EFFECT OF NITROGEN ON PHENOLOGY, LIGHT INTERCEPTION AND GROWTH IN AROMATIC RICE

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ABSTRACT

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A field experiment was conducted to study the effect of nitrogen fertilizer on yielding ability of indigenous aromatic rice cultivars under stacking and non-stacking conditions. Rice cultivars were grown during Aman season, 2002. There were four cultivars, namely, Shakkorkhora, Chinigura, Kalijira and Kataribhog, each with three levels of nitrogen fertilizer (0, 60 and 120 kg N ha^{-1}). At the time of heading the experimental plots were equally divided into two parts. The crop in the half of the plot was left on the fate of the nature and that in the other half of the plot was mechanically supported by stacking to prevent lodging. Irrespective of cultivars, the days required to flowering and maturity significantly increased with the increase in the amount of nitrogen applied. Throughout the growth period Shakkorkhora with 120kg N ha^{-1} produce the tallest plant and Chinigura without nitrogen application produced the shortest plants. The internode length and culm hollowness significantly increased with the increase in N fertilizer levels. The lodging score was higher with the higher amount of nitrogen fertilizer applied. The cultivar Shakkorkhora remained erect up to 60 kg N ha^{-1}. Lodging occurred at different stage of grain development, Kataribhog lodged within four days after heading at 120 kg N ha^{-1} while it took 26 days to lodge at 0 kg N ha^{-1}. Irrespective of cultivars and nitrogen levels, higher N dose produced higher number of tillers. Leaf area index increased sharply after transplanting attaining a peak at heading stage and then decreased gradually. In non-stacking plant, all the cultivars showed lower LAI at maturity stage than stacking plant. At heading stage the higher light interception was found in all the cultivars with the increment of N levels.

Key words: Nitrogen, phenology, light interception and aromatic rice

INTRODUCTION

Among various nutritional requirements for production, nitrogen is the key element for its significant role in rice physiology. Production potentials of rice are realized only when optimum growth conditions are provided. Achieving high yields in rice requires increased biomass production and favorable partitioning to grains. Crop environmental conditions with high solar radiation during the growing season and abundant supply of N (Akita, 1989) favored accumulation of high amount of biomass and high yields provided varieties respond favorably to N. Without a strong thick culm and proper partitioning of assimilates, increased biomass production results in lodging and reduced grain yield (Vergara, 1988). The commercial varieties grown in the region are particularly susceptible to serious lodging in the monsoon season because of their tall stature, leafy growth, late maturity, weak culms and poor leaf sheath, wrapping of the culms. In addition, lodging is partially responsible for the deduced grain quality and is the primary cause of low nitrogen responsiveness among the tropical varieties. Lodging is a complex and continuous process resulting the interplay and balance of morpho-physiological characters of the plant, environmental factors primarily in terms of solar radiation and mineral nutrition and impact of external forces such as rain and wind. Lodging is thus often a constrain to achieving higher yields for the currently available varieties when N supply is high (Settar *et al*., 1995). It is necessary for breeding research aiming at higher yields to develop plant type that is resistant to lodging at luxuriant supply of N.

Considering the above facts, the present study was undertaken to know the phenology and growth characteristics of four indigenous aromatic rice cultivars at three levels of nitrogen under stacking and non-stacking conditions.

MATERIALS AND METHOD

A field experiment was carried out at the experimental field of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur during the rainy season of 2002. The experimental site is located at the center of Madhupur tract ($24^{o}09^{/}$ N latitude and $90^{o}26^{/}$ E longitude) having shallow red-brown terrace type soil of Salna series. The soil is characterized by poor fertility and impeded internal drainage.

Rice cultivars, Chinigura, Kalijira, Shakkorkhora and Kataribhog were grown with three levels of nitrogen fertilizer (0, 60 and 120 Kg N ha^{-1}).The experiment was laid out in a randomized complete block design.

Triple Super Phosphate, Muriate of Potash, Gypsum and Zinc Sulphate were applied as the sources of P_2O_5, K_2O, S and Zn, respectively. P_2O_5, K_2O, S and Zn were applied at the rate of 90, 50, 40, and 5 kg ha^{-1}, respectively. All fertilizers except urea were applied and thoroughly mixed with the soil at the time of final land preparation. Urea was applied as top dressing in three equal installments, first at active tillering stage (18 Days after transplanting), 2nd at maximum tillering stage (35 days after transplanting) and 3rd before panicle initiation stage (50 Days after transplanting). The seedlings were transplanted at 30 days after seeding. One seedling per hill was used maintaining 25 cm row to row and 10 cm plant to plant distance in well prepared land. Weeding, irrigation and application of pesticide were done as and when necessary. Standing water of 2 to 4 cm. was maintained in the field until the crop attained hard dough stage.

At the time of heading the experimental plots were equally divided into two parts. Thus every part of the plot occupied 3.75 m^2 land area. The crop in the half of the plot was left on the fate of the nature (treated as 'non-stacking') and that in the other half of the plot was mechanically supported by stacking (treated as 'stacking') to prevent lodging. Bamboo sticks and plastic ropes were used for stacking. Mechanical supports were provided in such a fashion that the canopy architecture and light interception remained almost unaffected.

When the panicles of about 50% tillers in each plot were fully headed, the day was recorded as 50% flowering date as days after transplanting (DAT). When the base of the panicles of about 50% tillers in each plots were changed up its color from greenish to brown, then the day was recorded as maturity date as DAT. The total number of tillers per hill was recorded at active tillering, maximum tillering, heading and maturity stages.

Leaf area was measured at active tillering, maximum tillering, heading and maturity stages. The leaf area was measured with an automatic leaf area meter (Model AAM, Hayshi Denkoh Co., Tokyo, Japan). Mean of five hills was taken for calculating leaf area index as follows:

$$\text{LAI (Leaf Area Index)} = \frac{\text{Total leaf area of 5 hills (cm}^2\text{)}}{\text{Ground area covered by 5 hills (cm}^2\text{)}}$$

Light interception was recorded by measuring the incident PAR (photosynthetically active radiation) above and below the canopy by Sunflec ceptometer, 1 m long light quantum sensor (Decagon, Pullman, Washington, USA), at around 11.0 to 13.00 hours. PAR receiving on the top of the canopy (I_o) and at beneath of the canopy near the soil surface (I) were taken in three rows comprising total of 6 readings. In each case the sensor was kept at right angle to the row direction and parallel to the soil surface. Light interception (LI) was calculated as following formula:

$$\text{LI (\%)} = 100 - (I\ I_o^{-1} \times 100)$$

The extent of lodging was scored (Anonymous, 1988) within the period from heading to maturity with the scale: No lodging (score 0), less than 20% of plants lodged (score 1); 20-40 % of plants lodged (score 3); 41-60 % of plants lodged (score 5); 61-80 % of plants lodged (score 7) and more than 80 % of plants lodged (score 9),

The data were analyzed by partitioning the total variance by using MSTATC program. The treatment means were computed using Least Significant Difference test and interrelationship was worked out employing regression analysis.

RESULTS AND DISCUSSION

Phenology

Growth duration of the cultivars is presented in the Table 1. Days to 50% flowering and days to maturity were recorded as days after transplanting (DAT). Significant variations among the cultivars were found with different nitrogen levels for flowering and maturity date. Irrespective of cultivars, the days required to flowering and maturity significantly increased with the increase in the amount of nitrogen applied. Crop maturity was delayed by almost 9, 6, 13 and 7days at 60 kg N ha^{-1} and by 17, 14, 11 and 12 days at 120 kg N ha^{-1} in Shakkorkhora, Chinigura, Kalijira and Kataribhog, respectively. Accelerated vegetative growth might be a factor for delaying flowering and crop maturity with the increase in the amount of nitrogen fertilizer.

Lodging characteristics

The extent of lodging was highest with the highest amount of nitrogen fertilizer applied (Table 1). At 60 kg N ha^{-1} statistically similar lodging score was obtained in the cultivars Chinigura, Kalijira and Kataribhog while at 120 kg N ha^{-1} all the cultivars lodged severely except Shakkorkhora. Cultivar Shakkorkhora remained erect upto 60 kg N ha^{-1}. Lodging occurred at different stage of grain development. Kataribhog lodged within 4 days after heading at 120 kg N ha^{-1} while it took 26 days to lodge at 0 kg N h^{-1}. Chinigura and Kalijira lodged 15 days after heading at 120 kg N ha^{-1} whereas, Shakkorkhora remain erect up to 23.6 days after heading.

Tiller number per hill

The number of tillers per hill increased over time showing a peak at around maximum tillering stage and thereafter declined (Figure 1). At maximum tillering stage, the cultivar Kataribhog produced the highest number of tillers per hill (18.53) at 120 kg N ha^{-1} and it was statistically similar at 60 kg N ha^{-1}. The highest number of tillers per hill was also recorded in Kataribhog at heading and maturity stages with 120 kg N ha^{-1} whereas the cultivar Shakkorkhora produced the least number of tillers at entire growth period when grown without nitrogen.

Table 1. Phenology and lodging characteristics of aromatic rice cultivars as influenced by N fertilizer

Cultivar	N dose (kg ha^{-1})	Phenological data (DAT)		Lodging characteristics	
		Days to 50% flowering	Days to maturity	Lodging occurrence (days after heading)	Lodging score*
Shakkorkhora	0	114.67	142.33	0.00	0
	60	121.67	155.00	0.00	0
	120	122.00	159.33	23.67	5
Chinigura	0	102.00	135.00	15.00	5
	60	110.67	144.67	13.67	7
	120	113.67	149.33	15.33	9
Kalijira	0	107.33	141.67	25.33	3
	60	111.33	147.00	21.67	7
	120	115.67	152.67	15.00	9
Kataribhog	0	109.00	142.67	26.67	5
	60	113.00	149.33	13.00	7
	120	113.67	154.67	3.67	9
LSD $_{(0.05)}$		2.81	2.10	0.77	1.792
CV (%)		1.47	0.84	2.34	14.15

*= Lodging score: No lodging (0), Less than 20% of plants lodged (1), 20-40 % of plants lodged (3), 41-60 % of plants lodged (5), 61-80 % of plants lodged (7), More than 80 % of plants lodged (9)

Around 12 to 21% reduction in tiller number was observed at maturity than heading stage. From maximum tillering to maturity Shakkorkhora exhibited the highest reduction in tiller number (21.26%) while cultivar Kataribhog the lowest (12.76%). The cultivar Kataribhog produced 71% and 99.65% more tiller at 60 kg N ha^{-1} and 120 kg N ha^{-1}, respectively, which was the highest increment in tiller number among the cultivars.

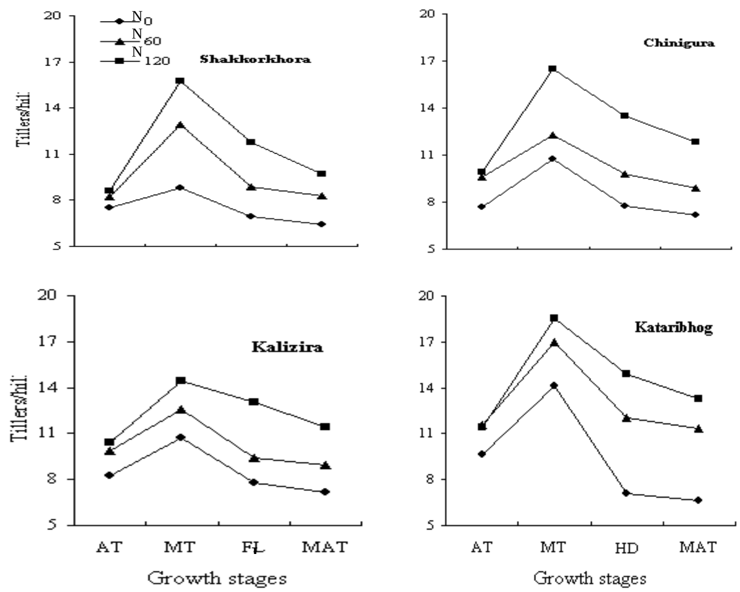
It appears that the number of tillers at maturity stage was the function of the number of tillers developed at maximum tillering stage. The functional relationship can be expressed as Tf = (0.6787 x Tm) - 0.0406 (R^2 = 0.7498), Where, Tf is the final tillers per hill at maturity stage and Tm stands for the tiller number per hill at maximum tillering stage. The present study showed that, after maximum tillering stage tillers per hill decreased considerably until maturity. This suggests that during the reproductive and ripening phases the rate of tiller mortality exceeded the tiller production rate. A high tiller mortality rate was also observed by Roy and Sattar (1992) during the later stage of plant growth.

Leaf area index

The surface area of the green leaves produced by rice crop per unit area of land or leaf area index (LAI) was taken as a determining factor of photosynthetic production of the crop. This is an important character to evaluate the characteristics of dry matter production (Kusuda, 1993). The LAI of four cultivars throughout the crop growth duration is presented in Figure 2. Irrespective of cultivars and nitrogen levels, LAI increased sharply after transplanting attaining a peak at heading stage and then decreased gradually. This result agreed with that of Amano *et al.* (1993). At all growth stages, Kataribhog gave the highest LAI with 120 kg N ha^{-1} which was statistically similar to those of Chinigura and Kalijira.

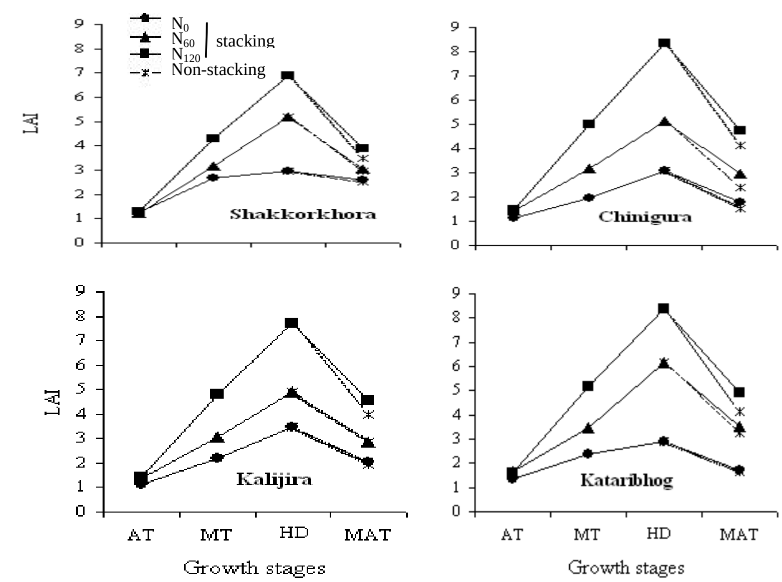
The increase in LAI was might be due firstly to production of higher number of functioning leaves, which increased total photosynthetic surface with the increase in leaf area and secondly to increased availability of nitrogen under the higher levels of nitrogen, which resulted in larger leaves. Kumar and Gangwar (1985) made similar observation.

In non-stacking plant, all the cultivars showed lower LAI at maturity stage than stacking plant. After heading stage LAI declined due to senescence of the lower leaves.



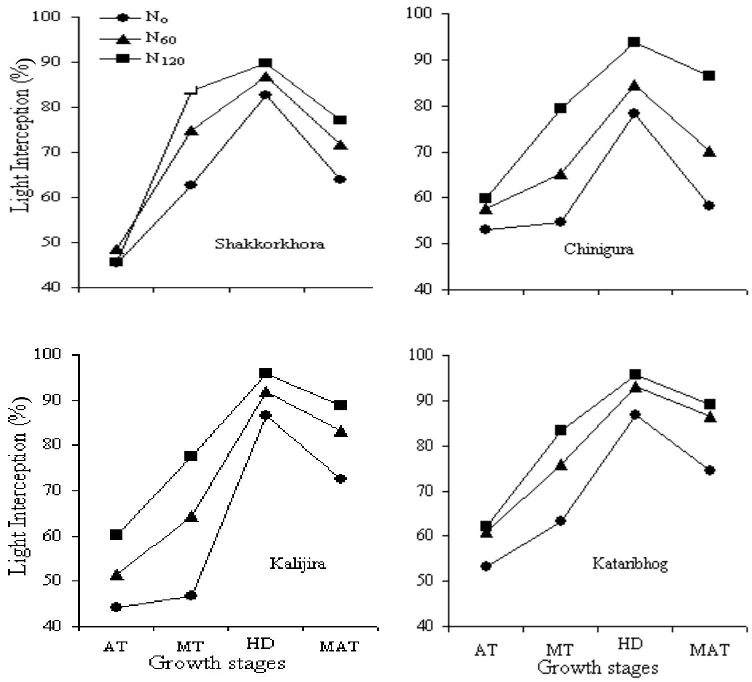
AT: Active tillering; MT: Maximum tillering; HD: Heading; MAT: Maturity

Fig. 1. Tillering dynamics of four aromatic rice cultivars at three nitrogen levels



AT: Active tillering; MT: Maximum tillering; HD: Heading; MAT: Maturity

Fig. 2. Leaf Area Index (LAI) of four aromatic rice cultivars at three nitrogen levels under stacking and non-stacking conditions.



AT: Active tillering; MT: Maximum tillering; HD: Heading; MAT: Maturity

Fig. 3. Light interception (%) of four aromatic rice cultivars at three nitrogen levels under stacking condition.

Increase in leaf area due to the application of N fertilizer resulted from the increase in both tiller number and leaf number per hill. The higher leaf number and large leaf size might have caused increased rate of production of leaves. This indicates that the production of higher tiller number per unit area due to higher N supply was one of the major factors for increasing LAI.

Light interception

With the interception of light energy by crop canopy and conversion of this energy into dry matter resulted in dry matter production. Figure 3 reveals the light interception (LI) of four cultivars of aromatic rice at three N levels under stacking and non-stacking conditions.

Biomass is the function of photosynthetic carbon metabolism. This in turn is dependent on leaf area development and light interception. Higher value of LI indicated that, most of the incident light was intercepted by the upper canopy. Proper interception by each segment of crop canopy is essential for high productivity (Tripathi and Singh, 1989).

At heading stage, the LI value ranged from 78.4% (Chinigura without N application) to 95.7% (Kalijira with 120 kg Nha^{-1}). Application of 60 kg N ha^{-1} increased the LI by 4, 6, 5, 6 % and 120 kg N ha^{-1} by 7, 15, 9, 8 % in Shakkorkhora, Chinigura, Kalijira and Kataribhog, respectively. Higher light interception was corresponded to higher LAI (Ahmed *et al*., 1996). Nitrogen greatly influences the production of dry weight. Dry weight increases with the increase in nitrogen (Khanam, 1994). The more the leaf area, greater was the light interception.

It is concluded with the above findings that irrespective of cultivars, the days required to flowering and maturity significantly increased with the increase in the amount of nitrogen applied. Lodging occurred at different stage of grain development, Kataribhog lodged within four days after heading at 120 kg N ha^{-1} while it took 26 days to lodge at 0 kg N ha^{-1}. Irrespective of cultivars and nitrogen levels, higher N dose produced higher number of tillers. At heading stage the higher light interception was found in all the cultivars with the increment of N levels.

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