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EFFECT OF AGE OF SEEDLINGS AT STAGGERED TRANSPLANTING AND NUTRIENT MANAGEMENT ON YIELD PERFORMANCE OF AROMATIC FINE RICE (cv. BRRI dhan38)

A. Roy, M.A.R. Sarkar and S.K. Paul*

Department of Agronomy, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

ABSTRACT

An experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during July to December 2014 with a view to finding out the effect of age of seedlings at staggered transplanting and nutrient management on growth and yield of aromatic fine grained rice (cv. BRRI dhan38). The experiment consisted of three ages of seedlings (30, 45 and 60 day-old) at staggered transplanting and six nutrient managements viz. control (no nutrients), recommended dose of inorganic fertilizers, 50% of recommended dose of inorganic fertilizers + cowdung @ 5 t ha^{-1}, 75% of recommended dose of inorganic fertilizers + cowdung @ 5 t ha^{-1}, 50% of recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1} and 75% of recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1}. The experiment was laid out in a randomized complete block design with three replications. The effect of age of seedlings at staggered transplanting, nutrient management and their interactions were significant on crop characters, yield components and yield of aromatic fine rice. The tallest plant was recorded due to transplanting 30-day old seedlings fertilized with 75% of recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1}. The highest leaf area index (6.55), number of total tillers $hill^{-1}$ (12.56), number of effective tillers $hill^{-1}$ (8.54), panicle length (24.07cm) and number of grains $panicle^{-1}$ (141.3) were recorded in 30-day old seedlings fertilized with 75% of recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1} while the lowest values were recorded in 60-day old seedling with control. In case of sterile spikelets $panicle^{-1}$, 60-day old seedlings with control treatment showed the highest value (30.94). The highest grain (3.85 t ha^{-1}) and straw (5.29 t ha^{-1}) yields were obtained in 30-day old seedlings fertilized with 75% of recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1}. Therefore, 30-day old seedlings

*Corresponding author email: skpaul@bau.edu.bd

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fertilized with 75% of recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1} appeared as the promising technique for appreciable growth and grain yield of aromatic fine grained rice (cv. BRRI dhan38).

Keywords: Aromatic fine grained rice, seedlings, staggered transplanting, nutrient, yield.

INTRODUCTION

Rice contributes 95% of total food production in Bangladesh. About 77.07% of cropped area of Bangladesh is used for rice production, with annual production of 33.83 million ton from 11.41 million ha of land which contributes about 19.70% of the country's GDP (BBS, 2013). Aromatic rice contributes a small but special group of rice which covers 2% of the national rice acreage of Bangladesh and 12.5% of the total transplant *Aman* rice cultivation (Ashrafuzzaman et al., 2009). Aromatic rice is rated best in quality and fetches much higher price than high quality non-aromatic rice in the domestic and international market. The demand of aromatic rice for internal consumption and also for export is increasing day by day. Most of the aromatic rice varieties in Bangladesh are traditional photo-period sensitive type and grown during *Aman* season (Kabir et al., 2004). In Bangladesh, Chinisagar, Badshabhog, Kataribhog, Kalizira, Tulsimla, Dulabhog, Basmati, Banglamati (BRRI dhan50), BRRI dhan34, BRRI dhan37, BRRI dhan38, Binadhan-9 and Binadhan-13 are grown as aromatic rice. Some of them have special appeal for their aroma. These varieties are cultivated by the farmers to meet domestic consumption mainly and very little amount goes to export purpose.

Staggered transplanting means, planting different fields in a community or in a farm over a period of several weeks, in contrast with simultaneous planting where all fields are planted over a period of a week or less. In Bangladesh, sometimes transplanting of *Aman* rice is delayed due to late recession of flood water, and unavailability of seedlings. In such cases more seedlings can be raised in the nursery bed to transplant in the main field at a later date than the optimum one so that, the damage caused by the flood is minimized. Here staggering of planting date with the seedlings of same source to be used because at this stage farmers are in shortage of time for raising new seedlings. The use of seedlings from the same source are planted at optimum date and thereafter at different dates are termed as staggered planting of rice seedlings having different ages. Transplanting of healthy seedlings of optimum age ensures better rice yield. When seedlings are transplanted at the right time, tillering and growth proceed normally. Age of seedling at the time of transplanting is an important factor for uniform stand establishment of rice (Ginigaddara, and Ranamukhaarachchi, 2011). Age of seedling influences yield components and yield of rice (Mishra and Salokhe, 2008; Amin and Haque, 2009 and Faghani et al., 2011).

The yield of aromatic fine grained rice can be increased with the improved cultivation practices like proper age of seedlings and proper nutrient management.

Optimum age of seedlings supports the plants to uptake more nutrients from the soil. Almost all soils of Bangladesh are deficient in nitrogen mainly due to low level of organic matter caused by continuous intensive cropping with high yielding varieties and adding of less amount of organic matter. Poultry manure and cowdung may play a vital role in soil fertility improvement as well as supplying primary, secondary and micronutrients in addition to N, P and K. It may supply sufficient amount of S, Zn and B for growth of rice plants. The application of cowdung and poultry manure to soil is considered a good management practice in any agricultural production system because of the stimulation of soil microbial growth and activity, subsequent mineralization of plant nutrients, and increased soil fertility and quality (Islam et al., 2007). Yield and grain protein content increased due to application of manure with inorganic fertilizers (Pal et al., 2015; Roy et al., 2015 and Biswas et al., 2016). The application of 75% of recommended dose of inorganic fertilizers + 50% cowdung showed superiority in terms of the growth, yield and quality of aromatic rice (Sarkar et al., 2014). So the efficient nutrient management increases crop yield and at the same time reduces fertilization cost. Therefore, the present study was carried out to delineate the effect of age of seedlings at staggered transplanting and nutrient management on the yield performance of aromatic fine rice (cv. BRRI dhan38).

MATERIALS AND METHODS

The experiment was conducted at the agronomy field laboratory of Bangladesh Agricultural University (BAU), Mymensingh during July to December 2014 to study the effect of age of seedlings at staggered transplanting and nutrient management on the growth and yield of aromatic fine grained rice (cv. BRRI dhan38). The experimental field is located at 24°75’ N latitude and 90°50’E longitude at an altitude of 18m. The experimental field belongs to the Old Brahmaputra Floodplain (AEZ-9). The soil of the experimental land belongs to the Sonatala series of non-calcareous dark grey floodplain. The land was medium high, silt loam in texture and more or less neutral in reaction (pH 6.5), and low in organic matter (1.29%). Aromatic rice variety BRRI dhan38 was used as plant material. The experiment consisted of three age of seedling at staggered planting *viz.* 30- (A_1), 45- (A_2) and 60- day old seedlings (A_3) and four nutrient managements *viz.* Control (no nutrients) (F_0), Recommended dose of inorganic fertilizers (i.e. 150, 97, 70, 60 and 12 kg Urea, TSP, MoP, Gypsum and ZnSO4, respectively ha^{-1}) (F_1), 50% of recommended dose of inorganic fertilizers + cowdung @ 5 t ha^{-1} (F_2), 75% of recommended dose of inorganic fertilizers + cowdung @ 5 t ha^{-1} (F_3), 50% of recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1} (F_4) and 75% of recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1} (F_5). The experiment was laid out in a randomized complete block design with three replications. The size of unit plot was 4.0 m × 2.5 m. The distances between blocks and plots were 1 m and 75 cm, respectively. Sprouted seeds were sown in the prepared wet nursery bed on 23 June 2014. Proper care was taken to raise the seedlings in the nursery bed. Weeds were removed and irrigation was given in the nursery bed as and when necessary. The experimental land was prepared by a power tiller 10 days before transplanting. It was then ploughed well with the help of country plough to make the soil nearly ready for transplanting. Weeds and stubble were removed and the field was then leveled by laddering. The experimental field was then divided into unit plots which were spaded one day before transplanting for incorporating the basal fertilizers. The specified amount of cowdung, poultry manure, triple superphosphate, muriate of potash, gypsum and zinc sulphate were applied at final land preparation. Urea was applied in three equal splits, at 15, 35 and 50 days after transplanting (DAT). Seedlings were transplanted on the well puddled experimental plots following staggering of transplanting on 23 July, 8 August and 23 August 2014, maintaining the spacing of 25 cm × 15 cm using three seedlings hill^{-1}. Intercultural operations were done for ensuring and maintaining the vigorous growth of the crop. Intensive care was taken throughout the growing season. The leaf area was measured by an automatic leaf area meter (Type AAN-7, Hayashi Dam KO Co., Japan). LAI was calculated as the ratio of total leaf area and total ground area of the sample as described by Hunt (1978) and Yoshida (1981). LAI = LA/P, Where, LA = Total leaf area of the leaves of all sampled plants (cm ^{2}), P= Area of the ground surface covered by the plant (cm ^{2}).

Maturity of the crop was determined when 90% of the grain became golden yellow in color. Five hills (excluding border hills and central 1 m^2 area) were selected randomly from each plot and uprooted prior to harvest to record data on crop characters and yield contributing characters. After sampling, central one square meter area was harvested to record the data on yield. The crop was harvested on 24 December 2014 with sickle at proper maturity. Then the crop was threshed, cleaned and sun dried to record the grain yield per square meter. The grain yield was adjusted to 14% moisture content. Straws were sun dried to record the straw yield per square meter. Grain and straw yields were then converted to t ha^{-1}. The recorded data were analyzed following analysis of variance technique and mean differences were adjudged by Duncan's Multiple Range Test (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Effect of seedling age at staggered transplanting

Plant height was significantly influenced by seedling age at staggered transplanting (Table 1). The tallest plant (106.30 cm) was found when 30-day old seedlings were transplanted followed in order by 45-day old seedlings at staggered transplanting. The tallest plant was found with 30-day old seedlings due to early recovery of transplanting shock and better growth of the plants. The maximum number of non-effective tillers hill^{-1} (2.39) was found when 60-day old seedlings were transplanted and the minimum number of non-effective tillers hill^{-1} (1.62) was obtained when 30-day old seedlings were transplanted (Table 1). Number of non- effective tillers hill^{-1} exhibited a trend of increase with the increase in seedling age. Similar results were also observed by Haque (2002). Older seedlings produced more non-effective tillers than the younger ones due to the short duration of vegetative period as they were generated from the tertiary tillers and thus those plants rapidly switched over to reproductive phase leaving behind many tillers non-bearing.

Effect of nutrient management

Plant height was significantly affected different levels of manures with inorganic fertilizers (Table 1). The tallest plant (107.1 cm) was recorded in treatment F_5 (75% inorganic fertilizer + poultry manure @ 2.5 t ha^{-1}) which was at par with F_3 (75% of recommended dose of inorganic fertilizers + cowdung @ 5 t ha^{-1}) and F_2 (50% of recommended dose of inorganic fertilizers + cowdung @ 5 t ha^{-1}) whereas the shortest one (99.70cm) was recorded in control treatment F_0 (no manures and no inorganic fertilizers). This might have occurred due to application of manure which regulated the exuberant vegetative growth. The number of non-effective tillers hill^{-1} showed opposite trend (ranged from 1.85 to 2.39) and the highest value was obtained in F_0 (no manures and no fertilizers) while the lowest one was produced in F_5 (75% inorganic fertilizer + poultry manure @ 2.5 t ha^{-1}).

Effects of interaction

Leaf area index (LAI), number of total tillers hill^{-1}, number of effective tillers hill^{-1}, panicle length and grains panicle^{-1} were significantly influenced by the interaction between age of seedlings at staggered transplanting and nutrient management (Table 2). The highest LAI (6.55), number of total tillers hill^{-1} (12.56) and effective tillers hill^{-1} (11.42) were recorded in 30-day old seedlings with F_5 treatment (75% inorganic fertilizer + poultry manure @ 2.5 t ha^{-1}) while the lowest values were recorded in 60-day old seedling with F_0 (no manure and no fertilizer). Younger seedlings produced more tillers than the older ones due to quick regeneration of seedlings and plant vigour. So, number of effective tillers hill^{-1} gradually decreased as the age of seedling increased (Table 2). The longest panicle (24.07 cm) and grains panicle^{-1} (141.3) were obtained in 30-day old seedlings with F_5 treatment (75% inorganic fertilizer + poultry manure @ 2.5 t ha^{-1}) while the corresponding lowest values were recorded in 60-day old seedlings with F_0 treatment (control). Number of grains panicle^{-1} exhibited a trend of decrease with the increase in seedling age. These finding are in conformity with that of Luna et al. (2017). Younger seedlings produced more grains panicle^{-1} than older ones due to longer vegetative period when spikelets are formed in the spike before emergence of the panicles. The maximum number of sterile spikelets panicle^{-1} (30.94) was obtained in 60-day old seedlings with F_0 treatment (control) and the minimum number of sterile spikelets panicle^{-1} (11.68) was found in 30-day old seedlings with treatment F_5 (75% inorganic fertilizer + poultry manure @ 2.5 t ha^{-1}). Number of sterile spikelets panicle^{-1} exhibited a trend of increase with the increase in seedling age. Similar findings were also reported by Yoshii and Sandier (1998). Older seedlings produced more sterile spikelets panicle^{-1} than the younger ones due to the short duration of vegetative period and the plants rapidly switched over to reproductive and ripening phase leaving behind many spikelets sterile. Integration of manure and inorganic fertilizer enhanced production of number of effective tillers hill^{-1} and grains panicle^{-1} was also reported elsewhere (Shaha et al., 2014, Sarkar et al., 2014 and Marzia et al., 2016). Weight of 1000-grains was not significantly influenced by the interaction between age of seedlings and nutrient management. The weight of 1000-grains ranged from 13.42 g. to 16.24g.

Grain yield, straw yield and harvest index were significantly influenced by the interaction between age of seedlings at staggered transplanting and nutrient management. It was found that the highest grain yield (3.85 t ha^{-1}) was obtained from 30-day old seedlings with F_5 (75% inorganic fertilizer + poultry manure @ 2.5 t ha^{-1}) treatment, which was as good as 30-day old seedlings with F_3 (75% of recommended dose of inorganic fertilizers + cowdung @ 5 t ha^{-1}) and 45-day old seedlings with F_5 (75% inorganic fertilizer + poultry manure 2.5 t ha^{-1})) and the lowest grain yield (2.73 t ha^{-1}) was observed in 60-day old seedlings with control (no manure and fertilizer). The highest grain yield occurred due to the contribution of more numbers of effective tillers hill^{-1} and grains panicle^{-1} in F_5 treatment. Straw yield and harvest index showed similar trend as that of grain yield. Straw yield (5.29 t ha^{-1}) and harvest index (47.63 %) were the highest in 30-day old seedlings with F_5 (75% inorganic fertilizer + poultry manure @ 2.5 t ha^{-1}) and the lowest values were observed in 60-day old seedlings with F_0 nutrient management. All parameters exhibited a regular trend of decrease with the increase in seedling age. These finding are in agreement with that of Upadhyay et al. (2003) and Singh and Singh (1998). Older seedlings remained more days in the nursery bed and as a result basal node was formed in the seedlings. Again it took more time to get established in the main field. On the contrary, the younger seedlings stayed in the nursery bed from a short period and thus nodes were not formed and they quickly recovered the transplanting shock in the main field. Thus they started re-growth quickly which ultimately helped in favour of better growth of plant, yield components and yield. Again panicle initiation started earlier within the plant and more spikelets were formed which ultimately resulted in more number of spikelets panicle^{-1}. Thus the yield components were improved and sterility percentage was decreased, which were mainly responsible for the improvement of grain yield. The longest plant and the highest number of total tillers in 30-day old seedlings with F_5 (75% inorganic fertilizer + poultry manure @ 2.5 t ha^{-1}) were responsible for the highest straw yield while the highest harvest index in this treatment occurred due to higher grain yield indicating efficient translocation of assimilates for grain production. Application of poultry manure combined with inorganic fertilizer encouraged the vegetative growth of rice in terms of plant height and number of effective tillers hill^{-1}, which ultimately resulted in the increase of grain yield. These findings are in accordance with that of Sarkar et al. (2014) and Pal et al. (2016). The highest harvest index (45.04%) was obtained from nutrient management treatment F_5 (75% inorganic fertilizer + poultry manure @ 2.5 t ha^{-1}), which was statistically identical with F_4 (50% inorganic fertilizer + poultry manure @ 2.5 t ha^{-1})

and F_3 (75% inorganic fertilizer + cowdung @ 5 t ha^{-1}) and the lowest one (33.92%) was obtained in F_1 (recommended dose of fertilizer), which was statistically identical with F_0 (control treatment).

Table 1. Effect of age of seedlings at staggered transplanting and nutrient management on plant height and number of non-bearing tillers $hill^{-1}$

Age of seedling (days)	Plant height (cm)	No .of non-effective tillers $hill^{-1}$
30	106.3a	1.62b
45	103.7b	2.39a
60	100.2c	2.39a
CV (%)	3.51	12.17
Nutrient management		
F_0	99.70d	2.40a
F_1	102.4bcd	2.18abc
F_2	104.2abc	2.13bc
F_3	105.6ab	1.97cd
F_4	101.4cd	2.29ab
F_5	107.1a	1.86d
CV (%)	3.51	12.17

In a column, values having the same letters under each treatment do not differ significantly whereas values with dissimilar letter differ significantly as per DMRT.

** = Significant at 1% level of probability, NS = Not significant.

F_0 = Control (no manures and fertilizers), F_1 = Recommended dose of inorganic fertilizers (i.e 150, 97, 70, 60 and 12 kg Urea, TSP, MoP, Gypsum and $ZnSO_4$, respectively ha^{-1}), F_2 = 50% of recommended dose of inorganic fertilizers + cowdung @ 5 t ha^{-1}, F_3 = 75% of recommended dose of inorganic fertilizers + cowdung @ 5 t ha^{-1}, F_4 = 50% of recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1}, F_5 = 75% of recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1}.

Table 2. Effect of interaction between age of seedlings at staggered transplanting and nutrient management on LAI, crop characters, yield components and yield of aromatic fine rice cv. BRRI dhan38

	Nutrient Management																	
Age of seedling (days)	F_0	F_1	F_2	F_3	F_4	F_5	F_0	F_1	F_2	F_3	F_4	F_5	F_0	F_1	F_2	F_3	F_4	**F_5**
	Leaf area index						Number of total tillers hill^{-1}						Number of effective tillers hill^{-1}					
30	4.38de	5.67c	6.03b	6.22b	5.45c	6.55a	7.13efg	9.91c	10.87b	11.55b	8.95d	12.56a	.05 g	.25 d	.32 c	0.18b	.05 e	11.42a
45	3.98fg	4.10ef	4.20def	4.27def	4.04fg	4.47d	5.67ij	6.00hij	6.68gh	7.62e	5.86hij	8.46d	3.04kl	3.56 j	4.25hi	5.40 g	3.34jkl	6.31f
60	3.75g	3.99fg	4.03fg	4.09efg	4.95fg	4.13ef	5.44j	5.88hij	6.46ghi	6.90efg	5.57j	7.36ef	2.96l	3.46jk	4.07i	4.56h	3.12kl	5.08g
CV (%)	3.79						6.09						4.20					
	Panicle length (cm)						Number of grains panicle^{-1}						Number of sterile spikelets panicle^{-1}					
30	15.32i	19.00de	20.07c	21.91b	17.15gh	24.07a	115.1 hi	122.0defg	126.6bcde	129.6bc	119.2fgh	141.3a	11.68m	16.05 k	17.94j	19.04hij	3.48i	20.69fg
45	15.32i	18.65ef	19.90cd	20.80c	17.80fg	21.99b	112.8ij	122.4defg	124.7cdef	127.3bcd	118.3ghi	130.5b	14.43l	19.58ghi	20.34fgh	21.60ef	18.73ij	22.78e
60	13.02j	15.17i	16.56 h	17.82fg	15.07i	18.07efg	108.7j	117.3ghi	119.8fgh	121.2efg	114.4hi	122.9defg	24.10d	27.55bc	28.07b	29.95a	26.38c	30.94a
CV (%)	3.36						2.55						3.63					
	Grain yield (t ha^{-1})						Straw yield (t ha^{-1})						Harvest index (%)					
30	3.14fgh	3.31de	3.55b	3.75ab	3.46bc	3.85a	4.43de	4.72bc	4.83b	4.62bcd	4.58cd	5.29a	41.51j	45.47b-e	42.38hij	44.89c-f	43.00ghi	47.63a
45	3.05 hi	3.10ghi	3.31de	3.41cd	3.22efg	3.76ab	3.95 hi	4.12fgh	4.18fg	4.29 ef	4.05gh	4.83b	43.57fgh	42.96ghi	44.17efg	44.25d-g	44.25efg	43.75fgh
60	2.73j	2.98i	3.15fgh	3.25ef	3.09ghi	3.39cd	3.27 l	3.58 jk	3.74 ij	3.82 i	3.39 kl	3.89 hi	41.20j	45.40bcde	45.67bcd	45.97bc	42.13ij	46.52ab
CV (%)	2.14						3.01						1.75					

Mean values under each parameter having the same letter do not differ significantly whereas mean values with dissimilar letters differ significantly as per DMRT.

F_0 = Control (no manures and fertilizers), F_1 = Recommended dose of inorganic fertilizers (i.e. 150, 97, 70, 60 and 12 kg Urea, TSP, MoP, Gypsum and $ZnSO_4$, respectively ha^{-1}), F_2 = 50% of recommended dose of inorganic fertilizers + cowdung @ 5 t ha^{-1}, F_3 = 75% of recommended dose of inorganic fertilizers + cowdung @ 5 t ha^{-1}, F_4 = 50% of recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1}, F_5 = 75% of recommended dose of inorganic fertilizers + poultry manure @ 2.5 t ha^{-1}.

Functional relationship between leaf area index (LAI) at 60 days after transplanting

(DAT) and grain yield of aromatic fine rice cv. BRRI dhan38

Leaf area index (LAI) is also an important growth parameter for the determination of yield of aromatic rice. It is closely related to the amount of photosynthesis and to the surface available for plant for photosynthesis, the basic process of higher yield. The relationship of LAI and grain yield of aromatic fine rice was determined by using the respective data of nutrient management. Experimental results revealed that grain yield showed significantly positive correlation with LAI. In figure 1, the regression equation indicates that an increase in LAI would lead to an increase in the grain yield of BRRI dhan38. The functional relationship was significant at $p \leq 0.01$. The functional relationship can be determined by the regression equation Y =1.0141x-1.2327 (R^2 = 0.9854). The functional relationship revealed that 99% of the variation in yield could be explained from the variation in Leaf area index at 60 DAT. Similar relationship was reported by Ray et al. (2015). This indicates that Leaf area index (LAI) might be critical growth characteristics in yield performance of aromatic rice.

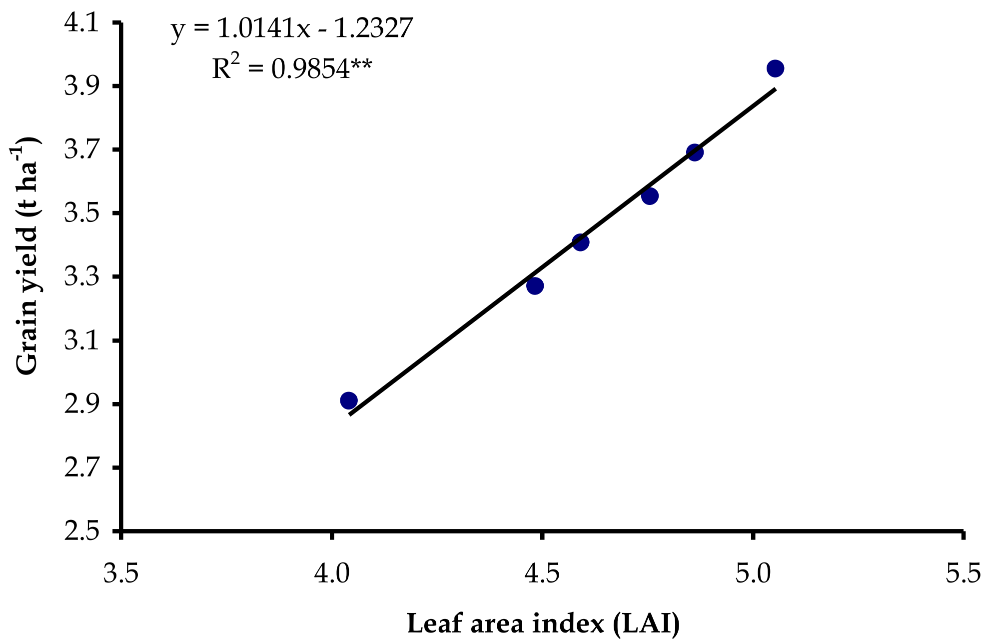

Figure 1. Functional relationship between leaf area index (LAI) at 60 DAT and grain yield aromatic fine rice cv. BRRI dhan38

CONCLUSION

It can be concluded that 30-day seedlings fertilized with 75% inorganic fertilizer + poultry manure @ 2.5 t ha^{-1} may be used for better performance compared to other combinations in respect of grain yield of aromatic fine rice (cv. BRRI dhan38). In case of staggered transplanting, 60-day old seedlings fertilized with 75% inorganic fertilizer + poultry manure @ 2.5 t ha^{-1} appeared as the promising technique to obtain an appreciable grain yield of 3.39 t ha^{-1} under late transplanted condition.

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