ISSN : 1812-5379 (Print)
ISSN : 1812-5417 (Online)
http://ansijournals.com/ja

JOURNAL OF AGRONOMY

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Journal of Agronomy 3 (2): 103-110, 2004
ISSN 1680-8207

Effect of Different Tillage Practices on Growth, Yield and Yield Contributing Characters of Transplant Amon Rice (BRRI Dhan-33)

Md. Shahidur Rahman, [1]Md. Asraful Haque and [1]Md. Abdus Salam
Department of Crop Botany, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh
[1]Bangladesh Institute of Nuclear Agriculture, Mymensingh, Bangladesh

Abstract: The experiment was carried out at the field laboratory of Bangladesh Institute of Nuclear Agriculture, Mymensingh, during amon season (July to October, 2001) to study the effects of different tillage practices on growth, yield and yield contributing characters of BRRI Dhan-33. The crop was grown under supplemented irrigation condition. The soil was calcarious grey belonging to Sonatola series of old Brahmaputra flood plain. The treatment of this study comprised of power tiller with 1, 2, 3 and 4 passes at 7 and 15 cm depth and 4 passes with country plough at normal depth. The 4 passes at 15 cm deep ploughing by power tiller showed the highest yield of grain (4.95 t ha^{-1}) and straw (5.89 t ha^{-1}) which was associated with higher leaf area index (LAI), crop growth rate (CGR), net assimilation rate (NAR), total dry matter (TDM), leaf numbers/hill, plant height, number of total and effective tillers, panicle length, number of filled grains/spikelets/panicle and with lower number of non-bearing tillers/hill and sterile spikelets/panicle. The lowest values of all parameters were found in 1 pass with power tiller at both 7.5 and 15 cm depth. Though 4 passes with country plough at normal depth and 3 passes with power tiller at 15 cm depth showed statistically identical results of 4 passes with power tiller at 15 cm depth in respect of yield performance, this treatment (4 passes with power tiller at 15 cm depth) gave the highest yield practically.

Key words: BRRI Dhan-33, growth, tillage practices, yield, yield contributing characters

INTRODUCTION

Tillage is the most important operation on crop production system. The process by which forces are imparted and changes in soil properties occur are known as tillage which is comprised of some technical operations such as ploughing and harrowing[1]. Tillage practices control weeds, provide a suitable seed bed for crop plants, incorporate crop residues into the soil, make the soil loose, enhance chemical reaction and thereby improves the physicochemical condition of soil which in turn affect the growth and development of crop plants. The preparatory land tillage by different tillage implements have different impact on physical, chemical and biological changes in soil. This is why production of the relevant crop may go up and down. Johnson[2] emphasized the importance of tillage in loosening the soil, benefiting chemical reaction, improving moisture condition and structure of the soil. This condition is essential for rice cultivation. The quantum of tillage is very important for amon rice cultivation because the puddling of soil facilitates easy transplanting of seedlings. Intensive and continuous rice-rice-rice crop culture is predominant in Bangladesh as rice is the staple food of her people. Although the agro-climatological conditions of Bangladesh are favourable for rice cultivation all the year round, the per hectare yield is still very low compared to other major rice growing countries like Australia, Japan, China and South Korea. This lower yield might be due to declining soil fertility status and lack of proper soil management practices including tillage operations.

In Bangladesh, about 80% of farm families use traditional wooden plough (country plough) pulled by draft animal for land preparation[3]. Tillage operation by country plough is a slow process and requires more time for complete preparation of seed bed. Shallow depth of ploughing (7.71 cm) was found with country plough which increased the bulk density, soil resistance and mechanical impedance of soil for which poor physical condition might be developed[4]. Moreover, draft power shortage is one of the major problems in cultivation process at present. Sarker[5] carried out surveys in four

Corresponding Author: Dr. Md. Shahidur Rahman, C/o Professor Dr. Hiroshi Miyake, Laboratory of Plant Resources and Environment, Graduate School of Bioagricultural Sciences, Nagoya University, Furo-cho, Chikusa-ku, Nagoya 464-8601, Japan Tel: +81-52-789-5746; Fax: +81-52-789-4064
E-mail: mshahidur2002@yahoo.com

areas of Bangladesh and observed that there was a shortage of draft power for land preparation in HYV boro irrigated areas. The number of draft animal is decreasing very rapidly among the farmers' level due to various reasons such as high rate of slaughtering, high death rate, slow rate of reproduction and reduced pasture area. In recent years, use of power tiller for land preparation has increased many folds to meet the acute draft power shortage. Power tiller is suitable for saving labour cost, maintaining timeliness in operation, better quality of soil preparation and desired depth of tilling which has its ultimate bearing on soil fertility and crop productivity[4]. Deep tillage by power tiller decreases the bulk density[6-9], increases the soil porosity, infiltration rate[10-12] and hydraulic conductivity[11]. As a result, soil becomes permeable, aerated and having good physical condition for crop growing. However, it might have a possibility of depletion of nutrients and soil organic matter due to deep ploughing and excess pulverization. Therefore, an optimum tillage practices in terms of number of passes and depth of tillage are to be found for better crop productivity and soil fertility. The present piece of work was therefore undertaken to find out the optimum number of passes and depth of tillage for better growth and productivity of transplant amon rice and to make a comparative assessment between the country plough and power tiller tillage.

MATERIALS AND METHODS

Experimental site and soil: The experiment was conducted at the field laboratory of Bangladesh Institute of Nuclear Agriculture, Mymensingh during the amon season (July to October 2001). The experimental field belongs to Old Brahmaputra Floodplain agro-ecological zone (AEZ-9). The soil was sandy loam in texture having a pH 6.95.

The experiment was laid out in a Randomized Complete Block Design using 9 tillage treatments with four replications. The treatments were: 1 pass with power tiller at 7.5 cm depth (T_1), 2 passes with power tiller at 7.5 cm depth (T_2), 3 passes with power tiller at 7.5 cm depth (T_3), 4 passes with power tiller at 7.5 cm depth (T_4), 1 pass with power tiller at 7.5 cm depth (T_5), 2 passes with power tiller at 15 cm depth (T_6), 3 passes with power tiller at 15 cm depth (T_7), 4 passes with power tiller at 15 cm depth (T_8) and 4 passes with country plough at normal depth (T_9). The unit of plot size was 7×6 m. The fertilizers added were Urea, TSP, MP, Gypsum and Zinc sulphate @ 150, 100, 60 and 10 kg ha^{-1}, respectively. The entire amount of TSP, MP, Gypsum and Zinc sulphate were applied at the time of final land preparation. Urea was applied in 3 equal installments at 15, 30, 45 Days after Transplanting (DAT) as top dressed.

Plant culture: BRRI Dhan-33, a high yielding variety of transplant amon rice developed by the Bangladesh Rice Research Institute (BRRI), was used as the test crop in the experiment. Sprouted seeds of rice were sown in the nursery bed on 4 July 2001. The nursery beds were made wet by application of water both in the morning and evening on the previous day before uprooting the seedlings. Without causing any mechanical injury to the roots, the seedlings were uprooted and kept on soft mud in shade before they were transplanted. Twenty nine-days-old seedlings were transplanted in the experimental field on 1 August 2001 using 2 seedlings/hill with a spacing of 20×15 cm between the rows and hills, respectively. Intercultural operations were done as and when required for ensuring and maintaining the normal growth of the crop.

Sampling and data recording: Sampling for data recording on growth parameters were done four times at an interval of 15 days starting from 20 DAT up to 65 DAT. In each sampling six hills excluding the border hills from each unit plot were randomly collected by cutting with sickle at root zone level. They were washed thoroughly in clean water to remove any mud/dirt and were taken to laboratory for recording data from them. Data were recorded on the following items: plant height (cm), number of leaves/hill, leaf area (cm^2)/hill and total dry matter (g)/hill. At each time of sampling all the green leaves were separated/hill basis and leaf area of one hill was measured by the automatic leaf area meter (Model: LI-3000, USA). All the plant parts/hill basis were oven dried at 80±5°C for 48 h and then weighed to get total dry matter (TDM) production. Leaf area index (LAI), crop growth rate (CGR) and net assimilation rate (NAR) were calculated according to the formulae rendered by Hunt[13].

At maturity 75 random hills were harvested from undisturbed area of each plots. Out of 75 hills, 5 hills were taken for data collection on the following yield attributes: plant height (cm), number of total tillers/hill, number of bearing and non-bearing tillers/hill, panicle length (cm), number of spikelets/panicle, number of filled and unfilled grains/panicle and 1000-grain weight (g). The rest 70 hills were used for recording data on grain yield (t ha^{-1}), straw yield (t ha^{-1}), biological yield (t ha^{-1}) and harvest index (%). The height of the plant was measured from the colar zone to the tip of the longest leaf or panicle. Tiller number/hill was determined on all tillers with emerged heads. The tillers, which had at least 25% or above spikelets of a normal panicle were counted as effective tillers. Panicle lengths were recorded from the basal node of the rachis to the apex of last grain of each panicle. All the spikelets from the panicles of 5 hills were first threshed and filled and unfilled spikelets were counted and they were divided by the number of bearing tillers and thus filled and unfilled grains/panicle were found out. Presence of any food material in the spikelet was considered as filled spikelet. On the other hand, the unfilled spikelets lacked any food materials inside. The number of filled spikelets/panicle plus the number of unfilled spikelets/panicle gave the total number of spikelets/panicle. Weight of 1000 randomly collected filled grains was determined by an electrical balance from the dried seed of 5 hills. Finally the weight was adjusted at 14% moisture level taking moisture % reading by an automatic moisture meter (Model Gmk-303RS, Jewon Machinery Co. Ltd. Japan). The grains of 70 hills were threshed, properly sun dried and cleaned and then their weight was converted to t ha^{-1}. Straw of 70 hills from each unit plot was weighed after repeated sun drying and the values were converted to t ha^{-1}. Harvest index was calculated as grain yield divided by total biological yield which was the sum of grain yield and straw yield and it was expressed in percentage.

Data recorded for different growth and yield parameters were statistically analysed and the mean differences among the treatments were compared with DMRT or LSD.

RESULTS AND DISCUSSION

Growth parameters

Plant height: Plant height was significantly affected by different tillage practices. Plant height was increased with the advancement of growth stages. Number of passes and depth resulted significant effect, higher number of passes caused higher plant height (Fig. 1). The 1 pass with power tiller of both depths (7.5 and 15 cm) gave the lowest plant height and the 4 passes with power tiller at 15 cm depth gave the highest plant height at all growth stages. At 90 DAT, the highest plant height was observed in T_8 (4 passes with power tiller at 15 cm depth) treatment, which was followed by T_9, T_7, T_6, T_4 and T_3, respectively. A similar results on tillage treatment was obtained by Olofintoye[14] and Rahman[15]. However, our result is quite contradictory to the findings of Basunia[16] who reported that maximum plant height was found by country plough with 4 passes than power tiller treatment.

Number of leaves/hill: Number of leaves/hill was significantly affected by different tillage practices at different DAT (Fig. 2). The 4 passes with power tiller at 15 cm depth gave the highest number of leaves from 20 to 60 DAT. The second highest number of leaves/hill was found in 3 passes with power tiller at 15 cm depth. The lowest number of leaves/hill was found in 1 pass with power tiller at both the depths (7.5 and 15 cm) which were significantly different from other treatments. The number of leaves/hill were low at the earlier stage and reached maximum at 35-50 DAT and thereafter declined due to senescence of leaves.

Table 1: Yield and yield contributing characters of transplant amon rice (BRRI Dhan-33) using various tillage practices

Treatments	Total tillers /hill (No.)	Effective tillers /hill (No.)	Non-bearing tillers/hill (No.)	Panicle length (cm)	Grains /panicle (No.)	Sterile spikelets /panicle (No.)
T_1	7.90d	5.12f	2.78a	19.95c	60.63c	25.57a
T_2	9.00c	7.38d	1.62c	20.38bc	85.83b	23.43a-c
T_3	9.23c	7.83cd	1.40cd	21.00a-c	87.62b	22.57a-d
T_4	9.71b	8.41bc	1.30cd	21.20a-c	91.75ab	21.00b-d
T_5	8.01d	5.91e	2.10b	20.40bc	85.25b	23.98ab
T_6	9.78b	8.37bc	1.41cd	21.65a-c	93.25ab	23.35a-c
T_7	10.03b	8.70ab	1.33cd	21.98a-c	98.50a	20.81cd
T_8	10.51a	9.42a	1.09d	22.65a	101.5a	19.74d
T_9	10.02b	8.74ab	1.28cd	22.25ab	99.75a	20.60cd
LSD(0.05)	0.44	0.70	0.39	1.82	8.85	2.78

Table 1: Continue

Treatments	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
T_1	22.25	2.10g	3.40c	5.49f	38.25b
T_2	22.52	3.91e	4.87b	8.78d	44.53a
T_3	22.65	3.98d	4.97b	8.95d	44.47a
T_4	22.80	4.21c-e	5.12b	9.33cd	45.12a
T_5	22.35	3.09f	3.95c	7.04e	43.89a
T_6	22.93	4.42b-d	5.45ab	9.87bc	44.78a
T_7	23.06	4.57a-c	5.55ab	10.12b	45.16a
T_8	23.21	4.95a	5.89a	10.84a	45.66a
T_9	23.15	4.79ab	5.75a	10.54ab	45.45a
LSD(0.05)	NS	0.43	0.65	0.45	3.89

NS = Not significant. Figures in a column having common letter (s) do not differ significantly as per DMRT

T_1 = 1 pass with power tiller at 7.5 cm depth, T_2 = 2 passes with power tiller at 7.5 cm depth, T_3 = 3 passes with power tiller at 7.5 cm depth, T_4 = 4 passes with power tiller at 7.5 cm depth, T_5 = 1 pass with power tiller at 15 cm depth, T_6 = 2 passes with power tiller at 15 cm depth, T_7 = 3 passes with power tiller at 15 cm depth, T_8 = 4 passes with power tiller at 15 cm depth and T_9 = 4 passes with country plough at normal depth

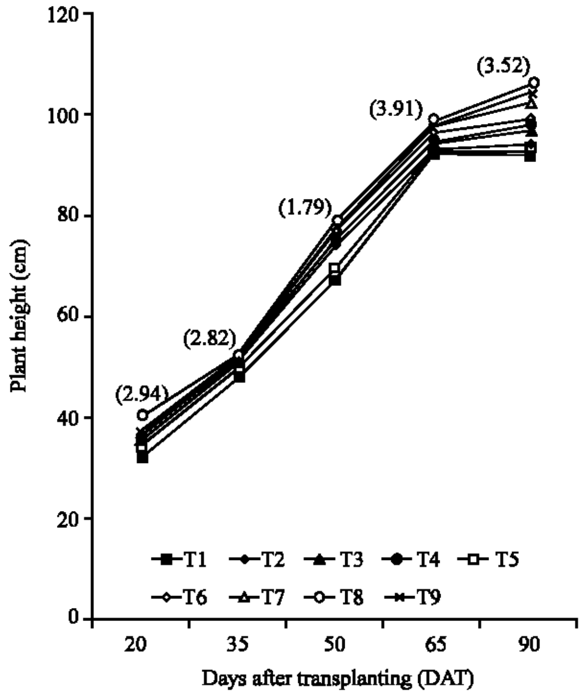

Fig. 1: Effect of different tillage practices on plant height of BRRI Dhan-33 at different days after transplanting (values in parentheses indicate LSD at 5% level)

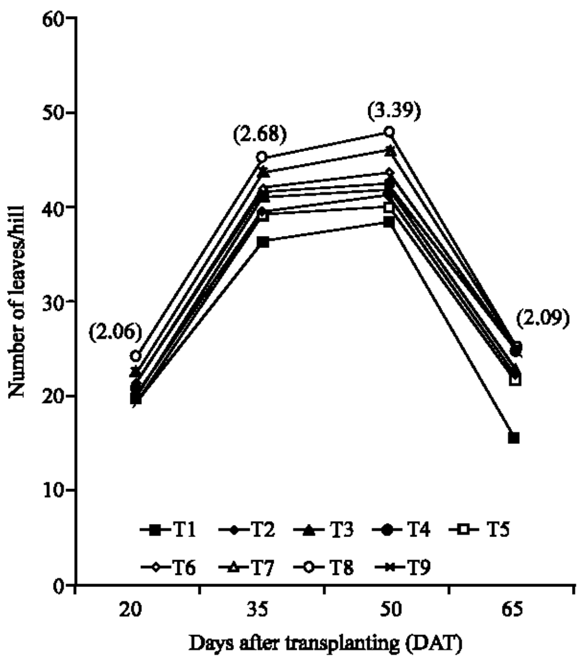

Fig. 2: Effect of different tillage practices on number of leaves/hill of BRRI Dhan-33 at different days after transplanting (values in parentheses indicate LSD at 5% level)

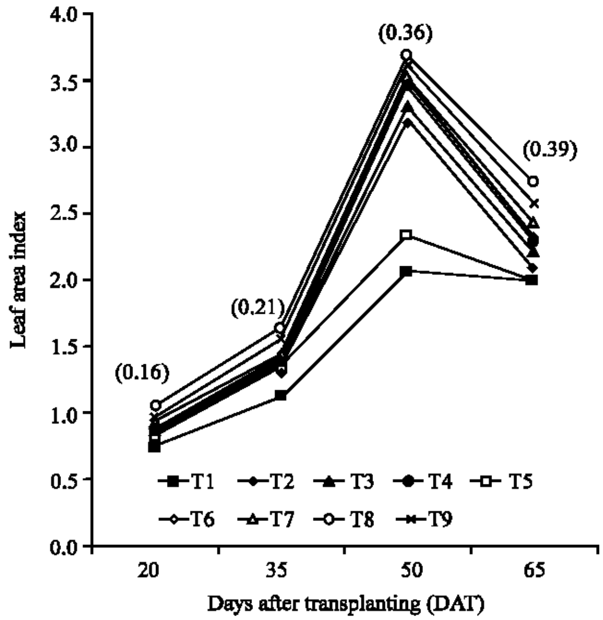

Fig. 3: Effect of different tillage practices on leaf area index of BRRI Dhan-33 at different days after transplanting (values in parentheses indicate LSD at 5% level)

T_1 = 1 pass with power tiller at 7.5 cm depth, T_2 = 2 passes with power tiller at 7.5 cm depth, T_3 = 3 passes with power tiller at 7.5 cm depth, T_4 = 4 passes with power tiller at 7.5 cm depth, T_5 = 1 pass with power tiller at 15 cm depth, T_6 = 2 passes with power tiller at 15 cm depth, T_7 = 3 passes with power tiller at 15 cm depth, T_8 = 4 passes with power tiller at 15 cm depth and T_9 = 4 passes with country plough at normal depth.

Leaf area index (LAI): Different tillage treatments showed significant effect on LAIs during 20-65 DAT. At all growth stages, 1 pass with power tiller at 7.5 cm depth showed the lowest LAI followed by 1 pass with power tiller at 15 cm depth (Fig. 3). The 4 passes with power tiller at 15 cm depth showed the highest LAI values at 20-65 DAT. The plant age also showed different significant effect on LAI. At earlier growth stage the LAI were lower and reached to the maximum at 50 DAT and thereafter declined at 65 DAT that means LAI became higher before the panicle emergence stage and then declined rapidly with advancing maturity. Deep ploughing (15 cm) resulted in higher LAI values as compared to the shallow ploughing (7.5 cm) by power tiller irrespective of the number of passes.

Crop growth rate (CGR): CGR is an important index of agricultural productivity[13]. Figure 4 shows significant effect of tillage practices on CGR. 1 pass with

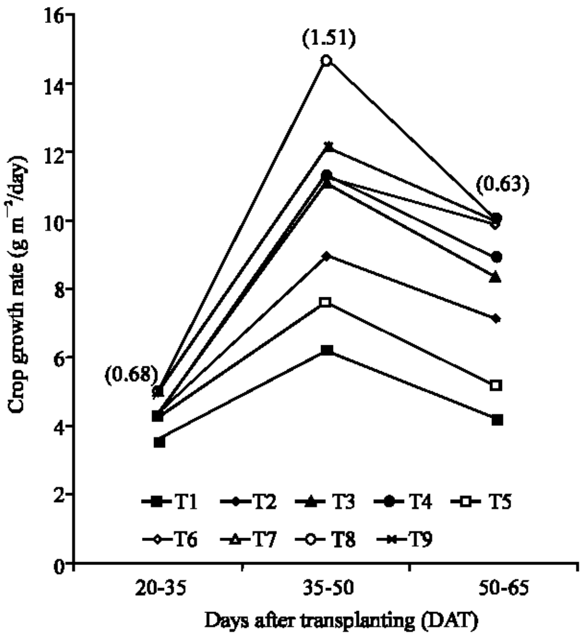

Fig. 4: Effect of different tillage practices on crop growth rate of BRRI Dhan-33 at different days after transplanting (values in parentheses indicate LSD at 5% level)

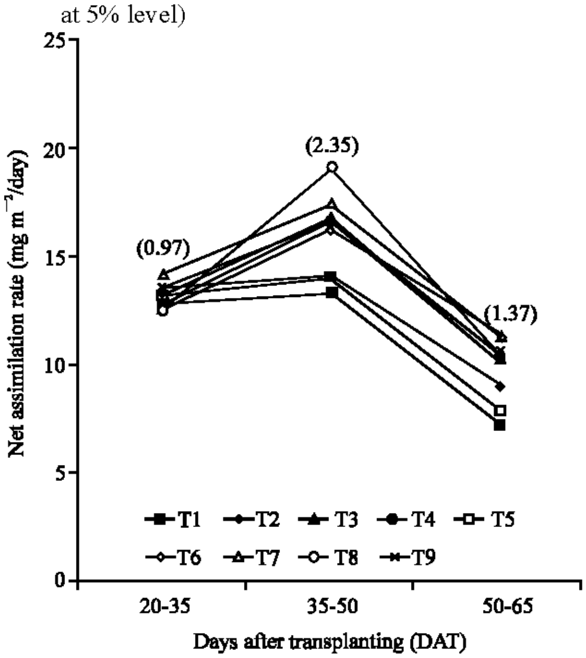

Fig. 5: Effect of different tillage practices on net assimilation rate of BRRI Dhan-33 at different days after transplanting (values in parentheses indicate LSD at 5% level)

power tiller at both the depths (7.5 and 15 cm) showed the lowest CGR values (4.65) at 35-50 DAT. The higher number of passes showed higher CGR values and

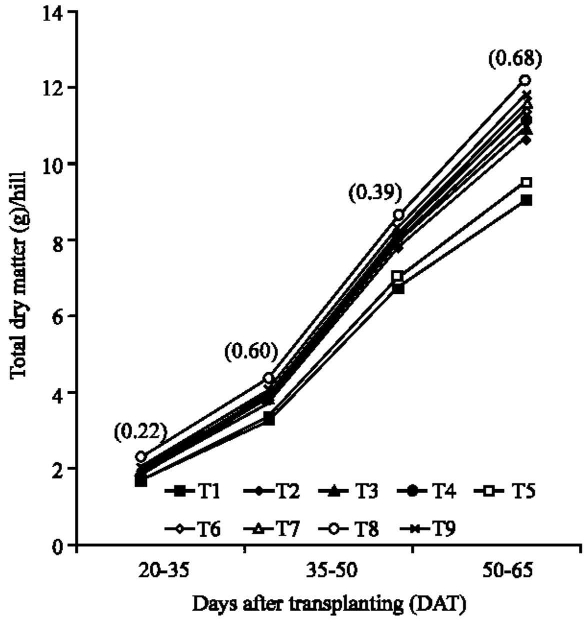

Fig. 6: Effect of different tillage practices on total dry matter of BRRI Dhan-33 at different days after transplanting (values in parentheses indicate LSD at 5% level)

T_1 = 1 pass with power tiller at 7.5 cm depth, T_2 = 2 passes with power tiller at 7.5 cm depth, T_3 = 3 passes with power tiller at 7.5 cm depth, T_4 = 4 passes with power tiller at 7.5 cm depth, T_5 = 1 pass with power tiller at 15 cm depth, T_6 = 2 passes with power tiller at 15 cm depth, T_7 = 3 passes with power tiller at 15 cm depth, T_8 = 4 passes with power tiller at 15 cm depth and T_9 = 4 passes with country plough at normal depth

maximum CGR was obtained in the 4 passes with power tiller at 15 cm depth. Plant age showed significant effect on CGR. At the earlier growth stage the CGR values were low and reached to the maximum at 35-50 DAT and they declined after panicle emergence stage (50-65 DAT) which might be due to high respirational loss of assimilates at that stage. A similar effect of tillage treatment was obtained by Tanaka[17] and Wilson and Eillis[18].

Net assimilation rate (NAR): Different tillage practices showed significant effect on NAR during vegetative phase (20-65 DAT). 1 pass with power tiller at both the depths (7.5 and 15 cm) showed the lowest NAR values and the 3 passes with power tiller at 15 cm depth showed the highest NAR (14.20 mg m^{-2}/day) at 20-35 DAT and 4 passes with power tiller at 15 cm depth showed the highest NAR (19.07 mg m^{-2}/day) at 35-50 DAT (Fig. 5). Plant age showed significant effect on NAR. At 20-35 and 35-50 DAT, the NARs were not so much different, but they declined at the panicle emergence stage (50-65 DAT) might be due to high respirational loss of assimilate at that stage. A similar effect of tillage treatment was obtained by Koller *et al.*[19] who reported that NAR became higher at the earlier growth stage and declined rapidly with advancing the maturity of soybean plants.

Total dry matter (TDM)/hill: TDM/hill was significantly affected by tillage operations (Fig. 6). The maximum TDM (2.29, 4.54, 11.10 and 13.12 g/hill at 20, 35, 50 and 65 DAT, respectively) was found by 4 passes with power tiller at 15 cm depth which was significantly different from other treatments at 20 DAT, but in 65 DAT it was statistically similar with T_7 and T_9 treatments. The lowest TDM/hill was found by 1 pass with power tiller at 7.5 cm depth, which was significantly different in comparison to other treatments. Matin and Uddin[20] found the significant highest TDM of rice with power tiller treatment over country plough treatment.

Yield and yield contributing characters

Total tillers/hill: Tillage treatments under study significantly influenced the total number of tillers/hill of BRRI Dhan-33 (Table 1). The total tillers/hill ranged from 7.90 to 10.51. The highest number of tillers/hill was recorded in treatment of 4 passes with power tiller at 15 cm depth which was significantly different from all treatments. The lowest total number of tillers/hill was recorded from 1 pass with power tiller at 7.5 cm depth which was significantly different from all treatments except 1 pass with power tiller at 15 cm depth. Shallow depth of ploughing (7.5 cm) resulted less tiller than the deep ploughing (15 cm). Number of passes affected the tiller growth; the higher the passes the more was the tiller number.

Number of effective tillers/hill: Tillage treatments showed significant variation in the number of effective tiller/hill (Table 1). The lowest number of effective tillers/hill (5.12) was resulted from the 1 pass with power tiller at 7.5 cm depth. The highest number of effective tiller/hill was found under 4 passes with 15 cm depth by power tiller (9.42) which was significantly different from 1, 2, 3 and 4 passes at 15 cm depth and 2 passes at 15 cm depth, but 3 passes with power tiller at 15 cm depth and 4 passes with country plough at normal depth treatments failed to show any significant differences for the characters. The conventional tillage by country plough showed the second highest number of effective tiller which is in agreement with the findings of Kadir *et al.*[4].

Non-bearing tillers /hill: Number of non-bearing tillers/hill was affected by different tillage operations. The maximum number of non-bearing tillers/hill (2.78) was produced due to the use of 1 pass with power tiller at 7.5 cm depth. The lowest number of non-bearing tiller/hill (1.09) was produced due to the use of 4 passes with power tiller at 15 cm depth. The treatments of 2, 3 and 4 passes with power tiller at 7.5 cm depth, 2 and 3 passes with power tiller at 15 cm depth and 4 passes with country plough at normal depth failed to show any significant difference among themselves (Table 1).

Panicle length: Panicle length was significantly affected by different tillage treatments (Table 1). The panicle length ranged from 19.95 to 22.65 cm. The longest panicle (22.65 cm) was found in 4 passes with deep ploughing (15 cm depth) by power tiller and the second heighest panicle length (22.25 cm) was obtained by the country plough with 4 passes at normal depth. The shortest panicle (19.95 cm) was recorded in 1 pass with power tiller at shallow depth of ploughing (7.5 cm) which was similar to 2, 3 and 4 passes at 7.5 cm depth and 1, 2 and 3 passes at 15 cm depth. A similar effect was also reported by Unhu *et al.*[21].

Number of grains/panicle: Like as panicle length, the highest and the lowest number of grains/panicle were obtained due to the use of 4 passes at 15 cm depth and 1 pass at 7.5 cm depth ploughing by power tiller. Relatively higher number of grains/panicle (101.5) was produced by 4 passes at 7.5 cm depth which was statistically similar the treatments of 2 passes at 15 cm depth by power tiller and 4 passes at normal depth by country plough (Table 1). These results are in agreement with the findings of many authors[4,15,21,22].

Number of sterile spikelets/panicle: The production of sterile spikelets/panicle was significantly influenced by various tillage treatments (Table 1). The maximum number of sterile spikelets/panicle was produced due to the use of 1 pass with power tiller at 7.5 cm depth which was followed by 2, 3 and 4 passes with power tiller at 7.5 cm depth and 1 pass at 15 cm depth. The lowest one was produced by 4 passes with power tiller at 15 cm depth. A similar effect was also reported by Unhu *et al.*[21].

1000-grain weight: Weight of 1000-grains was not significantly affected by tillage treatment. However, the highest 1000-grain weight (23.21 g) was obtained by 4 passes at 15 cm depth ploughing by power tiller and the lowest (22.25 g) was with 1 pass at 7.5 cm depth (Table 1). This result is in agreement with many authors[4,14,15,23]. All of them reported that tillage practices insignificantly influenced 1000-grain weight.

Grain yield: Different tillage treatments significantly influenced the grain yield of BRRI Dhan-33 (Table1). The highest grain yield (4.95 t ha^{-1}) was found with 4 passes at 15 cm depth and the lowest (2.10 t ha^{-1}) was with 1 pass at 7.5 cm depth by power tiller. The treatments of 2, 3 passes at 15 cm depth and 4 passes with country plough at normal depth produced statistically similar grain yield per hectare but significantly different from rest of the treatments. This finding was supported by Matin and Uddin[20], Rezaul and Ahmed[24] and Ardell *et al.*[25].

Straw yield: Different tillage treatments significantly influenced the straw yield of BRRI Dhan-33 (Table 1). The straw yield ranged from 3.40 t ha^{-1} to 5.89 t ha^{-1}. The highest straw yield was recorded in 4 passes with power tiller at 15 cm depth. The lowest straw yield was obtained under 1 pass with power tiller at 7.5 cm depth. 4 passes with power tiller at 15 cm depth was statistically significant over 1, 2, 3 and 4 passes at 7.5 cm depth and 1 pass with 15 cm depth but failed to show any significant differences between 2 and 3 passes of power tiller at 15 cm depth and country plough at normal depth. A similar effect was also reported by Shadidullah and Mazumder[26] and Matin and Uddin[20].

Biological yield: Biological yield was significantly affected by tillage operations. The maximum biological yield was found in 4 passes with power tiller at 15 cm depth which was significantly different from all other treatments expect conventional tillage by country plough (Table 1). The lowest biological yield was found in 1 pass with power tiller at 7.5 cm depth, which was significantly different from all treatments. Biological yield is the sum of grain and straw yield. Therefore, the increase or decrease in biological yield is obviously correlated to the increase or decrease in grain and straw yield.

Harvest index: Harvest index was significantly affected by different tillage practices. The highest harvest index was found in 4 passes with power tiller at 15 cm depth. The second highest harvest index was found in 4 passes with country plough at normal depth which was followed by 3 passes with power tiller at 15 cm depth. The lowest harvest index was found in 1 pass with power tiller at 7.5 cm depth, which was significantly different from all other treatments.

The magnitude of tillage effects varies with the use of tillage implements. Power tiller is used for deep ploughing, sub soiling and rotating the soil much better than that of country plough. Deep tillage decreases the bulk density[6-9], increases the soil porosity, infiltration rate[10-12] and hydraulic conductivity[11]. As a result, soil becomes permeable, aerated and having good physical condition for crop growing. On the other hand, shallow tillage increases the bulk density, soil resistance and mechanical impedance of soil for which poor physical condition may be developed. In our experiment, under 4 passes with deep ploughing (15 cm depth) soil perhaps were more loose compared to other tillage treatments, which might have permited the roots to enter into the deeper layer for uptaking water and mineral nutrients. Positive physiological and metabolic activities of rice were indicated by higher LAI values, higher CGR and consequently the NAR values in the treatment of higher passes at deep ploughing especially by 4 passes with power tiller at 15 cm depth. Hence, highest grain yield of rice was obtained using 4 passes with power tiller at 15 cm depth ploughing because of higher number of panicle/hill, higher panicle length, higher number of grains/panicle and higher 1000-grain weight.

In conclusion, most of the growth and yield parameters of rice responded significantly to different tillage practices. However, power tiller treatment with 4 passes at 15 cm depth was found to be the better tillage practice than the rest. Therefore, it may be practiced for BRRI Dhan-33 rice cultivation in Bangladesh.

REFERENCES

1. Brady, N.C., 1974. The nature and properties of soils. McMillan publications Co., New York.
2. Johnson, S.W., 1978. On reasons for tillage of corn. Agril. Annual Rep., 11: 133-151.
3. Satter, M.A., S. Wahab, F.R. Borhan Khan and M.I. Hossain, 1993. Development of an animal drawn mouldboard plough. Bangladesh J. Agric. Res., 18: 137-144.
4. Kadir, A., M.S.U. Talukder, S.M. Shirazi and M. Ahmed, 1999. Performance of different tillage implements and their influence on soil fertility and paddy yield. Agricultural Mechanization in Asia, Africa and Latin America, 30: 13-16.
5. Sarker, R.I., 1993. Draft power constraint affecting irrigated crop diversification. In Biswas, M.R. and M.A.S. Mandal (Ed.). Irrigation management for crop diversification in Bangladesh. The University Press Limited, Dhaka, Bangladesh, pp: 100-115.
6. Al-Tahan, Y.H., H.M. Hassam and I.A. Hamadi, 1992. Effect of ploughing depths using different plough types on some physical properties of soil. Agricultural Mechanization in Asia, Africa and Latin America, 23: 21-24.
7. Abbas, M.K. and K.A. Al-Rawi, 1989. Effect of tillage practices on growth and yield components of wheat under dry farming. Mesopotamia J. Agric., 21: 73-84.

8. Prochazka, F. and M. Hudcova, 1989. Effect of some tillage practices on the yield and quality of spring barley grain. Rostlinna Vyroba, 35: 795-806.
9. Sharma, P.K., S.K. De Datta and C.A. Redulla, 1988. Tillage effects on soil physical properties and wet land rice. Agron. J., 80: 34-40.
10. Adeoye, K.B., 1982. Effect of tillage depth on physical properties of tropical soil and on yield of maize, sorghum and cotton. Soil and Tillage Res., 2: 225-231.
11. Rahman, S.M. and A. Islam, 1989. Water transmission of two Bangladesh soils as affected by tillage depths. II. Soil water flux and hydraulic conductivity. Ann. Agric. Res., 19: 307-312.
12. Zuzel, J.F., J.H.J. Pikul and P.E. Rasmussen, 1990. Effect of tillage reduction and fertilizer type on soil properties during corn (*Zea mays* L.) production. Soil and Tillage Res., 17: 63-76.
13. Hunt, R., 1978. Plant growth analysis. Studies in biology, no. 96. Edward Arnold Ltd., London, pp: 67.
14. Olofintoye, J.A., 1989. Tillage and weed control practices for upland rice (*Oryza sativa*) on hydromorphic soil in the Guinea Savana of Nigeria. Tropical Agric., 66: 43-48.
15. Rahman, M.S., 1997. Different tillage methods on soil properties, root growth and yield of BRRI Rice-29. M.S. Thesis, Bangladesh Agril. Univ., Mymensingh, Bangladesh.
16. Basunia, M.S.H., 2000. Effect of land tilling by country plough and power tiller on some soil properties and yield of transplant amon rice (cv. BR11). M.S. Thesis, Bangladesh Agric. Univ., Mymensingh, Bangladesh.
17. Tanaka, A., 1983. Physiological aspects of productivity of field crops under different environments. IRRI, Los Banos, Phillippines.
18. Wilson, J.H. and R.D. Ellis, 1981. Supply of dry matter from stem and grain in rice grown under dry land condition. Int. Rice Newslett., 6: 23-24.
19. Koller, H.R., W.E. Nyquist and I.S. Chorvsh, 1970. Growth analysis of the soybean communities, Crop Sci., 10: 407-412.
20. Matin, M.A. and M.S. Uddin, 1994. Effects of different tillage operations on soil physical properties, root growth and yield of rice. Proceedings of 13th ISTRO [International Soil Tillage Research Organization] conference, Denmark, pp: 1087-1092.
21. Unhu, R., J. Lee and G. Muller, 1998. Effect of no tillage and conventional tillage on soil properties. I. Agriculture aspects. Z. Aekeru. Pfiban, 89: 102-118.
22. Razzaq, A., A. Karim and B.A. Sabir, 1993. Appropriate tillage package for wheat production after in rice tract. Agricultural Mechanization in Asia, Africa and Latin America, 24: 23-26.
23. Gill, K.S. and B.S. Aulakh, 1990. Wheat yield and soil bulk density response to some tillage systems on Oxisol. Soil and Tillage Res., 18: 37-45.
24. Rezaul, S.M.K. and S. Ahmed, 1997. Effect of degree of land preparation and spacing on weed growth and yield of transplanted amon rice. Bangladesh J. Agril. Sci., 24: 40-42.
25. Ardell, D., H. Alvorson, A.L. Black, J.M. Krupingley, S.D. Merril, B.J. Wienhold and D.L. Tanaka, 2000. Spring wheat response to tillage system and nitrogen fertilization in rotation with sunflower and winter wheat. Agron. J., 92: 151.
26. Shahidullah, M. and M.K. Mazumder, 1989. Effect of different tillage systems on wheat under dry land condition. Proceedings of the 14th Annual BAAS conference, Dhaka, Bangladesh, pp: 110.