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# Biomass accumulation and energy conversion efficiency in aromatic rice genotypes

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ABSTRACT

A field experiment was conducted to evaluate photosynthetic efficiency along with different growth parameters of aromatic rice genotypes. Forty genotypes including three non-aromatic checks exhibited enormous variations for leaf area index (LAI), crop growth rate (CGR), relative growth rate (RGR), net assimilation rate (NAR), grain yield, total dry matter, harvest index and photosynthetic efficiency or energy use efficiency (Eμ) at panicle initiation and heading stages. Minimum LAI-value was 0.52 in Khazar at PI stage and maximum was 4.91 in Sakkor khora at heading stage. The CGR-value was in the range of 4.80–24.11 g $m^{-2}$ per day. The best yielder BR39 produced grain of 4.21 t $ha^{-1}$ and the worst yielder Khazar gave 1.42 t $ha^{-1}$. Total dry matter (TDM) yield varied from 4.04 to 12.26 t $ha^{-1}$ where genotypes proved their energy use efficiency a range between 0.58 to 1.65%. Eμ showed a significant positive relation with TDM ($r = 0.80^{**}$), CGR ($r = 0.72^{**}$) and grain yield ($r = 0.66^{**}$). A negative correlation was established between TDM and harvest index and LAI and RGR. Path analysis result showed that NAR at heading stage exerted highest positive direct effect (0.70) on Eμ.


## 1. Introduction

Rice is the grain that has shaped cultures, diets and economies of billions of Asians. For them, rice is more than a food; it is an inseparable part of life. It alone is a staple food for one-third of the world population [1]. It is a crop that is planted in a very wide range of solar radiation values ranging from around 300 to more than 600 MWh $cm^{-2}$ per day [2]. Through the centuries of cultivation and selection, thousands of rice cultivars have been evolved, which are well adapted to the local environments. Many of those also possess good taste and qualities and are preferred by the people. A group of such rice characterized by the presence of scent in it and often slender in shape is termed as aromatic rice [3,4]. The International Fine Grain Aromatic Rice Nursery (IRFAON) suggested that aromatic rice should have aroma and an elongation ration of 1.95 [5]. These rice emit aroma in fields, at harvesting, in storage, during milling, cooking and eating [6]. Aroma development is influenced by both genetic factors and the environment. Pleasant aroma is a result of a large number of compounds present in specific proportion. In Bangladesh, aromatic rice varieties are normally transplanted in rainy season (T. Aman) and most of them are popularly grown in a specific location. This is believed to be due to the variations of agro-ecological conditions.

Biomass accumulation or biological yield of a rice crop is dependent on the conversion efficiency of light energy into dry matter. Economic yield is the product of aboveground biomass and harvest index. Previous experience indicated that a further increase in grain yield potential will be attained mainly by increasing biomass

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production, since increasing harvest index for cereal crops is difficult [7,8]. Photosynthetic efficiency is not the only determinant for grain yield; however, a higher photosynthetic rate is an obvious prerequisite for higher yield [9,10]. Canopy net photosynthetic rate is a function of LAI, canopy structure and single leaf photosynthetic rate [11]. Crop growth rate and NAR are important parameters that indicate the level of photosynthetic efficiency. In general, aromatic rice genotypes are low yielding in nature. For the improvement of aromatic rice, it deserves the investigation of growth parameters and hence photosynthetic efficiency of available germplasm. With this view, an attempt was initiated to study the growth parameters, dry matter production and energy use efficiency of aromatic rice genotypes of native and exotic sources.

## 2. Materials and methods

### 2.1. Crop management

The experiment was conducted at the farm of Bangladesh Rice Research Institute (BRRI), Gazipur in T. Aman season (July to December), 2005. A total of 40 rice germplasm composed of 32 local aromatic, five exotic and three non-aromatic rice cultivars as standard checks were selected for this research (Table 1). Among the three non-aromatic varieties, BR28 is a modern Boro, BR39 is a modern T. Aman variety and Nizersail is a local improved variety and are popularly grown in farmers' fields. The exotic genotypes were collected from Pakistan (Basmati PNR346), Nepal (Sarwati and Sugandha-1) and Iran (Khazar and Neimat). The rest of the genotypes represented their distribution throughout Bangladesh. Forty rice genotypes formed the treatment variables and were assigned randomly to each unit plot of 5 m × 2 m dimension.

Thirty day-old seedlings were transplanted on 15 August 2005 following Random Complete Block Design (RCBD) with three replications. Transplanting was done at the spacing of 20 cm × 20 cm. A fertilizer rate of 25–35–10–3 kg $ha^{-1}$ of P–K–S–Zn in the form of triple super phosphate, muriate of potash, gypsum and zinc sulphate, respectively, was applied as basal dose at final land preparation. Because of wide genotypic variation in phenological development and yield potential, varieties differed enormously in attaining panicle initiation (PI) stage and in the requirement of nutrient elements. For this reason, nitrogen was top-dressed as urea in two to three splits to the contrary of common practice with fixed dose and time routine. The amount of urea and time of application were determined with the help of a leaf colour chart [12].

### 2.2. Data collection

Data collection was started at 20 days after transplanting (DAT), i.e., 50 days after sowing (DAS) and continued with a 10-day interval up to harvesting (4th September to 18th December, 2005). Random samples of four plants from each plot were uprooted. In each sample plant, the mid-tiller was separated. All green leaf blades of four mid-tillers were taken for the measurement of leaf area through the length-width method [13]. Also the leaves were dried and weighed. The leaves from the rest of the tillers of the sample plants were dried and weighed. Leaf area index was estimated as follows:

$$\text{Specific leaf area}\ (\mathrm{cm^2\,g^{-1}}) = \frac{a}{w}$$

$$\text{Leaf area of the sample plants}\ (\mathrm{cm^2}) = \frac{aW}{w}$$

where, $a$ = leaf area of middle tillers
$w$ = dry weight of leaves of mid-tillers
$W$ = total dry weight of all leaves of the whole sample

$$\mathrm{LAI} = \frac{Sum\ of\ leaf\ area\ of\ sample\ plants\ (\mathrm{cm^2})}{Area\ of\ land\ covered\ by\ the\ plants\ (\mathrm{cm^2})}$$

The whole plant samples were oven dried at 70 °C for 72 hours to determine the CGR (crop growth rate) after Radford [14]. Shoot dry weight was used from 20 DAT up to crop maturity with an interval of 10 days.

$$\mathrm{CGR}\ (\mathrm{g\,m^{-2}\ per\ day}) = \frac{W_2 - W_1}{t_2 - t_1}$$

where, $t_1$ = day of starting, $t_2$ = day of final record
$W_1$ = dry weight at $t_1$, $W_2$ = dry weight at $t_2$

Relative growth rate (RGR) was measured as growth rate per unit plant biomass following the formula described below [15] :

$$\mathrm{RGR}\ (\mathrm{mg\,g^{-1}\ per\ day}) = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1}$$

Net assimilation rate (NAR) is the ratio of crop growth rate to average leaf area and calculated as follows [16] :

$$\mathrm{NAR}\ (\mathrm{g\,g^{-1}}\ per\,\mathrm{m^2 LA}) = \frac{CGR}{L_m} = \frac{W_2 - W_1}{t_2 - t_1} \div \frac{L_2 - L_1}{\log_e L_2 - \log_e L_1} = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{\log_e L_2 - \log_e L_1}{L_2 - L_1}$$

where, $L_m$ = average leaf area, $L_1$ = leaf area at $t_1$, $L_2$ = leaf area at $t_2$.

Plants were harvested at crop maturity. All the plants of a 5-$m^2$ sample area were cut at base. After threshing and cleaning, the fresh weight of grains was recorded and adjusted to 14% moisture content as follows:

$$\text{Grain yield} = \frac{\mathrm{FW}\,(100 - \mathrm{MC})}{100 - 14}$$

where, FW = fresh weight of the grains
MC = % moisture in the fresh grains

The fresh weight of straw from 5-$m^2$ harvested area was recorded. Three sub-samples were composed and well mixed. Then a representative sub-sample of 500 g fresh straw, separated from the mixture, was oven-dried at 80 °C for 3 days. Then the straw yield was calculated as follows [16]:

$$Con\ factor\ (CF) = \frac{Dry\ weight\ of\ sub\ sample}{Fresh\ weight\ of\ sub\ sample}$$