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EVALUATION OF DIFFERENT RICE VARIETIES FOR GROWTH AND YIELD CHARACTERISTICS

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ABSTRACT

Crop genotypes play a dominant role in crop production systems. They affect crop productivity by their higher yield potentials, resistance against insect pest and diseases under different climatic conditions. To evaluate different varieties of rice for their growth and yield characteristics, an experiment was conducted during 2012. Four varieties including IR-28, NERICA-4, Koshihikari and Nipponbare were evaluated in a randomized complete block design (RCBD) with three replications. All varieties were transplanted at spacing of 30x15 cm using 3 seedlings / hill. Data on various growth and yield parameters revealed that Koshihikari was the tallest (117 cm) and Nipponbare the shortest one (102 cm). Japonica varieties produced higher number of tillers/m^2, dry weight (t/ha), LAI, number of panicles/m^2, ripening ratios and lower nitrogen contents in panicle, stem and leaves. NERICA-4 gave higher values of SPAD, number of spikelets/ panicle (106) and harvest index (0.47). The highest straw weight (11.53 t/ha) and paddy yields (6.79 t/ha) were obtained from IR-28. The lowest values of harvest index (0.37) were also recorded from IR-28. Japonica and IR-28 produced higher paddy yields than NERICA-4 (5.77 t/ha) so they can be cultivated successfully under temperate climatic conditions.

Key words: Varieties; Productivity; Characteristics.

INTRODUCTION

Rice (*Oryza sativa* L.) is an important staple food of more than half of the world population. It is dominantly produced and consumed in the Asia. Since the beginning of civilization, thousands of rice cultivars have been selected for increasing productivity (Singh *et al*., 2000). Manipulation of genetic resources has contributed much towards meeting rising demands of food for ever escalating world population. In late 1960s "Green revolution" boosted yield of cereal crops including rice by the utilization of high yielding short statured varieties with high sink capacity. The impact of green revolution is diminishing due to rising demands of food commodities. The area under rice cultivation is same but population has become manifold. The options available are to enhance yield of rice on per unit area basis (Cassman *et al*., 2003) and development of rice cultivars with high yielding ability which can increase production (IRRI, 1993). Producing varieties having resistance against biotic and abiotic stress by using conventional and modern biotechnology can increase rice yields to meet world requirement (Khush, 2005). The varieties have different physiological and morphological characteristics that contribute towards yield (Yang *et al*., 2007; Yang and Hwa, 2008). Ashrafuzzaman *et al*. (2009) found variation in morphological and yield components in different varieties of aromatic rice. Yield of rice can be enhanced by improving fertilization, irrigation management and good pest and disease control. Genotype of a crop has a decisive role towards utilization of these resources and finally production of economic yield. Growth and yield characteristics of genotypes depend on genetic and environmental factors. Alam *et al*. (2008) reported that among production factors varietal selection at any location has an important role. Proper crop management depends on the growth characteristics of various varieties to get maximum benefit from new genetic material.

For successful crop production knowledge of varietal morphological and physiological characteristics is necessary. The objective of present study was to compare the growth and yield characteristics of different rice varieties under conditions of Tsukuba, Japan. The findings of the experiment may be beneficial to students, researchers and farmers to manage particular varieties for higher yield targets.

MATERIALS AND METHODS

Selected and disinfected seeds of four varieties were soaked in water bath at 30 ℃ until sprouting. Sprouted seeds were sown @ 80 g/tray in special seedling raising plastic trays. After incubation for 48 hours the trays were shifted to green house and kept under plastic sheets to control temperature for greening process. Plastic sheets were removed after a week and seedlings were managed uptill transplanting.

The experiment was conducted at external paddy field of JICA International Center Tsukuba in a randomized complete block design (RCBD) with three replications. Four rice varieties i.e. IR-28 (*indica*), NERICA-4 (*NERICA*), Koshihikari and Nipponbare (*Japonica*) were randomized in plots of size 3.6x5.7 m. Twenty eight days old seedlings at 3.4 leave stage were transplanted manually on 16th May, 2012 using 3 seedlings per hill at spacing of 30 x 15 cm. A granular herbicide ZARK was applied one week after transplanting with manual herbicide spreader. Water was maintained at 5 cm for a week to improve the efficacy of herbicide. Fertilizers were applied @ 80-100-90 NPK Kg/ha. Basal dose of fertilizers (60-100-60 N, P_2O_5, K_2O Kg/ha) was applied before puddling and top dressing of N and K was done at panicle initiation. The source of fertilizers was NK compound fertilizer (17-17% N and K_2O) and single super phosphate (17.5% P_2O_5).

Data on plant length, numbers of tillers, leaf area index, leaf chlorophyll concentration using soil plant analysis development (SPAD) values and dry matter production (t/ha) were collected at different growth stages. Data on yield and yield components were also recorded at crop maturity. Collected data were analyzed using Fisher's analysis of variance technique and treatment means were compared using Tukey's HSD at 5% level of significance (Steel *et al*., 1997).

RESULTS

Crop duration and critical growth stages: NERICA-4 was the earliest variety among four and Nipponbare was the late maturing variety with total growth duration of 122 days (Table 1) from transplanting. Koshihikari and IR-28 had similar duration of crop growth stages.

Table 1. Dates of different critical growth stages and total duration of varieties

Varieties	Trans-planting	Ac. Tillering	Max. Tillering	Panicle initiation	Heading	Grain development	Maturity days
IR-28	16 May	11-June	20- June	13-July	2-Aug	6- Sep	114
NERICA-4	16 May	11-June	20- June	7-July	28-July	31- Aug	108
Koshihikari	16 May	11-June	20- June	13-July	3-Aug	7- Sep	115
Nipponbare	16 May	11-June	30- June	23-July	10-Aug	14- Sep	122

Ac. Active; Max. Maximum.

Plant length (cm): Plant length increased in all varieties steadily from transplanting to full heading stage (Fig. 1). The rate of increase was higher from panicle initiation to full heading stage in all varieties. The length became constant from full heading to maturity for all varieties except IR-28 whose length increased upto grain development stage but the rate of increase was lower than previous stages. The rapid increase of plant length was an indication of changing vegetative to reproductive phase of crop growth (Krishnan *et al*., 2011). Koshihikari was the tallest variety with plant length 117.0 cm followed by IR-28 (111.8). The lowest plant length among all varieties was achieved by Nipponbare (102.5). The increase of plant length was due to elongation of stem internodes.

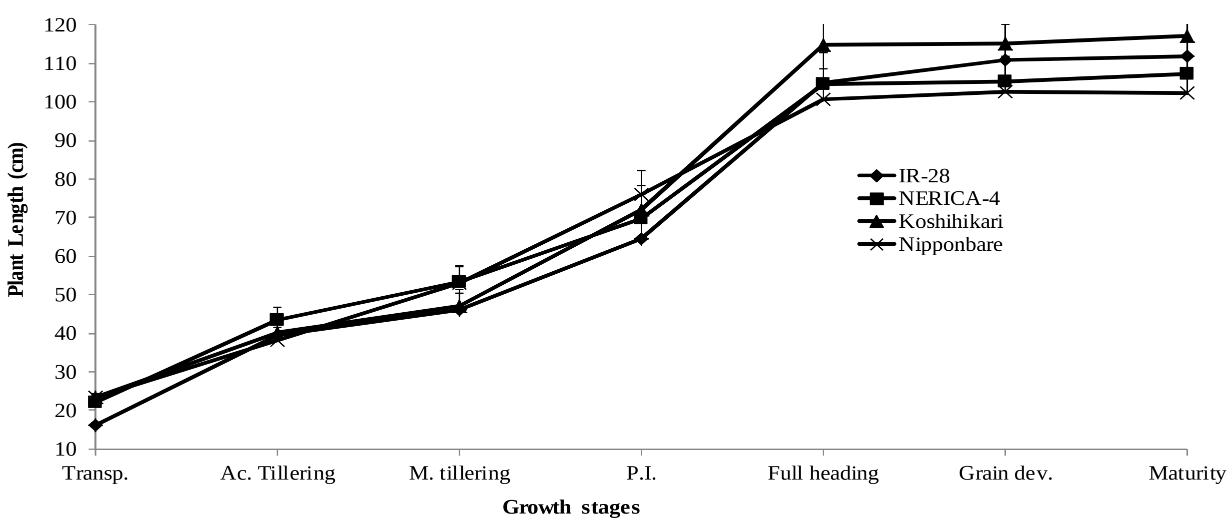

Fig. 1. Effect of varieties on plant length (cm) at different growth stages of rice.

Abbreviations: Transp. Transplanting; Ac., Active; M., Maximum; Dev. Development

Number of tillers/m^2: Number of tillers per unit area increased from transplanting to maximum tillering stage in all varieties, however, NERICA-4 produced significantly lower numbers/m^2 (403) as compared to other varieties (Fig. 2). Nipponbare produced the highest numbers (790) but it was statistically at par with Koshihikari and IR-28. After maximum tillering stage, tillers decreased in all varieties but rate of decline was lower in NERICA-4 than other varieties. The number diminished uptill full heading stage in NERICA-4 while in other varieties mortality of tillers continued up to maturity stage. This was due to high competition among tillers in *Japonica* and *Indica* varieties as compared to NERICA-4.

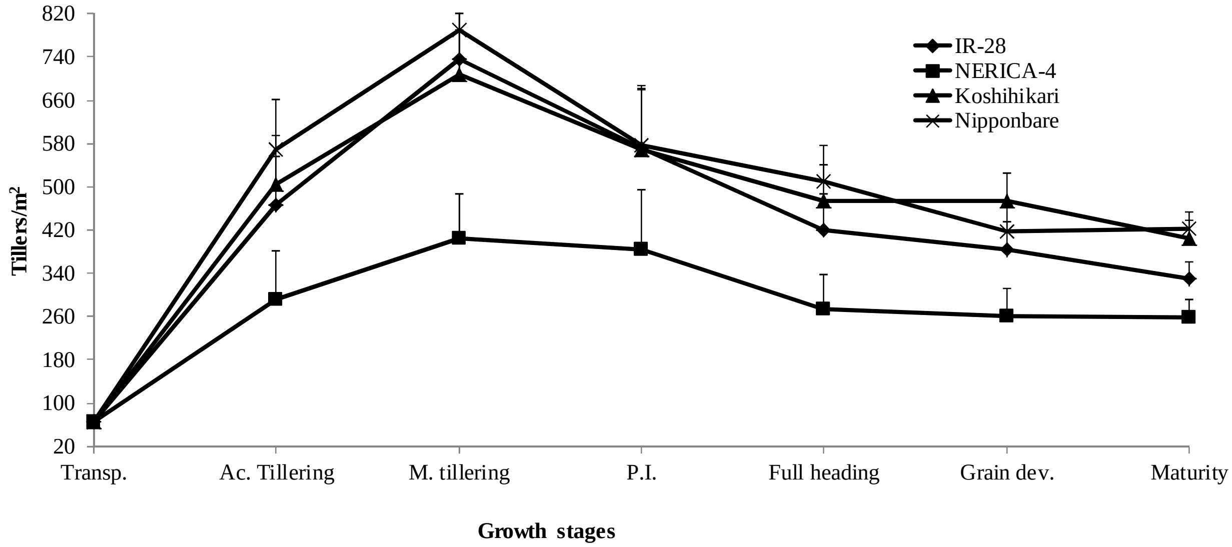

Fig. 2. Effect of varieties on number of tillers/m^2 at different growth stages of rice.

Dry matter production (t/ha): Biomass production is represented in Fig. 3. Dry matter of all varieties increased from transplanting upto maturity. Nipponbare produced the highest biomass (16.3) but it was statistically similar with Koshihikari and IR-28 at maturity stage. NERICA-4 produced significantly lower dry weight (12.0) than Nipponbare but it was at par with other two varieties. The difference of dry matter production was due to different number of tillers/m^2 and leaf area index.

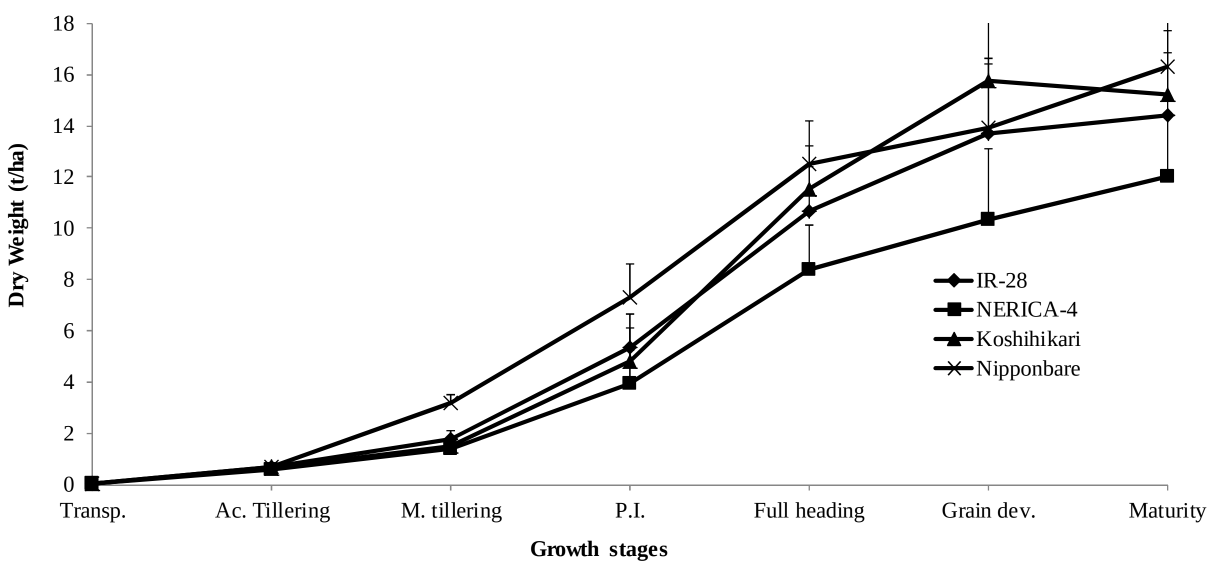

Fig. 3. Accumulation of dry matter (t/ha) at different growth stages of four rice varieties.

SPAD value: SPAD value indicates chlorophyll contents and colour of crop. *Japonica* varieties achieved lower SPAD values at all growth stages as compared to *indica* and *NERICA* (Fig. 4). SPAD value decreased sharply in Nipponbare and Koshihikari from active tillering to panicle initiation stage as compared to IR-28 and NERICA-4. It increased initially in Nipponbare from transplanting to active tillering stage but in IR-28 it remained constant for this period and then declined at P. I. stage for both varieties. At P. I. stage second dose of N and K_2O was top dressed which increased SPAD value at full heading stage and again it decreased reaching minimum level at maturity stage in all varieties. NERICA-4 was the most responsive variety to increase SPAD value. It may be due to lower number of tillers and competition among tillers as compared to other varieties.

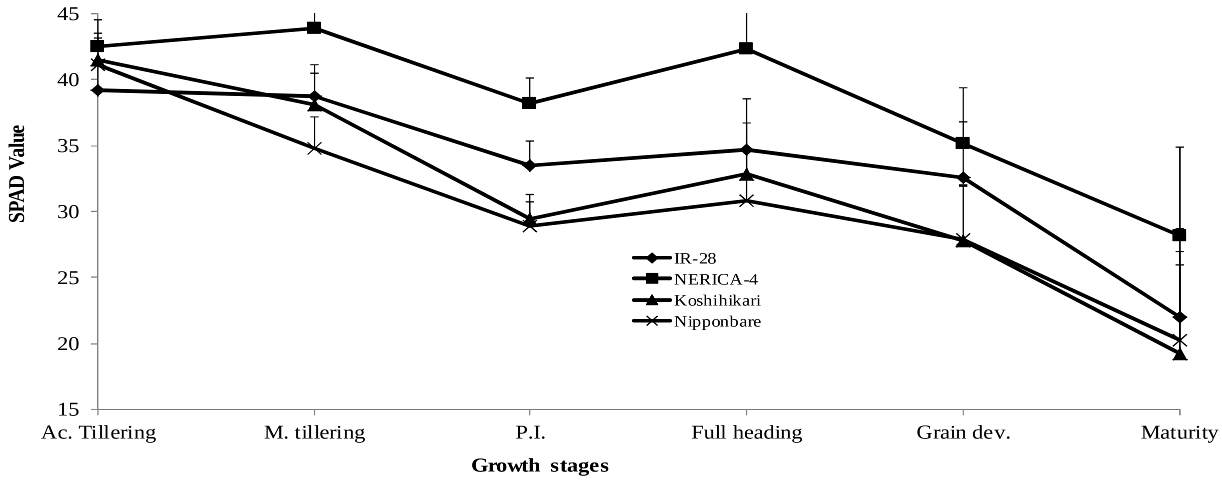

Fig. 4. Variation in SPAD values at different growth stages of four rice varieties.

Leaf Area Index (LAI): Leaf area index is a measure to know the size of photosynthetic machinery of a plant. Variation of LAI with growth stages among different varieties is shown in Fig. 5. Nipponbare exhibited higher LAI at all growth stages while NERICA-4 was the lowest one. IR-28 and Koshihikari were intermediate and statistically at par with each other. LAI increased with crop growth period and reached at its maximum value at full heading stage in each variety. Afterwards, it started declining as crop moved towards maturity. The highest and lowest values of LAI in Nipponbare and NERICA-4 respectively, were due to number of tillers/ m^2 exhibited by these varieties.

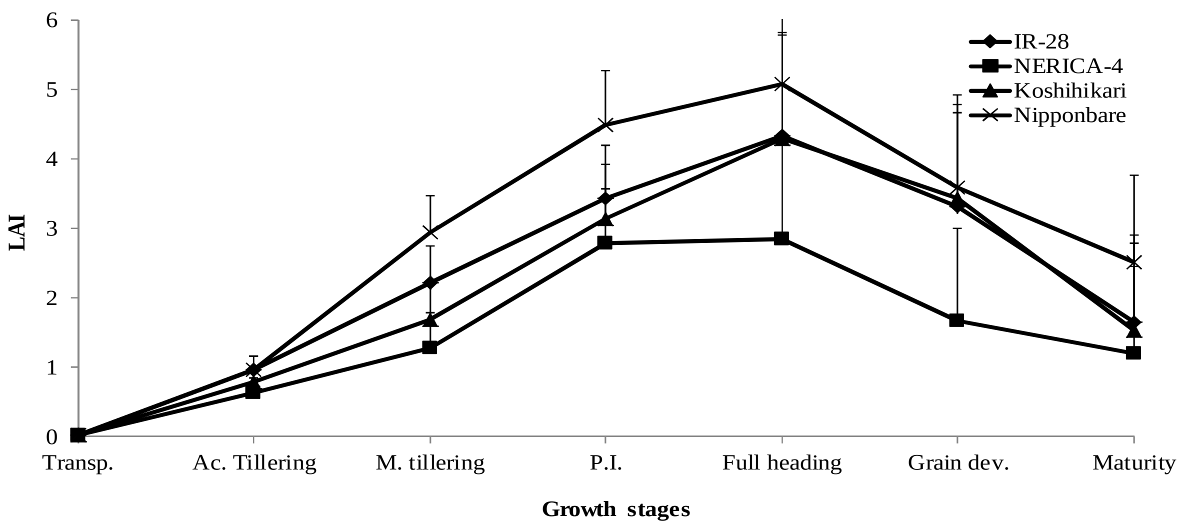

Fig. 5. Variation in leaf area index (LAI) at different growth stages of four rice varieties.

Panicle, culm and internodes lengths (cm): Koshihikari produced smaller panicles (17.9 cm) as compared to other varieties which exhibited similar panicle lengths (Table 2). The longest panicle lengths were observed in IR-28

(23.7) followed by NERICA-4 and Nipponbare. Different panicle lengths were observed due to different genotype of the varieties.

The highest culm length was measured in Koshihikari (90.2 cm) followed by IR-28 while the minimum was found in Nipponbare (77.3 cm). Koshihikari had similar culm length with IR-28 but it was significantly higher than NERICA-4 and Nipponbare (Table 2). Changes in culm length were due to variations in internodal lengths in the varieties.

Significant difference between lengths of internodes was found in varieties. NERICA-4 produced shorter 1st and 2nd internodes and longer 3rd and 4th internodes than other varieties. Koshihikari gave longer 4th and 5th internodes thus was prone to lodging.

Table 2. Panicle length, internode and culm lengths of different varieties.

Varieties	Panicle length (cm)	Length of internodes (cm)						Culm length (cm)
		1st	2nd	3rd	4th	5th	6th	
IR-28	23.7 a	38.2 a	20.5 ab	14.2 b	5.9 b	3.6 ab	1.2 a	83.6 ab
NERICA-4	21.7 a	33.2 b	17.6 b	18.0 a	9.9 a	0.7 b	0.0 b	79.2 b
Koshihikari	17.9 b	37.7 ab	22.0 a	15.0 b	9.9 a	5.7 a	0.1 b	90.2 a
Nipponbare	21.4 a	38.2 a	19.9 ab	10.9 c	6.4 b	1.9 b	0.1 b	77.3 b
HSD (5%)	2.69	4.93	4.00	2.39	0.81	3.35	0.39	9.62

Figures having different letters within a column differ significantly at 5% level of significance using Tukey's test.

Yield and yield components of rice varieties: Most of the varieties differed significantly for panicles/m^2. Koshihikari was the leading variety in panicles production followed by Nipponbare (Table 3). Both of these varieties were statistically similar with each other but significantly different from IR-28 and NERICA-4 having less number of panicles/m^2. The lowest number of panicles was observed in NERICA-4 (246.3) due to low number of tillers in this variety (panicle weight type).

NERICA-4 produced the highest number of spikelets/panicle but it was at par with IR-28 and significantly higher than *japonica* varieties. Spikelets in IR-28 were statistically at par with all other varieties. Difference in spikelets number can be attributed to genetic nature of different varieties. IR-28 and NERICA-4 produced higher number of spikelets because of their high sink size characteristics which is the product of spikelets number and 1000 grain weight.

Higher values of ripening percentage were observed in *japonica* as compared to other varieties (Table 3). Koshihikari was the most efficient variety for maturing grains while IR-28 had the lowest percentage of ripening. The differences may be attributed to better acclimatization of *japonica* in conditions of Japan than other groups.

There were a non significant difference in 1000-grain weight of all varieties, however, it varied between 28.5 to 29.9 g.

Table 3. Yield and yield components of different rice varieties

Varieties	Panicles/m^2	Spikelets/ panicle	Ripening % age	1000-grain weight (g)	Paddy yield (t/ha)	Straw yield (t/ha)	Harvest index (%)
IR-28	343.1 b	88.2 ab	71.8 b	29.5	6.79	11.53 a	37 b
NERICA-4	246.3 c	106.2 a	72.2 b	29.7	5.77	6.64 b	47 a
Koshihikari	417.8 a	72.9 b	84.6 a	29.9	6.70	9.74 ab	41 b
Nipponbare	417.0 a	70.5 b	82.0 ab	28.5	6.46	8.93 ab	42 ab
HSD (5%)	68.96	28.02	11.44	NS	NS	3.27	5.23

Figures having different letters within a column differ significantly at 5% level of significance using Tukey's test.

All varieties produced statistically similar yields (Table 3), however, IR-28 gave the highest paddy yields (6.79 t/ha) followed by Koshihikari (6.70 t/ha) and Nipponbare (6.46 t/ha). NERICA-4 produced the lowest yields (5.77 t/ha) which may be due to lower number of panicles/m^2.

IR-28 produced the highest straw yield (11.53 t/ha) but it was similar to *japonica* group and different than *NERICA* (6.64 t/ha). NERICA-4 gave lower straw weight due to lower number of tillers/m^2. IR-28 produced new shoots before harvesting so they contributed towards increasing straw yield.

Almost similar harvest index values were calculated in different varieties, however, NERICA-4 gave the highest values (47%) followed by Nipponbare and Koshihikari. The lowest harvest index was determined in IR-28 (37%) which was due to higher straw yields.

DISCUSSION

The objective of the study was to evaluate and compare growth and yield characteristics of different rice varieties. All varieties gained different plant height at maturity due to various internodal lengths. The varieties having longer internodes produced taller plants. The findings are in agreement with those of Ashrafuzzaman *et al*. (2009) who stated that longer internodes increased plant heights in rice. Genetic differences between different varieties also caused variation in plant lengths. Similar results were recorded by Mohammad *et al*. (2002) who described that plant height depends on genetic makeup of a plant and environmental conditions. Koshihikari gained the highest plant length at maturity. From transplanting to maximum tillering stage it was similar to other varieties but afterwards length increased at much faster rate than others so it became vulnerable to lodging. Sum of fourth and fifth internodal length was the highest (15.5 cm) in Koshihikari while that of others was equal to / lower than 10.7 cm (IR-28). Kanegana and Kargbo (2011) reported lodging in varieties having length of 4th and 5th internode equal to or more than 15 cm.

Japonica varieties produced higher number of tillers as compared to IR-28 and NERICA-4 varieties. It was due to their genetic variations. At maximum tillering stage IR-28 achieved higher number of tillers than Koshihikari but this number decreased rapidly as compared to Koshihikari which retained significantly higher number at maturity. Higher tiller mortality rate in IR-28 showed severe competition among tillers. NERICA-4 had the lowest mortality rate due to lower competition among tillers.

Nipponbare produced higher biomass than other varieties at all stages of crop growth except grain development stage where Koshihikari was the first one. The higher weight in Nipponbare and Koshihikari can be attributed to higher number of tillers and LAI values. NERICA-4 produced lower number of tillers so its dry weight was also lower. IR-28 was comparable with Koshihikari as both varieties had similar LAI which produced almost similar biomass. Rate of crop growth was higher for Koshihikari from P.I. stage to grain development stage which is related with fast enlargement of cells contributing towards stem elongation and biomass production. Our results were in accordance with those of Yoshinaga *et al*. (2006) who reported that late heading varieties had a heavy top dry weight at full heading and at maturity stages.

SPAD values of NERICA-4 and IR-28 were higher during all growth period while those of *japonica* were lower at each stage. The difference of SPAD values was also due to number of tillers/m^2 and competition among tillers for growth factors. NERICA-4 had lower number of tillers so it experienced lower competition and each tiller could absorb more nutrients which enhanced the value. In *japonica*, there was a higher competition among tillers so it depressed SPAD value. Our results were against the findings of Miah *et al*. (1996) who reported that SPAD values decreased rapidly in *indica* as compared to *japonica* varieties. Contrary to SPAD values Nipponbare and NERICA-4 achieved the highest and the lowest LAI values respectively, due to production of different number of tillers per unit area.

Japonica varieties showed higher number of panicles/m^2 due to more number of tillers production by these varieties. NERICA-4 produced lower number of panicles because it had less number of tillers/m^2, however, it had the highest number of spikelets and longer panicles as compared to *japonica*. Hossain *et al.* (2008) also reported similar results that number of panicles depends on number of tillers and proportion of effective tillers. Panicle length was same in all genotypes except Koshihikari which produced shorter panicles. Shrirame and Muley (2003) found non-significant difference of panicle length in tested genotypes but Sharma (2002) reported significant difference in panicle length among fine grain rice genotypes. Ripening ratio was lower in IR-28 and NERICA-4 as compared to *japonica* which may be due to environmental conditions prevailed during the ripening period. *Japonica* types are well adjusted to the conditions of Japan so they performed better while changing spikelets into grains as compared to other varieties. Almost similar 1000-grain weight was recorded in all varieties possibly due to their genetic nature. The results were against the findings of Mondal *et al*. (2005) who reported difference of 1000-grain weight among 17 studied cultivars. Higher paddy and straw yields were recorded from *japonica* and *indica* varieties as compared to *NERICA* due to higher number of panicles/m^2. Similar results were achieved by Kusutani *et al*. (2000) and Dutta *et al*. (2002) who reported that genotypes producing higher number of effective tillers produced more grain yields in rice. NERICA-4 was the most efficient variety for conversion of biomass towards economic parts. Higher yields can be obtained by physiological process involving high accumulation of photosynthates and their partitioning (Miah *et al*., 1996). IR-28 gave the lowest harvest index because of emergence of new shoots from nodes before harvesting which contributed only towards straw yield.

Koshihikari and IR-28 can mature one week before Nipponbare. *Japonica* and IR-28 produced higher biomass, more number of tillers/m^2, higher number of panicles/m^2 better ripening ratio and gave better paddy yields as compared to NERICA-4 so they can be cultivated in the conditions of Tsukuba Japan to enhance field productivity.

REFERENCES

Alam, M.M., M. Hasanuzzaman and K. Nahar (2008). Growth pattern of three high yielding rice varieties under different Phosphorus levels. Advances in Biol. Res. 3 (3-4): 110-116.

Ashrafuzzaman, M., M.R. Islam, M.R. Ismail, S.M. Shahidullah and M.M. Hanafi (2009). Evaluation of six aromatic rice varieties for yield and yield contributing characters. Int. J. Agric. Bio., 11: 616-620.

Cassman, K.G., A. Dobberman, D.T. Walters and H. Yang (2003). Meeting cereal demand while operating resources and improving environmental quality. Annu. Rev. Env. Resour. 28: 315-358.

Dutta, R.K., M.A. Baset Mia and S. Khanam (2002). Plant architecture and growth characteristics of fine grain and aromatic rices and their relation with grain yield. IRC Newsletter. 51: 51-56.

Hossain, M. B., M. O. Islam and M. Hasanuzzaman (2008). Influence of different nitrogen levels on the performance of four aromatic rice varieties. Int. J. Agric. Biol. 10: 693-696.

IRRI. (1993). Rice Research in a time of change. IRRI's Medium term plan for 1994-1995, pp: 79. International Rice Research, Los Benos, Philippines.

Kanegana, M.Z. and A.M. Kargbo (2011). Effect of nitrogen topdressing at different growth stages on rice plant growth, yield and yield components. In: Report on experiments in rice cultivation techniques development course. 3. Tsukuba Int. Center. Japan Int. Coop. Agency. pp- 43-45.

Khush, G. (2005). What it will take to feed 5.0 billion rice consumers in 2030. Plant Mol. Biol. 59: 1-6.

Krishnan, P., B. Ramakrishnan, K.R. Reddy and V.R. Reddy (2011). High-temperature effects on rice growth, yield, and grain quality. In Donald L. Sparks, Editor: Advances in Agronomy. 111, Academic Press Burlington. pp. 87-206.

Kusutani, A., M. Tovata, K. Asanuma and J. Cui (2000). Studies on the varietal differences of harvest index and morphological characteristics of Rice. Japanese J. Crop Sci. 69: 359-364.

Miah, M.N.H., T. Yoshida, Y. Yamamoto and Y. Nitta (1996). Characteristics of dry matter production and partitioning of dry matter to panicles in high yielding semidwarf indica and japonica indica hybrid rice varieties. Japanese J. Crop Sci. 65: 672-685.

Mohammad, T., W. Deva and Z. Ahmad (2002). Genetic variability of different plant and yield characters in rice. *Sarhad* J. Agric. 18: 207-210.

Mondal, M.M.A., A.F.M. Islam and M.A. Siddique (2005). Performance of 17 modern transplant aman cultivars in northern region of Bangladesh. Bangladesh J. Crop. Sci. 16: 23-29.

Sharma, N. (2002). Quality characteristics of non aromatic and aromatic rice (*Oryza sativa* L.) varieties of Punjab. Indian J. Agri. Sci. 72: 408-410.

Shrirame, M.D. and D.M. Muley (2003). Variability and correlation studies in rice (*Oryza sativa* L.). J. Soil & Crop. 13: 165-167.

Singh, R.K., P.L. Gautam, S. Saxena and S. Singh (2000). Scented Rice Germplasm: Conservation, evaluation and utilization, pp: 107-133. In: Aromatic Rices, Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi, India.

Steel, R.G.D., J.H. Torrie and D. A. Dickey (1997). Principles and Procedures of Statistics. 3rd Ed. McGraw Hill Book Co. Inc. Singapore: 172-178.

Yang, W., S. Peng, R.C. Laza, R.M. Visperas and M.L.D. Sese (2007). Grain yield and yield attributes of new plant type and hybrid rice. Crop Sci. 47:1393-1400.

Yang, X.C. and C.M. Hwa (2008). Genetic modification of plant architecture and variety improvement in rice. Heredity, 101: 396-404.

Yoshinaga, S., K. Nagata and A. Fukuda (2006). Characteristics of seedling emergence and dry matter production of direct-seeded rice cultivars for whole-crop silage in Tohoku region. Bull. Natl. Res. Cent. Tohoku Reg. 105: 63-71.