevation of above 18 m from the sea level. The soil of the experimental field belongs to the Shallow Red Brown Terrace Soils. Physical and chemical properties of initial soil have been presented in Table 1.

Experimental treatments and design

The 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 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

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	1.48	0.29	0.75	24
Poultry manure	29	2.19	1.98	0.81	8
Sesbania Green manures	46	2.95	0.26	1.56	15
Vermicompost	11.54	1.66	1.25	0.254	9.60

Crop establishment and application of treatments

The experiment was carried out with rice variety BRRI dhan40 which is suitable for aman (autumn) season. A common procedure was followed in raising of seedling 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 20 cm × 15 cm. Organic manures was 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 55 days after transplanting (DAT). All intercultural operations were done carefully. The first weeding was done at 15 DAT followed by second and third weeding were done at 15 days interval after first and second weeding. Irrigation was done 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.

Data collection and analysis

The number of tillers $hill^{-1}$ was recorded at the maximum tillering stage. Ten sample hills were collected from each plot for collection of data on plant characters and yield components. Leaf area index (LAI) was worked out by using average leaf area plant^{-1} with the help of the formula as suggested by Watson (1952). The grain and straw 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. Harvest index was calculated by dividing the economic (grain) yield by the total biological yield (grain + straw) from the same area (Donald, 1963) and multiplying by 100.

The data was analyzed using MSTAT-C (Russel, 1994) programme. The mean differences among the treatments were compared by multiple comparison tests using Duncan's Multiple Range Test (DMRT).

From beginning to ending of the experiment, individual cost data on all the heads of expenditure in each treatment were recorded carefully and classified according to Mian and Bhuiya (1977) as well as posted under different heads of cost of production. Gross return from transplant rice cultivation was calculated by summing the value of grain (Tk ha^{-1}) and value of straw (Tk ha^{-1}). Net return was calculated by subtracting total cost of production (Tk ha^{-1}) from gross return (Tk ha^{-1}). Benefit cost ratio indicated whether the cultivation is profitable or not which was calculated as the gross return multiplied by the total cost of production.

Results and Discussion

Plant characters

From the study it was observed that different plant characters of rice viz. Plant height, number of tillers and leaf area indices significantly influenced by different manure application in combination with inorganic fertilizers (Table 3). From the observation the tallest plants of rice were observed with the application of $N_{80}P_{12}K_{72}S_{10}$ (100% NPK) which was statistically identical with the application of 50% NPK and *Sesbania* green manure incorporation (T_3). Significant roles of *Sesbania* green manures to plant height might be due to it high N content which influence the vegetative at the earlier stage of plant growth. Any organic manure applied in combination with 50% NPK gave identical results in this study (Table 3). 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 suppliant the required amount 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).

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 (Table 3). In the present study maximum number of tillers (13.4 per hill) was produced with T_{10} which was followed by T_5 and T_9. Tiller production with these treatments was 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 rendering the higher number of tillers. 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 (Poultry manure @ 4 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$) which was at per with T_{10} and T_9. However, application of cowdung with 50% NPK (T_7) also gave higher number of effective tillers than any organic manures alone (Table 3). From this study it was observed that excess application of inorganic fertilizers is not necessary to produce effective tillers if we can supplement it from 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 partially supported by Rakshit et al. (2008).

In case of any plant leaves are important organs which have an active role in photosynthesis. To achieve high yield maximization of leaf area might be an important factor. In our study we found that leaf area indices were significantly affected by different manuring treatments. From Table 3 it is observed that maximum leaf area index was resulted with the treatment T_{10} (5.9) which was statistically similar with T_5 (5.8), T_9 (5.5) and T_7 (5.3). Sufficient nutrient facilitated to plant might have maximum cell elongation or cell division rendering better size of leaves and hence the maximum leaf area index. Control treatments produced the lowest leaf area index (2.6) In our study the treatments T_{10}, T_5, T_9 and T_7 gave 126.92%, 123.07%, 111.53% and 103.84%, respectively over control. Leaf area index in untreated control remained generally flat and well below other treatments. Sarker et al. (2004) also reported the increased LAI with manure application in combination of inorganic N fertilizers.

Table 3. Plant characters of wetland rice cv. BRRI dhan40 as affected by different organic manures.

Treatments	Plant height (cm)	No. of total tillers hil^{-1}	No. of effective tillers hill^{-1}	Leaf area index
T_1	74.6 g	7.1 f	4.2 f	2.6 e
T_2	81.7 f	8.3 ef	5.6 d	3.1 de
T_3	106.5 ab	10.9 bcd	7.1 c	4.6 bc
T_4	95.7 cd	9.0 ef	6.3 cd	4.1 c
T_5	91.4 de	12.8 ab	10.4 a	5.8 a
T_6	87.7 ef	8.5 ef	5.8 d	3.7 d
T_7	101.2 bc	11.2 bc	8.3 b	5.3 ab
T_8	95.0 cd	10.2 cde	5.3 de	4.0 d
T_9	103.4 b	12.1 abc	10.1 a	5.5 ab
T_{10}	110.5 a	13.4 a	10.3 a	5.9 a
$LSD_{0.05}$	6.3	1.9	1.1	0.9
CV (%)	5.44	8.23	8.08	6.78

Values in a column sharing common letter(s) do not vary significantly 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)

Yield attributes

Yield contributing characters are directly correlated with economic yield of plant. In this study a significant response of different manuring treatments was observed on the yield attributes viz. panicle length, spikelets per panicle, fertile grains per panicle and grain weight

(Table 4). Panicle length of BRRI dhan40 was highest with the treatment T_5 which was even higher than 100% NPK application. It was statistically identical with T_{10} and T_9. The treatment T_7 also gave better results compared with single application of any manures. This result revealed that combined application of organic manures and inorganic fertilizers can uplift the panicle formation and panicle growth which gave maximum number of grains per plant. From Table 4 it was observed that maximum number of spikelets (139.3) in a panicle was produced by the treatment T_5 (Poultry manure @ 4 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$) which was statistically superior to any other treatments except T_{10}. It means that even 50% of the recommended NPK can give best results if it is combined applied with poultry manures. It might be due to more grain formation as well as growth of rice which was enhanced by poultry manures. Grain fertility was also enhanced by the same treatment (T_5) which was statistically different from other treatments (Table 4). The treatment T_5 and T_{10} produced 144.54% and 126.89% higher number of fertile grains compared to control treatment. In our study 100% of the recommended NPK which was supplied from inorganic fertilizer produced the second highest number of fertile grains per panicle. A significant loss of grain was occurred due to less fertility mediated by only single application of manures. It was due to less nutrient capacity of organic manures which did not meet the requirements of the rice plant to produce fertile grains. It was also observed significant differences in 1000-grain weight of rice cv. BRRI dhan40 as affected by variation in fertilizer packages (Table 4).

Table 4. Yield contributing characters of wetland rice cv. BRRI dhan40 as affected by different organic manures.

Treatments	Panicle length (cm)	No. of spikelets $panicles^{-1}$	No. of fertile grains $panicle^{-1}$	1000-grain weight (g)
T_1	14.5 g	72.1 g	54.1 h	18.3 e
T_2	17.1 f	91.2 f	73.0 g	19.8 de
T_3	20.4 cde	123.4 d	104.9 d	21.4 a-d
T_4	18.9 def	103.4 e	82.7 e	21.0 bcd
T_5	23.6 a	139.3 a	129.3 a	23.9 a
T_6	17.8 f	92.4 f	73.9 fg	20.7 cd
T_7	21.1 bcd	129.4 c	110.0 cd	22.6 abc
T_8	18.5 ef	98.2 e	78.6 ef	20.3 de
T_9	22.6 abc	133.2 bc	113.2 c	22.9 ab
T_{10}	22.9 ab	136.3 ab	122.7 b	22.5 abc
$LSD_{0.05}$	2.3	5.3	5.1	2.1
CV (%)	6.54	7.54	6.09	8.11

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).

The treatment T_5 also produced the heaviest grain which was statistically similar to any combined application of 50% NPK and organic manures (T_9, T_7, T_{10} and T_3). Thousand grain weight is mostly mediated by genetic potential but in this case it declines significantly with single application of organic manures as well as with control treatment due to severe deficiency of essential nutrients and hence the plants failed to produced a bold grain. The increased values of yield attributes with the application of manures was due to the fact that use of green manures and other organic matter can improve soil structure, improve nutrient exchange and maintain soil health has again raised interest 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. These findings were supported by Meelu and Singh (1991) who reported that 4 t ha^{-1} poultry manure along with 60 kg N ha^{-1} as urea produce grain yield of crop similar to that with 120 kg N ha^{-1} as urea alone. Uddin et al. (2002) also observed the beneficial effect of poultry manures on the yield contributing characters of rice.

Yield and harvest index

Yield is the ultimate reflection of the yield components. In this study the differences in yield attributes by different combination of manures application rendered the differences in yield of rice cv. BRRI dhan40 (Table 5). Grain yield, straw yield and biological yield were significantly affected by different combination of organic and inorganic manures. From our study we observed that among the treatments T_5 (Poultry manure @ 4 t ha^{-1} + 50% of recommended NPK) produced the highest grain yield (4.79 t ha^{-1}) of rice which was statistically identical to T_{10} (100% of recommended NPK) and T_9 (Vermicompost @ 8 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$) which resulted grain yield of 4.57 t ha^{-1} and 4.51 t ha^{-1}, respectively. From Figure 1 it was observed a clear difference in yield by different fertilizer/manure application over control. The treatment T_5, T_{10} and T_9 produced 153.44%, 141.80% and 138.62% more grain yield compared to control treatments (1.89 t ha^{-1}). The little extent of grain yield was produced by control treatment which might be due to some residual effect of soil nutrients. Single application of vermicompost @ 8 t ha^{-1} produced the better grain yield (2.78 t ha^{-1}) compared to others organic manures which were followed by grain yield (2.43 t ha^{-1}) produced by poultry manure @ 4 t ha^{-1} (Table 5). The increase in yield with these treatments was attributed to panicles per hill, grains per panicle and seed weight which were highest with T_5. The residual effect was attributed to panicles $hill^{-1}$ and seeds $panicle^{-1}$. These results were corroborated with the findings of Channabasavanna and Biradar (2001). Grain yield is a function number of panicle bearing tillers per hill and grains per panicle besides grain weight. The results suggest that poultry manures offered better nutritional quality and favorable balance of nutrients when supplemented with NPK which provided the maximum yield. Rakshit et al. (2008) also observed similar findings. Uddin et al. (2002) reported that if poultry manure can be added @ 4 t ha^{-1} the use of NPK can be reduced and S, Zn and B fertilizers may not be needed.

In this study straw yield as well as biological yield was highest with the treatment T_{10} (100% of the recommended NPK) which was identical with yield produced by T_5 and T_9. The treatment T_{10} provided maximum requirement of primary essential elements which were needed for plant's vegetative growth and hence the highest straw yield was obtained. Biological yield is the sum of grain yield (economic yield) and straw yield and thus it was also followed the trend like straw yield. These results were supported by Channabasavanna and Biradar (2001).

Harvest indices were also significantly varied with different treatments (Table 5). In this study T_5 produced the highest harvest index (41.43%) which was followed by T_9, T_{10} and T_7. It might be due to better grain yield with corresponding biological yield. The plots having cowdung @ 12 t ha^{-1} gave the lowest harvest index. The higher harvest indices with the treatments were due to more economic yield caused by more availability of nutrients.

Table 5. Yield and harvest index of wetland rice cv. BRRI dhan40 as affected by different organic manures.

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
T_1	1.89 d	3.61 f	5.50 f	34.36 cd
T_2	2.32 cd	4.72 e	7.04 ef	32.95 d
T_3	3.41 b	5.91 cd	9.32 cd	36.59 bc
T_4	2.43 cd	4.91 e	7.34 e	33.11 d
T_5	4.79 a	6.77 ab	11.56 ab	41.43 a
T_6	2.50 c	5.12 de	7.62 e	32.81 d
T_7	3.91 b	6.11 bc	10.02 bc	39.02 ab
T_8	2.78 c	5.05 e	7.83 de	35.50 cd
T_9	4.51 a	6.72 abc	11.23 ab	40.16 a
T_{10}	4.57 a	7.01 a	11.58 a	39.46 ab
$LSD_{0.05}$	0.56	0.84	1.67	2.59
CV (%)	7.34	8.12	10.11	6.01

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)

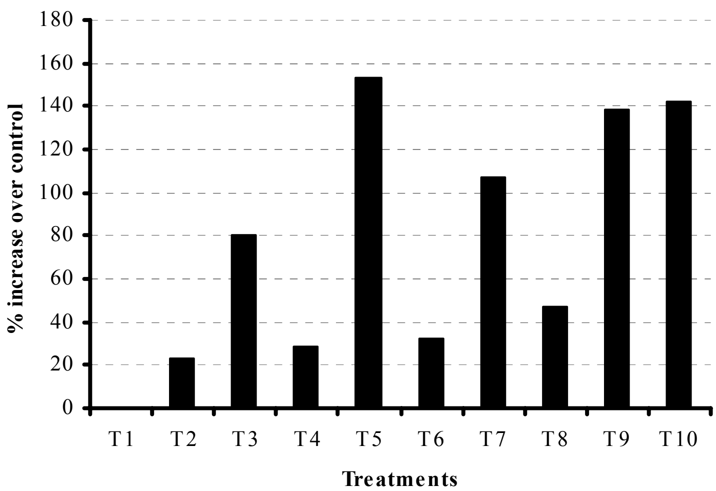

Figure 1. Increases in grain yield of BRRI dhan40 with various manure treatments over control. T_1= Control; T_2= Green manure @ 15 t ha^{-1}; T_3= Green manure @ 15 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ (50% NPK); T_4= Poultry manure @ 4 t ha^{-1}; T_5= Poultry manure @ 4 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ (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).

Economic comparison

By economic analysis it was observed that the maximum cost of manures was involved in case of T_9 (Vermicompost @ 8 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$). The treatment T_5 (Poultry manure @ 4 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$) needed the second highest cost (Table 6) which was almost two-third of T_9. Due to the differences of cost of manures/fertilizers among the treatments, the total cost of production was varied in this experiment. The treatment T_9 involved the maximum cost of production whereas the lowest cost of production was involved in T_1 which does not include any fertilizer/manures. The gross return from rice cultivation was found to be the maximum with the treatment T_5 which was slightly higher than T_{10} and T_9 (Table 6). Net profit was highest from the treatment T_5 which was even more than T_{10} (100% of the recommended fertilizers NPK). The lowest net profit was obtained from T_1 (control) due to its lowest production of grain and straw. The economic analysis also showed that the application of T_5 maximized the profit and benefit-cost ratio (BCR) was the height (1.75) in the treatment which was almost similar to T_{10} (Table 6). The lowest BCR (1.07) was obtained from control treatment (T_1). This is due to the lowest yield of grain and straw.

Table 6. Cost of production and economic returns from BRRI dhan40 as affected by different organic manures.

Treatments	Cost of production (Tk)			Gross return (Tk)	Net profit (Tk)	BCR
	Variable cost (except manures)	Cost of manures	Total cost			
T_1	27,000.00	0.00	27,000.00	29,348.00	2,348.00	1.07
T_2	27,000.00	6,800.00	33,800.00	36,256.00	2,456.00	1.09
T_3	27,000.00	13,300.00	40,300.00	52,468.00	12,168.00	1.30
T_4	27,000.00	8,000.00	35,000.00	37,948.00	2,948.00	1.08
T_5	27,000.00	14,500.00	41,500.00	72,476.00	30,976.00	1.75
T_6	27,000.00	6,000.00	33,000.00	39,096.00	6,096.00	1.18
T_7	27,000.00	12,500.00	39,500.00	59,628.00	20,128.00	1.51
T_8	27,000.00	12,000.00	39,000.00	42,960.00	3,960.00	1.10
T_9	27,000.00	22,500.00	49,500.00	68,516.00	19,016.00	1.38
T_{10}	27,000.00	13,000.00	40,000.00	69,588.00	29,588.00	1.74

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).

Price for Urea, TSP, MP, Gypsum, Cowdung, Poultry manures and Vermicompost are Tk. 20.00, Tk. 35.00, Tk. 40.00, Tk. 30.00, Tk. 0.50, Tk. 2.00, Tk. 1.50 per kg, respectively.

Price for Rice grain and straw are Tk. 14.00 and Tk. 0.80 per kg, respectively.

1 US doller = Tk. 69.50.

Conclusion

From the above discussion it is clear that organic manures have a significant influence on the productivity of wetland rice. Organic manure can be a better supplement of inorganic fertilizer to produce better growth and yield or rice. All the treatments showed significant influence on growth and productivity of rice. Form the present study it was observed that Poultry manures combined with 50% of the recommended NPK fertilizers gave the best results compared to other combination. Organic manure alone could not give the better yield. However, among the manures vermicompost @ 8 t ha^{-1} itself produced the better grain yield compared to others organic manures. From the economic point of view farmers can use the combination of poultry manures and reduced rate of inorganic fertilizers to uplift the yield of rice as well as to maintain and improve soil health.

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