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Research Article

Growth performance of Aus rice varieties under Rainfed condition

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Keywords

Aus rice,
Growth,
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Abstract

The experiment was conducted at the research field of the Department of Agronomy of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur during April to August 2014 to assess growth performance of Aus rice varieties under rainfed condition. The experiment was conducted in split plot design with three replications, where (i) two irrigation levels as irrigated (control) and rainfed were assigned in the main plot, and (ii) 15 varieties into sub plot. The results indicated that growth parameters were significantly influenced by irrigation levels, varieties and their interaction. The highest TDM, LAI and CGR were noticed at 59 DAS, whereas plant height was the maximum at 66 DAS. RGR and NAR were the highest at 24-31DAS. Among the varieties BRRI dhan27 gave the highest plant height (153.59cm), TDM (883.35 g m^{-2}), LAI(3.11) and CGR (41.36 g m^{-2} day^{-1}) under irrigated condition. Under rainfed condition also the same variety showed the maximum plant height (147.37cm),TDM (840.48 g m^{-2}), LAI (2.33) and CGR (39.21 g m^{-2} day^{-1}).However, at 24-31 DAS, the highest RGR(0.244 g g^{-1} day^{-1}) and NAR (0.0202 g m^{-2} day^{-1})were found in Nerika1 under irrigated treatment. Nerika10, Nerika ABSS, BRRI dhan43, Nerika1 and BRRI dhan55 were found early maturing varieties. It was concluded that among the fifteen aus rice varieties, BRRI dhan27 exhibited the best performance in relation to growth characteristics under both growing environment except RGR and NAR.

Introduction

Rice (*Oryza sativa*) ranks second next to wheat in area and production, which is the staple food of more than three billion people globally (Abodolereza and Racionzer, 2009). It is grown in more than a hundred countries with a total harvested area of about 160 million hectares and production of more than 700 million tons every year (IRRI, 2013). Rice contains a number of energy rich compounds such as carbohydrate, fat, protein and reasonable amount of iron, calcium, thiamine, riboflavin and niacin (Juliano, 1993). It alone provides 76% of the calorie intake and 66% of total protein requirement. According to BBS 2012, Bangladesh is the fourth largest country of the world with respect to rice cultivation. Being the staple food rice is grown on nearly 11.25 million hectares of land, covering about 82% of the total cropped area. The areas under Aus, Aman and Boro seasons rice are 1.2, 5.63 and 4.78 million hectares respectively with a corresponding production of 2.75, 13.3 and 18.7 million tons and average yield of 2.29, 2.36 and 3.91 ton ha^{-1} respectively (BBS, 2011).The population of Bangladesh is grown by about two million every year and may increase by another 30 million over the next 20 years. Thus, Bangladesh will require about 27.26 million tons of rice by 2020. During this time however, total rice area will supposed to be shrinked to 10.28 million hectares from 11.25 million ha (BRRI, 2011).To feed the ever increasing population of Bangladesh rice production must be increased either by increasing arable land or by increasing per hectare yield. First prerequisite for increasing yield is to ensure abundant growth of a particular crop (Mahamud *et al*., 2012). However, natural calamities are the main barrier to enhance performance of growth characters and ultimately affect yield. Among the natural calamities drought or water scarcity is the most considered one. Drought affects crops which are mostly grown under rainfed condition. Water scarcity or crop water deficit presents increasing risk for agricultural sustainability and food security (Kijne *et al.*, 2003; CAWMA, 2007). Water scarcity is a severe constraint to crop production in rainfed, semiarid and sub-humid regions throughout Asia (Wade *et al.*, 1999; Ali and Talukder, 2008).Globally, about 69% of the total cereal area is under rainfed cultivation including 40% of rice, 66% of wheat, 82% of maize and 86% of other coarse grains. Paddy faces the highest loss due to drought for its high requirement of water. It adversely affects the crop production and causes annual damages of 2.32 million hectares crop (Habiba *et al.*, 2011).Aus rice is generally cultivated under rainfed condition during April to August. The vegetative stage of this crop passes April to May when rainfall is very erratic in nature. This crop suffers from moisture stress when the rainfall ceases. It passes through reproductive stage in June to July. The total rainfall in these two months is very irregular and often inadequate to meet the evapotranspirational demand of Aus rice. Consequently water stress develops and affects translocation of assimilates and grain development in rice. The performance of rice varieties varies under water stress conditions at different growth stages. Water deficit causes loss of yield, particularly when strikes at booting stage (Islam *et al.*, 1994a). Aus rice requires less number of days compared to Aman and Boro rice. Being a less water demanding crop, Aus rice can reduce pressure on utilization of groundwater table. Water is becoming scarce day by day during Boro season. Increasing Aus rice productivity may become substitute of declining Boro rice production. Considering the above facts, this research was initiated to evaluate some Aus rice varieties for growth characters under rainfed condition.

Materials and Methods

The experiment was conducted at the research field of the Department of Agronomy of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur-1706 during April to August 2014 to assess growth performance of Aus rice varieties under rainfed condition. The site was high land and located in Madhupur Tract under Agro Ecological Zone (AEZ)-28. The soil of the experimental site belongs to Sanla series representing shallow Red-Brown Tarace soil type which falls under the order of Inceptisols of soil taxonomy (Brammer, 1996). Fifteen Aus rice varieties viz. BR3, BR14, BR16, BR21, BR24, BR26, BRRI dhan27, BRRI dhan42, BRRI dhan43, BRRI dhan48, BRRI dhan55, BRRI dhan55(2), Nerika1, Nerika10 and Nerika ABSS were used as planting materials. The experiment was laid out in a split plot design with three replications. The treatments viz. irrigated and rainfed were given to main plot and the varieties were placed into the sub plots. Three sprouted rice seeds hill^{-1} was sown in line by hand on 9April 2014. Seeds were placed at 15cm intervals in lines and line to line distance was 20 cm which made 5 rows in each sub plot and to ensure uniform emergence irrigation was provided in all plots. In main plots treatments were started 20 DAS (days after sowing). The size of unit plot was 3m×1m and the distance between two adjacent main plots was 1m. The total number of plots was 90 and the experimental area was 414m^2. Variety specific recommended dose of fertilizer were applied which were suggested by Bangladesh Rice Research Institute. Nitrogen fertilizer was given in three splits first split applied as basal dose and the second and third splits were applied at 35 and 55 DAS respectively. Gap filling was done 15 DAS for maintaining the optimum plant population. Four times weeding were performed at 20, 40, 60 and 80 DAS. Rice bug (*Leptocorisa acuta*) was controlled instantly by using insecticide Diazinon 60EC @ 3ml/L sparing at 65 and 75 DAS. A total number of twelve samplings were performed. Ten hills were selected randomly from each sub plot for recording necessary data in each sampling. Following data were recorded for growth analysis viz. plant height (cm), total dry matter (g m^{-2}), leaf area index (LAI), crop growth rate (CGR) (g m^{-2} day^{-1}), relative growth rate (RGR) (g m^{-2} day^{-1}), net assimilation rate (NAR) (g g^{-1} day^{-1})and days to maturity (days).

The following formula were used for different parameters

Leaf area index= leaf area/ ground area

$$\text{Crop Growth Rate} = \frac{1}{GA} \times \frac{dw}{dt}\ \text{g m}^{-2}\ \text{day}^{-1}$$

$$\text{Relative Growth Rate} = \frac{1}{W} \times \frac{dw}{dt}\ \text{g g}^{-1}\ \text{day}^{-1}$$

$$\text{Net Assimilation Rate} = \frac{1}{LA} \times \frac{dw}{dt}\ \text{g m}^{-2}\ \text{day}^{-1}$$

Where,

dw = dry weight increased in t days in g
dt = Number of days
W = initial dry weight in g,
LA = Leaf area (m^2)
GA= ground area (m^2)

The recorded data were analyzed statistically using the analysis of variance technique and mean difference were adjudged by Duncun's Multiple Range Test (DMRT) with the help of computer package program Statistix-10 (Gomez and Gomez 1984).

Results and Discussion

Plant height

Plant height was influenced by irrigation treatment and varieties at different growth stages of Aus rice (Figure 1). Plant height was increased progressively with increased growth duration from 10 to 66 DAS (days after sowing) and then decreased. The peak plant height of all varieties was recorded at 66 DAS. Plant height was higher in irrigation treatment and lower in rainfed. The increase in plant height might be due to functional role of water in plant body. Reduction in plant height under water stress might be due to inhibition of cell division and cell enlargement. At 66 DAS, the highest (153.59 cm) plant height was recorded in BRRI dhan27 under irrigated treatment whereas in rainfed condition the plant height was 147.37 cm. On the other hand, the lowest (103.73 cm) plant height was observed in BRRI dhan55 (2) under irrigation treatment whereas in rainfed the plant height was 100.12 cm. Similar observations were found in case of other varieties in all sampling dates. In irrigated treatment plant height was higher due to have sufficient water. It is known that water increases plant height by maintaining cell turgidity and it is the fundamental input for occurring photosynthesis and thus produces photosynthetic products required for growth. On the other hand, plant height was reduced in rainfed due to reducing transpiration rate for their survival and having low relative water content of the cells. Ashfaq *et al.* (2012) and Sarvestani *et al.* (2008) reported that water stress condition reduced plant height.

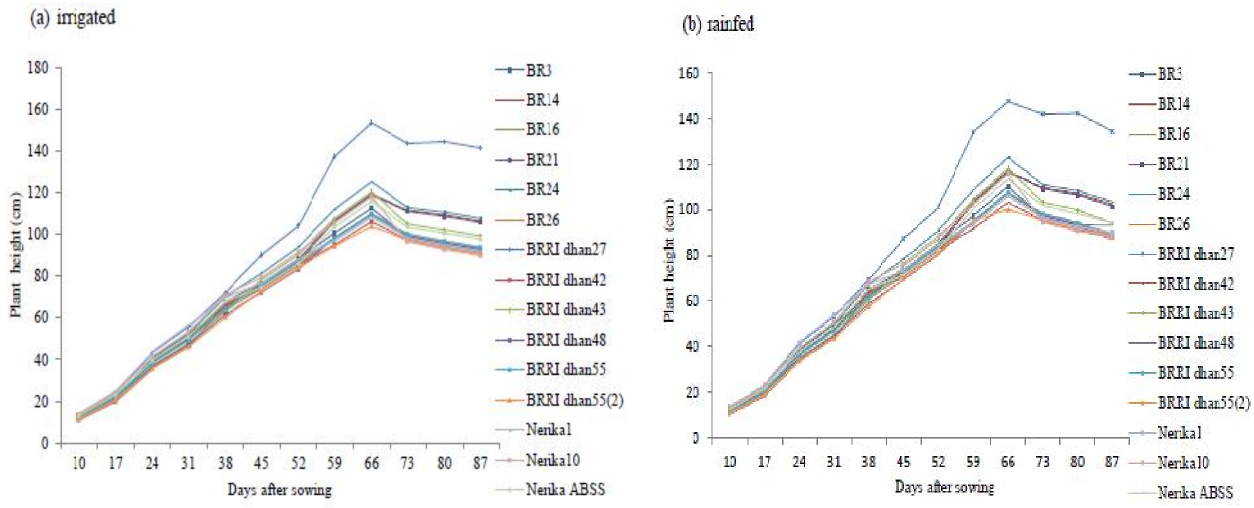

Figure 1. Plant height on irrigated (a) and rainfed (b) condition of Aus rice varieties

Total dry matter (TDM)

TDM production indicates the production potential of a crop. It is the function of crop growth rate and growth duration (Tanaka, 1983). Dry matter production depends upon the balance of photosynthesis and respiration (Tanaka *et al.*, 1964). The first prerequisite for higher yield is to produce total dry matter as much as possible. TDM was influenced by irrigation treatment and varieties (Figure 2). TDM of Aus rice increased progressively with increased growth duration from 10 to 59 DAS and then decreased. As most of the plants attained phenology at 56-63 DAS, plant was progressively translocating its dry matter stored into stems towards panicle formation and grain development and that’s why TDM was decreasing from 59 DAS. The maximum TDM of all varieties was noticed at 59 DAS. The highest (883.35 g m^{-2}) TDM was found in BRRI dhan27 under irrigation treatment but in case of rainfed TDM was 840.48 g m^{-2}. The lowest (663.05 g m^{-2}) TDM was found in BR14 in irrigated treatment whereas in rainfed treatment TDM was 630.05 g m^{-2} at 59 DAS. Irrigated treatment exhibited better performances in case of all varieties. TDM was increased in irrigated treatment condition compared to rainfed due to have adequate water and greater expansion of leaf. So, interception of incoming solar radiation was higher and key to produce more photosynthate and responsible for higher sheath and stem dry weight. Similar results were found by Nam *et al.* (1998) who stated that water stress inhibited dry matter production largely through its inhibitory effects on leaf expansion, leaf development and consequently reduced light interception.

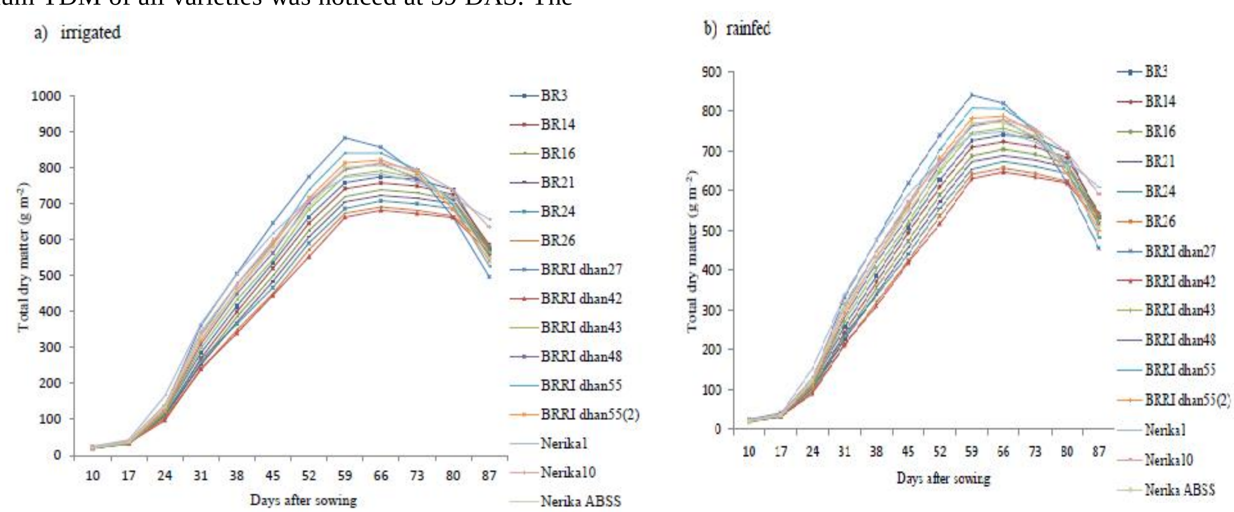

Figure 2. Total dry matter on irrigated (a) and rainfed (b) condition of Aus rice varieties

Leaf area index (LAI)

Reduction of leaf area and LAI is a major mechanism for moderating water use and reducing injury under water stress condition. LAI is the ratio of leaf area to its ground area. The leaf area index is the most important for interception of light and photosynthesis. The more LAI caused more photosynthesis and produced more dry matter. LAI was influenced by irrigation treatment and varieties over time (Figure 3). LAI of Aus rice increased progressively with increased growth duration up to 59 DAS and then decreased. The decreasing trend might have been occurred due to plants priority towards the panicle formation and grain development instead of leaf area expansion. LAI was noticed higher in irrigated treatment and lower in rainfed. At 59 DAS, the highest (3.11) and the lowest (2.49) LAI were found in BRRI dhan27 and BRRI dhan42 under irrigated treatment whereas in case of rainfed LAI of those varieties were 2.33 and 2.92 respectively. The initial increase of LAI is associated with tillering, higher leaf number and higher photosynthetic leaf surface area. The decline of LAI after attaining the peak might be due to senescence of leaves from the base of the stem approaching upward. It was also occurred due to increase in respiration rate than photosynthesis. The results are agreed with the findings of Kumar *et al.* (2014) and observed that leaf area index was reduced in water deficit situation. Similar result was found by Katiya (1980) and reported that after germination LAI increases and reaches the peak levels after that it declines due to increased leaf senescence. Murayama (1979) also reported that the increase in LAI is caused by increased in number of tillers and in size of successive leaves.

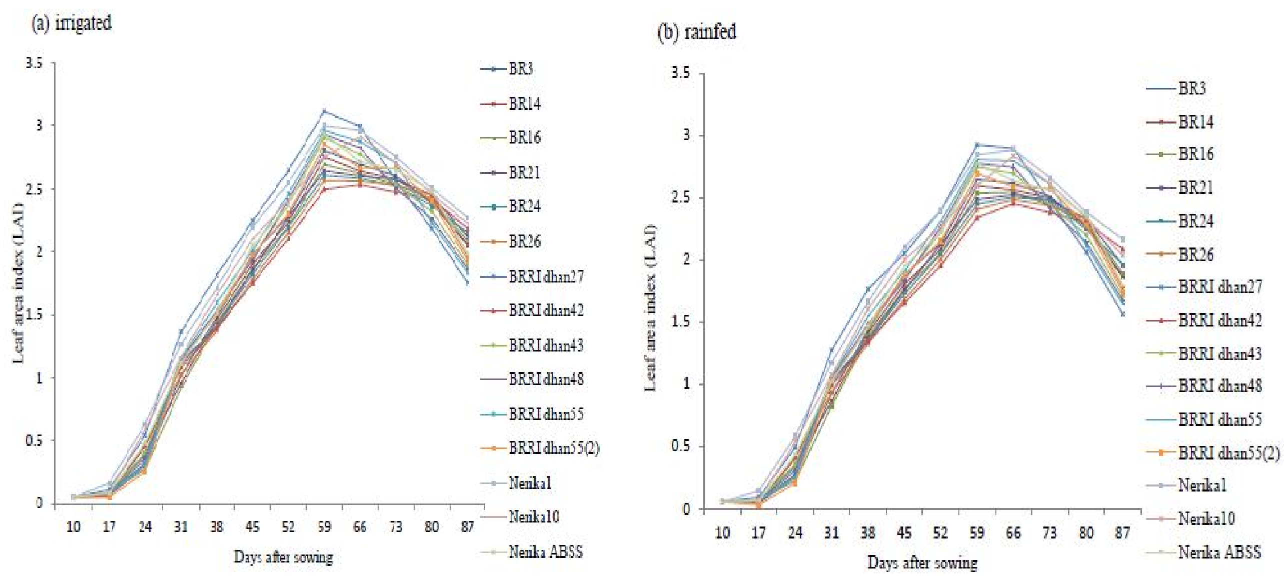

Figure 3. Leaf area index on irrigated (a) and rainfed (b) condition of Aus rice varieties

Crop growth rate (CGR)

CGR is the rate of increase in dry matter of a crop per unit land area per unit time (Hunt, 1978). It is an indicator of the biomass production efficiency of a particular crop. CGR expresses the efficiency of unit land area. CGR was influenced by irrigation treatment and varieties over time (Figure 4).CGR of Aus rice increased progressively with increased growth duration from 10 to 59 DAS and then decreased. Initially, at 10-17 DAS and 17-24 DAS, CGR was slow due to small foliage canopy resulting to lower photosynthetic rate and plant begins to develop above ground shoot system i.e. stem, leaves and below ground root system and respiration was higher than photosynthesis. The maximum CGR of all varieties was recorded at 52-59 DAS. The higher CGR was noticed in irrigated treatment due to having greater leaf area, more light interception, increased growth of photosynthetic tissues, availability of water and nutrients compared to rainfed treatment. At 52-59 DAS, the highest (41.36 g m^{-2} day^{-1}) CGR was recorded in BRRI dhan27 under irrigated treatment whereas in rainfed condition the CGR was 39.21 g m^{-2} day^{-1}. On the other hand, the lowest (27.76 g m^{-2} day^{-1}) CGR was observed in BR26 under irrigation treatment whereas in case of rainfed the CGR was 51.37 g m^{-2} day^{-1}. Similar observations were found in case of other varieties. In that time, CGR was dramatically increased due to rapid growth of foliage canopy resulting increased photosynthetic rate. Another reason might be produced high proportion of photosynthetic tissues. After that, CGR was increased up to 59 DAS. This might be due to both photosynthesis and respiration occurred in photosynthetic tissues. From then, CGR was decreasing due to further increase in non-photosynthetic tissues. At 80-87 DAS, CGR was drastically decreased due to light interception and photosynthesis were not increased.

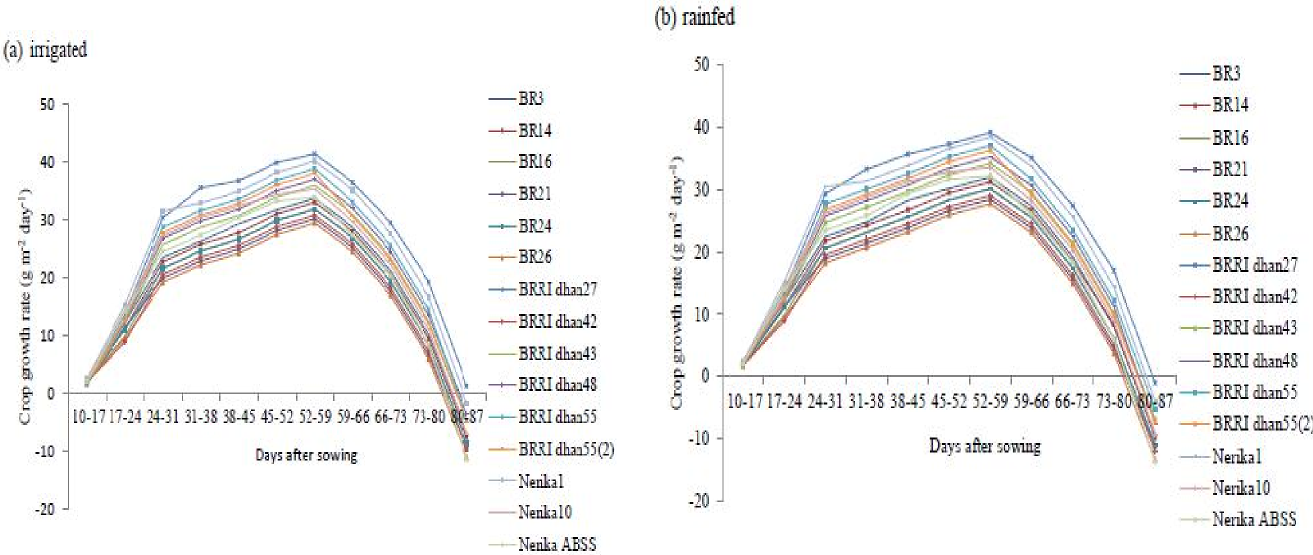

Figure 4. Crop growth rate on irrigated (a) and rainfed (b) condition of Aus rice varieties

Relative growth rate (RGR)

RGR is the rate of increase in dry matter accumulation of a crop per unit time (Milthorpe and Moorbby, 1979). It quantifies the efficiency of existing biomass in producing new biomass. Irrigation treatment and varieties had influence on RGR over time (Figure 5).The maximum RGR of all varieties was recorded at 24-31DAS. RGR was higher in irrigated treatment and lower in rainfed condition. At initial stage RGR was slow due to small foliage canopy resulting to lower photosynthetic rate and plant begins to develop above ground shoot system i.e. stem, leaves and below ground root system and respiration was higher than photosynthesis. At 24-31 DAS, the highest (0.244 g g^{-1} day^{-1}) and the lowest (0.192 g g^{-1} day^{-1}) RGR were found in Nerika1 and BR26 respectively under irrigated treatment whereas in case of rainfed, RGR of those varieties were 0.224 g g^{-1} day^{-1} and 0.172 g g^{-1} day^{-1} respectively. During that time RGR was dramatically increased due to rapid growth of foliage canopy resulting increased photosynthetic rate. Another reason might be produced high proportion of photosynthetic tissues. At 80-87 DAS, RGR was reduced due to light interception and photosynthesis were not increased.

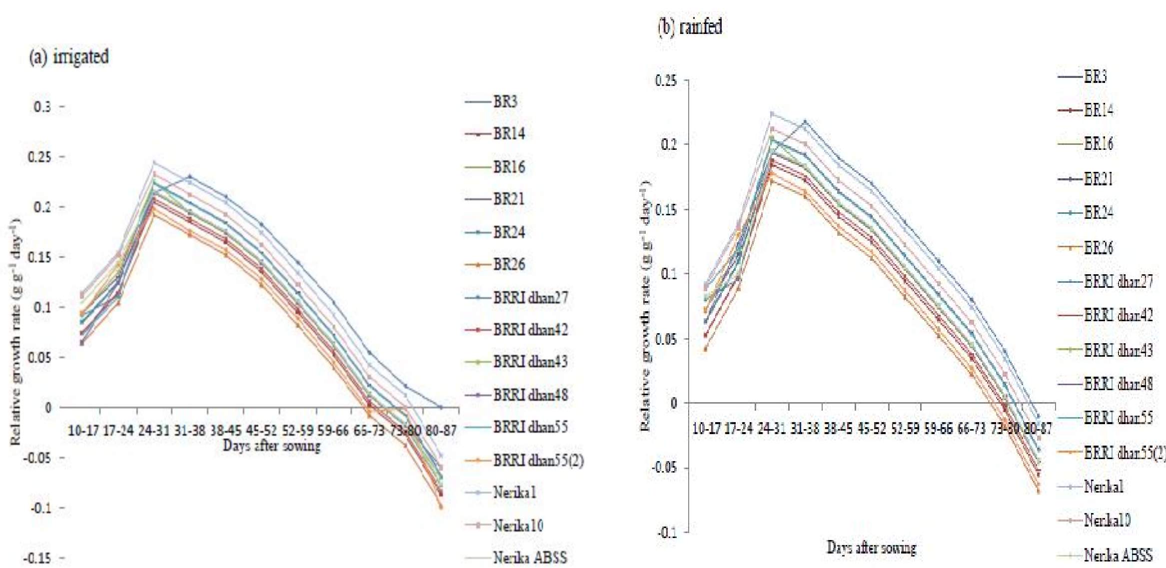

Figure 5. Relative growth rate on irrigated (a) and rainfed (b) condition of Aus rice varieties

Net Assimilation Rate (NAR)

NAR is the most important index of mean photosynthetic efficiency of a plant under a particular environment. It is the increase of dry weight per unit leaf area present (Milthorpe and Moorbby, 1979). It defines the efficiency of biomass production specifically in terms of the amount of photosynthetic tissue. NAR expresses the efficiency of unit leaf area. NAR was influenced by irrigation treatment and varieties of Aus rice (Figure 6). The maximum NAR was recorded at 24-31 DAS. Initially, NAR was slow due to small foliage canopy resulting to lower photosynthetic rate and plant begins to develop above ground shoot system and respiration was higher than photosynthesis. At 24-31 DAS, the highest (0.0202 g m^{-2} day^{-1}) and the lowest (0.0174 g m^{-2} day^{-1}) NAR were observed in Nerika1 and BR26 respectively under irrigated treatment whereas in rainfed condition the NAR of those varieties were 0.0188 g m^{-2} day^{-1} and 0.0169 g m^{-2} day^{-1}. In that time, NAR was vividly increased due to rapid growth of foliage canopy resulting increased photosynthetic rate. Another reason might be produced high proportion of photosynthetic tissues. After that, NAR was increased linearly up to 52-59 DAS. This might be due to both photosynthesis and respiration occurred in photosynthetic tissues. From then, NAR was decreasing due to further increase in non-photosynthetic tissues. At 80-87 DAS it was drastically reduced due to light interception and photosynthesis were not increased. It was reported that the increase in net assimilation rate may be attributed to enhanced photosynthetic capacity of leaves with improved nutrition of the plants (Ahmad *et al.*, 1992). The higher NAR as found in irrigated treatment was probably due to more leaf area, increased photosynthesis and higher crop growth rate compared to rainfed treatment.

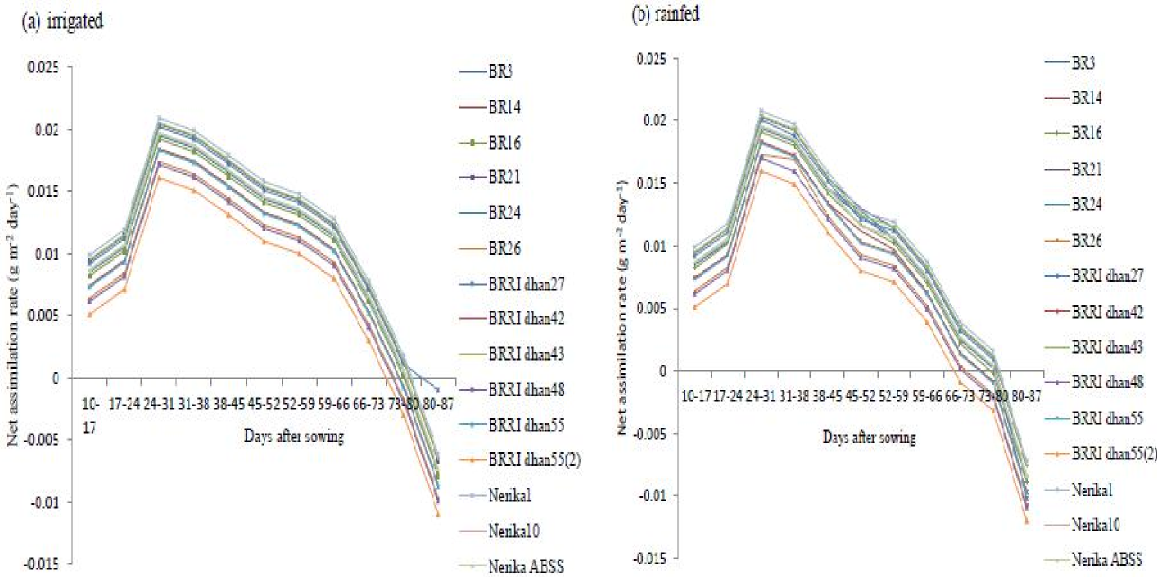

Figure 6. Net assimilation rate on irrigated (a) and rainfed (b) condition of Aus rice varieties

Days to maturity

It was evident from the table 1 that Nerika10 and Nerika ABSS required less number of days (100days) for maturity compared to other varieties followed by BRRI dhan42, BRRI dhan43, Nerika1 (102days), BR24, BRRI dhan55, BRRI dhan55(2) (105days), BR21, BRRI dhan48 (107days), BR26, BRRI dhan27 (109days), BR14 (120days) and BR3, BR16 (130days).

Table 1.Variation of days to maturity of different Aus rice varieties

Varieties	Days required to maturity(days)
BR3	130
BR14	120
BR16	130
BR21	107
BR24	105
BR26	109
BRRI dhan27	109
BRRI dhan42	102
BRRI dhan43	102
BRRI dhan48	107
BRRI dhan55	105
BRRI dhan55(2)	105
Nerika1	102
Nerika10	100
NerikaABSS	100

Conclusion

The results of this study indicated that all the growth characters of Aus varieties increased under irrigated treatment and decreased when varieties were faced to water shortage i.e. in rainfed condition. Among the varieties, BRRI dhan27 exhibited best performance under both growing environment except RGR and NAR. Nerika10, Nerika ABSS, BRRI dhan42, BRRI dhan43, Nerika1 and BRRI dhan55 were early maturing varieties.

References

Abodolereza, A. and P. Racionzer. 2009. Food Outlook: Global Market Analysis. pp.23-27.

Ahmed, M. and S. M. A. Hossain. 1992. Effect of seed rate, nitrogen fertilization and time of harvest on the seed yield of wheat. Bangladesh Agron. J. 4 (1 & 2): 35-43.

Ali, M. H. and M. S. U. Talukder. 2008. Increasing water productivity in crop production-a synthesis. Agric. Water Management. 95: 1201–1213.

Ashfaq, M., M. S. Haider, A. S. Khan and S. U. Allah. 2012. Breeding potential of the basmati rice germplasm under water stress condition. African J. of Biotech.11(25): 6647–6657.

BBS (Bangladesh Bureau of Statistics). 2011. Year book of Agricultural Statistics of Bangladesh. Bangladesh Bureau of Statistics.p.128.

BBS (Bangladesh Bureau of Statistics). 2012. Year book of Agricultural Statistics of Bangladesh. Bangladesh Bureau of Statistics.pp.136-140.

Brammer, H. 1996. The Geography of soils of Bangladesh, University Pub. Ltd., Dhaka.

BRRI (Bangladesh Rice Research Institute). 2011. AdhunikDhanerChash (in bengali). Bangladesh Rice Research Institute, Joydebpur, Gazipur. p.5.

CAWMA (Comprehensive Assessment of Water Management in Agriculture). 2007. Water for food, water for life: A comprehensive assessment of water management in agriculture. Earthscan, London, UK and International Water Management Institute, Colombo, Sri- Lanka.

Centritto, M., M. Lauteri, M. C. Monteverdi and R. Serraj. 2009. Leaf gas exchange, carbon isotope discrimination and grain yield in contrasting rice genotypes subjected to water deficits during the reproductive stage. J. Exp. Bot.60(8): 2325–2339.

Farooq, M., N. Kobayashi, O. Ito, A. Wahid and R. Serraj. 2010. Broader leaves result in better performance of indica rice under drought stress. J. of Plant Physiol. 167(13): 1066–1075.

Habiba, U., R. Shaw and Y. Takeuchi. 2011. Drought risk reduction through a Socio-economic, Institutional and Physical approach in the northwestern region of Bangladesh, Environmental Hazards. 10(2): 121-138.

Hunt, R. 1978. The fitted curve in plant growth studies. Math and plant physio(Eds)Rose, D. A. and Edwards, DAC). Aca.Press, London.pp.283-298.

IRRI (International Rice Research Institute). 2013. Annual report of rice cultivation. Int. Rice Res. Inst. Los Banos, Philippines. pp.155-171.

Islam, M. T. and M. A. Salam. 1994a. Growth and yield performance of some rice genotypes under different soil moisture regimes. Bangladesh J. of Trg. and Dev. 7(2): 57-62.

Juliano, B. O. 1993. Rice in human nutrition .Int. Rice Res.lnst. Manila, Philippines. pp.40-41.

Katiya, R. P. 1980. Development changes in LAI and growth parameters in chickpea. Indian J. of Agril. Sci. 50: 684-691.

Kijne, J., W. R. Barker and D. Molden. 2003. Improving water productivity in agriculture: editors' overview. In Kijne,J. W., R. Barker and D. Molden (Eds.), Improving water productivity in agriculture: limits and opportunities for improvement. Wallingford: CAB International in association with the International Water Management Institute.

Kumar, S., S. K. Dwivedi, S. S. Singh, B. P. Bhatt, P. Mehta, R. Elanchezhian, V. P. Singh and O. N. Singh. 2014. Morpho-physiological traits associated with reproductive stage drought tolerance of rice (*Oryza sativa* L.) genotypes under rain-fed condition of eastern Indo-Gangetic Plain. Ind. J. of Plant Physiol.19(2): 87–93.

Mahmud, J. A., M. M. Haque and A. M. M. Shamsuzzaman. 2012. Effect of modern inbred and some selected hybrid rice varieties in aman season. J. of Expt. Bio.sci. 3(2): 45–50.

Milthorpe, F. I. and A. Moorbby. 1979. Anintroduction to crop physiology. Univ. Press. p.75.

Mostajeran, A. and V. Rahimi-Eichi. 2009. Effects of drought stress on growth and yield of rice (*Oryza sativa* L.) cultivars and accumulation of proline and soluble sugars in sheath and blades of their different ages leaves. Am-Eur. J. of Agric. Environ. Sci. 5(2): 264–272.

Murayama, N. 1979.The importance of N for rice production.Nitrogen and rice. Int. Rice Res. Inst. Philippines.p.9.

Nam N. H., G. V. Subbaroa, Y. S. Chauhan and C. Johansen.1998. Importanceof canopy attributes in determining dry matter accumulation of pigeon pea under contrasting moisture regimes. Crop Sci. 38: 955-961.

Sarvestani, Z. T., H. Pirdashti, S. A. Sanavy and H.Balouchi. 2008. Study of water stress effects in different growth stages on yield and yield components of different rice (*Oryza sativa* L.) cultivars. Pak. J. of Biol. Sci.11(10): 1303–1309.

Tanaka, A. 1983.Physiological aspects of productivity. In. Potential productivity of field crops under different environments. Intl. Rice Res. Inst. Los Banos, Phillipines. pp.61-99.

Wade, L. J., S. Fukai, B. K. Samson, A. Ali and M. A. Mazid. 1999. Rainfed lowland rice: physical environment and cultivar requirements. Field Crops Res.64: 3–12.