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Evaluation of growth performance of some advanced rice lines in T. Aman season

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Abstract: An experiment was carried out at the farm of Bangladesh Institute of Nuclear Agriculture, Mymensingh during the Aman season of 2006 to observe the performances of five advanced rice lines along with a check variety. The advanced rice lines were PNR-381, RD-2586, PR-26305-M-2, TNDB-100 and DM-25 and the check variety was Binadhan 4. The experiment was laid out in a randomized complete block design with three replications. All the growth parameters recorded at different growth stages from 35-65 days after transplanting (DAT) were significantly different among the advanced lines/variety. DM-25 produced the tallest plant and PR-26305-M-2 produced the highest number of total tillers hill^{-1}, leaf area, leaf dry weight, stem dry weight, total dry matter, leaf area index, crop growth rate and net assimilation rate. Check variety Binadhan 4 produced the maximum relative growth rate. The yields were significantly different among the advanced rice lines/variety at harvest. Among the advanced rice lines/variety, DM-25 produced the highest plant height (125.3 cm). Advanced line RD-2586 produced the highest 1000-grain weight (28.47 g), grain yield (5.18 t ha^{-1}), straw yield (6.73 t ha^{-1}) and biological yield (11.91 t ha^{-1}). Check variety Binadhan 4 produced the highest number of grains in primary rachis branch panicle^{-1} (51.8) and grains panicle^{-1} (99.4).

Key words: Advanced rice lines, performance, T-aman season

Introduction

Rice (*Oryza sativa* L.) belongs to cereal crop under Gramineae family is the staple food of the people of Bangladesh. In Bangladesh, rice ranks the first position among the cereal crops grown as the main source of carbohydrate. It is one of the major and most extensively cultivated cereal of the world including Bangladesh that feeds half of the world total population. It is the most important cereal crop in Asia too which produces about 92% of the world rice (IRRI, 1995). It plays an absolutely dominant role in country's agriculture as it covers 77% of the total cropped area and 94% of the total food grain production (BBS, 2004). The yield of rice in Bangladesh is very low compared to other rice growing countries of the world. There are three distinct growing seasons of rice namely Aus, Aman and Boro in Bangladesh.

The present yield of rice is not sufficient enough to ensure the food security for the increasing population in near future. Variety plays an important role in maximizing yield. In this effort, research institutes are developing new rice varieties either through conventional breeding methods or mutation breeding or using tissue culture or biotechnology or introducing several rice lines from abroad. As such BINA collected rice lines from the International Atomic Energy Agency and they are under field trials in Bangladesh over different cropping seasons. But all the lines are not similar in respect of plant characters and also not equally responsive to environmental situations, which have profound effect on yield.

Growth attributes play an important role in different variety selection. Through comparative study of growth attributes one can easily select a variety having desirable architecture and attributes leading to high yield potential. Development of rice cultivars with a high yielding ability is one of the most fundamental approaches for dealing with world demand (IRRI, 1996). Therefore, the need of assessment of growth nature and their relation to yield and yield components are necessary to evaluate in the newly developed rice lines. The present study was conducted to observe the growth and growth efficiency of the advanced rice lines with a check variety. We examined the plant height, leaf area index, Dry matter production, CGR, RGR, NAR & Grain yield of advanced rice lines in treated soil.

Materials and Methods

The experiment was conducted at the farm of Bangladesh Institute of Nuclear Agriculture, Mymensingh during the period from July to November, 2006. There were five advanced rice lines viz., PNR-381, RD-2586, PR-26305-M-2, TNDB-100 and DM-25 and one check variety Binadhan 4. Binadhan 4 is a well established high yielding variety of Aman rice. The experiment was laid out in a randomized complete block design with the three replications. The whole field was divided into 3 blocks each containing 6 plots. In total, there were 18 unit plots. The size of a unit plot was 12 m^2 (4 m × 3 m). Plot to plot distance 50 cm and block to block distance was 1 m.

Healthy seeds of PNR-381, RD-2586, PR-26305-M-2, TNDB-100, DM-25 and check variety Binadhan 4 were soaked for 24 hours and then kept in a gunny bag in dark condition. After sprouting, the seeds were sown in the previously prepared wet seed bed on July 5, 2006. Fertilizers were applied to the plots at the rate of 75, 20, 40, 10 and 2 kg ha^{-1} of N, P, K, S, Zn (BARC, 1997) from the sources of urea, triple super phosphate, muriate of potash, gypsum and zinc oxide. The whole amount of P, K, S and Zn were applied at final land preparation before transplanting. The urea was applied 30% at 7 days after transplanting, 30% at active tillering stage (30 DAT) and the rest 40% at PI stage (when the primodia length is about 2-3 mm).

The uprooted seedlings of 28 days old were transplanted in the puddled land with row to row distance 20 cm and plant to plant distance 15 cm. Three seedlings were transplanted in each hill. Proper care was taken during the growing period of the crop.

The intercultural operations such as Gap filling, weeding, flood irrigation were maintained in the proper way. The crops were found to be infested with rice stem borer and green leaf hopper at the vegetative stage which was successfully controlled by applying Diazinon 60 EC @ 1 L ha^{-1}.

Two hills from each plot were marked by bamboo sticks excluding two border lines and hills. Growth measures on plant height, leaf area (LA), leaf area index (LAI), leaf dry weight, stem dry weight, total dry matter (TDM), crop growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR) were recorded from these two hills at an interval of 15 days from 35 days after transplanting (DAT) to 65 DAT for all the advanced lines/variety. Maturity of crop was determined when about 90% of the grains became golden yellow in colour. Five hills (excluding border hills) were randomly selected from each unit plot and were cut at soil surface for recording necessary data at maturity. After that 20 random hills (excluding border hills) were cut at soil surface from the whole plot at maturity and cut on different dates for different lines/variety. The harvested crop was threshed by pedal thresher and then they (grain and straw) were dried in sunlight and finally cleaned by winnowing. The grain and straw yields data of each plot was taken from these 20 hills. The grain yield was adjusted to 14% moisture content.

Plant height was measured from the adjoining line of root and culm to the tip of the longest leaf or panicle at 35, 50 and 65 DAT for growth data from 2 hills of each plot. Two hills at random from each plot were selected and number of total tillers $hill^{-1}$ was counted at 35, 50 and 65 DAT.

Leaf area index is the ratio of leaf area and its ground area. It was calculated by the following formula:

LAI = LA/ P Where, LA = Leaf area (cm^2 $hill^{-1}$), P = Ground area (20 cm × 15 cm = 300 cm $hill^{-1}$)

Increase of plant material per unit of time was calculated by the following formula:

$$CGR = \frac{1}{A} \cdot \frac{W_2 - W_1}{T_2 - T_1} \ \ g\,m^{-2}day^{-1}$$

Increase of plant material per unit of material present per unit of time is calculated by the following formula:

RGR = $LnW_2 - LnW_1 / T_2\text{-}T_1$ mg $g^{-1}day^{-1}$

Increase of plant material per unit of leaf area per unit of time is calculated by the following formula:

$$NAR = \frac{W_2 - W_1}{T_2\text{-}T_1} \times \frac{LnLA_2 - LnLA_1}{LA_2 - LA_1} \ \ g\,m^{-2}day^{-1}$$

Where, A = Ground area (cm^2) ,LA = Total leaf area, W_1 = Total plant dry weight at time T_1, W_2 = Total plant dry weight at time T_2, Ln = Natural logarithm, LA_1 = Leaf area at time T_1, LA_2 = Leaf area at time T_2. Grain yield was recorded at maturity from the 20 hills. The straw yields of the 20 hills at maturity were dried in sunlight and their weights were recorded. The collected data at harvest were analyzed following the ANOVA-technique and the mean differences were adjudged by the Duncan's Multiple Range Test (DMRT) as per Gomez and Gomez (1984).

Results and Discussion

Plant height: The data presented in Table 1 shows that the highest plant height at 35 DAT was in DM-25 (79.1 cm) which was followed by check variety Binadhan 4 (76.6 cm). The lowest plant height was recorded in RD-2586 (62.8 cm) which was statistically similar to TNDB-100 (64.7 cm). Plant height increased with the advancement of growth period. At 50 DAT, the tallest plant was produced by DM-25 (91.8 cm) and the shortest plant was produced by TNDB-100 (74.8 cm) which was statistically similar to RD-2586 (75.4 cm). The highest plant height at 65 DAT was recorded in DM-25 (104.2 cm) and the lowest plant height was recorded in RD-2586 (87.8 cm) which was statistically similar to TNDB-100 (88.17 cm) (Table 1). Among the advanced rice lines and check variety, DM-25 always maintained the highest height during the growth period 35 to 65 DAT.

Table 1. Growth nature of plant and number of total tillers $hill^{-1}$ of different advanced rice lines/variety during the growth period 35 to 65 DAT in Aman season, 2004

Treatment (Advanced rice line/variety)	Plant height (cm)			Number of total tillers $hill^{-1}$		
	35 DAT	50 DAT	65 DAT	35 DAT	50 DAT	65 DAT
PNR- 381	73.2 bc	87.8 c	94.2 c	11.8 ab	13.7 ab	10.7 ab
RD-2586	62.8 d	75.4 e	87.8 d	10.7 b	11.5 c	9.3 c
PR-26305-M-2	70.5 c	81.5 d	94.4 c	12.3 a	13.8 a	11.2 a
TNDB-100	64.7 d	74.8 e	88.2 d	10.8 b	12.0 c	9.8 bc
DM-25	79.1 a	91.8 a	104.2 a	10.8 b	12.0 c	9.7 bc
Binadhan 4	76.6 ab	89.2 b	99.0 b	10.8 b	12.3 bc	10.7 ab
Level of significance	**	**	**	*	*	*
CV (%)	4.80	3.90	4.89	5.37	6.01	5.16

Figures in the same column having similar letters do not differ significantly whereas dissimilar letters differ significantly as per DMRT; * = Significant at 5% level of probability; ** = Significant at 1% level of probability; DAT = Days after transplanting

Leaf area: At 35 DAT, the highest leaf area was produced by PR-26305-M-2 (487.8 cm^2 $hill^{-1}$) and the lowest leaf area was produced by check variety Binadhan 4 (366.1 cm^2 $hill^{-1}$). At 50 DAT, the highest leaf area was produced by PR-26305-M-2 (920.1 cm^2 $hill^{-1}$) and the lowest leaf area was produced by TNDB-100 (649.0 cm^2 $hill^{-1}$) which was statistically similar to check variety Binadhan 4 (651.9 cm^2 $hill^{-1}$) and RD-2586 (662.7 cm^2 $hill^{-1}$). AT 65 DAT, the highest leaf area was produced by PR-26305-M-2 (1466.3 cm^2 $hill^{-1}$) and the lowest leaf area was produced by TNDB-100 (953.8 cm^2 $hill^{-1}$) which was followed by RD-2586 (991.2 cm^2 $hill^{-1}$) (Table 2). This result among the advanced rice lines/variety PR-26305-M-2 had maintained the maximum leaf area $hill^{-1}$ at all sampling dates.

Leaf and Stem dry weight: At 35 DAT, the highest leaf dry weight was recorded in PR-26305-M-2 (2.93 g $hill^{-1}$) which was identically followed by DM-25 (2.71 g $hill^{-1}$) and the lowest leaf dry weight was recorded in Binadhan 4 (1.99 g $hill^{-1}$). At 50 DAT, the highest leaf dry weight was recorded in PR-26305-M-2 (5.60 g $hill^{-1}$) and the lowest was in TNDB-100 (3.34 g $hill^{-1}$) which was statistically similar to RD-2586 (3.43 g $hill^{-1}$). At 65 DAT, the highest leaf dry weight was recorded in PR-26305-M-2 (8.36 g $hill^{-1}$) and the lowest was in TNDB-100 (5.77 g $hill^{-1}$) which was statistically similar to RD-2586 (5.83 g $hill^{-1}$) (Table 2). Results revealed that leaf dry weight followed its area i.e., the higher the leaf area, the higher the leaf dry weight and as such as the rice line PR-26305-M-2 maintained the maximum leaf dry weight all sampling dates. The highest stem dry weight at 35 DAT was produced by PR-26305-M-2 (2.57 g $hill^{-1}$) which was statistically similar to RD-2586 (2.48 g $hill^{-1}$). The lowest stem dry weight was produced by Binadhan 4 (1.95 g $hill^{-1}$) which was statistically similar to TNDB-100 (1.98 g $hill^{-1}$). At 50 DAT, the highest stem dry weight (7.64 g $hill^{-1}$) was produced by PR-26305-M-2 which was statistically similar to PNR-381 (7.56 g $hill^{-1}$) and the lowest stem dry weight was produced by TNDB-100 (5.29 g $hill^{-1}$). At 65 DAT, the highest stem dry weight was produced by PR-26305-M-2 (10.75 g $hill^{-1}$) which was statistically similar to PNR-381 (10.51 g $hill^{-1}$) and the lowest stem dry weight was produced by TNDB-100 (8.46 g $hill^{-1}$) which was statistically similar to Binadhan 4 (8.54 g $hill^{-1}$), RD-2586 (8.71 g $hill^{-1}$) and DM-25 (8.86 g $hill^{-1}$) (Table 2). The results showed that stem dry weights at 35, 50 and 65 DAT of the advanced rice lines PNR-381 and PR-26305-M-2 were statistically similar but the latter's were numerically higher. This was mainly due to higher number of total tillers.

Table 2. Growth nature of leaf area, leaf dry weight, stem dry weight and total dry matter (TDM) (leaf + stem) of different advanced rice lines/variety during the growth period 35 to 65 DAT in Aman season, 2004

Treatments	Leaf area (cm^2 $hill^{-1}$)			Leaf dry weight (g $hill^{-1}$)			Stem dry weight (g $hill^{-1}$)			TDM (g $hill^{-1}$)		
	35 DAT	50 DAT	65 DAT	35 DAT	50 DAT	65 DAT	35 DAT	50 DAT	65 DAT	35 DAT	50 DAT	65 DAT
PNR- 381	382.1e	806.8b	1330.5b	2.4 bc	4.9b	7.0b	2.4ab	7.6a	10.5a	4.7b	12.5b	17.5b
RD-2586	433.5c	662.7d	991.2d	2.6 b	3.4d	5.8d	2.5a	6.6b	8.7 b	5.1b	10.0c	14.5c
PR-26305-M-2	487.8a	920.1a	1466.3a	2.9 a	5.6a	8.4a	2.6a	7.6a	10.8a	5.5a	13.2a	19.1a
TNDB-100	407.4d	649.0d	953.8d	2.5 b	3.3d	5.8d	2.0b	5.3c	8.5 b	4.4 bc	8.6d	14.2c
DM-25	447.6b	743.7c	1078.7c	2.7 ab	3.9c	6.3c	2.2ab	6.4b	8.9 b	4.9b	10.4c	15.1c
Binadhan 4	366.1f	651.9d	1033.8c	2.0 c	3.9c	5.9c	2.0b	6.3b	8.5 b	3.9c	10.1c	14.5c
Level of significance	**	**	**	*	**	**	*	**	**	**	**	**
CV (%)	3.79	3.05	3.89	8.71	4.39	3.29	9.18	5.66	3.43	3.63	4.36	5.21

Figures in the same column having similar letters do not differ significantly whereas dissimilar letters differ significantly as per DMRT; * = Significant at 5% level of probability; ** = Significant at 1% level of probability; DAT = Days after transplanting

Total dry matter: At 35 DAT, the highest total dry matter (5.50 g) was produced by PR-26305-M-2 which was followed by RD-2586 (5.12 g $hill^{-1}$) and the lowest total dry matter was produced by Binadhan 4 (3.94 g $hill^{-1}$) which was followed by TNDB-100 (4.43 g $hill^{-1}$). At 50 DAT the highest total dry matter (13.24 g $hill^{-1}$) was produced by PR-26305-M-2 and the lowest total dry matter was (8.63 g $hill^{-1}$) produced by TNDB-100 (Table 2). At 65 DAT, the highest total dry matter was produced by PR-26305-M-2 (19.11 g $hill^{-1}$) and the lowest total dry matter (14.23 g $hill^{-1}$) was produced by TNDB-100 which was statistically similar to Binadhan 4 (14.48 g $hill^{-1}$), RD-2586 (14.54 g $hill^{-1}$) and DM-25 (15.12 g $hill^{-1}$) (Table 2). The significant difference of total dry matter production among the cultivars was reported by Arjuna et al. (1990). Results indicated that among the rice lines/variety studied, the TDM of the line PR-26305-M-2 was the highest at all the sampling dates.

Leaf area index: The LAI of PR-26305-M-2 was the higher (1.76) at 35 DAT and the lowest LAI was in check variety Binadhan 4 (1.02) which was followed by PNR-381 (1.27). At 50 DAT, the highest LAI was recorded in PR-26305-M-2 (3.07) which was followed by PNR-381 (2.69) and DM-25 (2.48) and the lowest LAI was recorded in TNDB-100 (2.16) which was statistically similar to Binadhan 4 (2.17) and RD-2586 (2.21) (Table 3). At 65 DAT, the highest LAI was recorded in PR-26305-M-2 (4.88) which was statistically similar to PNR-381 (4.43) and the lowest LAI was recorded in RD-2586 (2.97) which was statistically similar to TNDB-100 (3.06), DM-25 (3.60) and Binadhan 4 (3.45).

Crop growth rate: It was observed that during 35 to 50 DAT the highest CGR was recorded in PR-26305-M-2 (18.99 g $m^{-2}day^{-1}$) and the lowest CGR was recorded in TNDB-100 (12.53 g $m^{-2}day^{-1}$) which was followed by RD-2586 (12.27g $m^{-2}day^{-1}$) and DM-25 (12.57 RD-2586 g $m^{-2}day^{-1}$). During 50 to 65 DAT, the highest CGR was recorded in PR-26305-M-2 (13.03 g $m^{-2}day^{-1}$) and the lowest CGR was recorded in RD-2586 (6.75 g $m^{-2}day^{-1}$) (Table 3). The experimental results reflected the similar finding of differences of CGR with Tsai (1991) and Paranhos et al. (1997).

Relative growth rate: At 35 to 50 DAT, the highest RGR was recorded in Binadhan 4 (63.24 mg $g^{-1}day^{-1}$) and the lowest RGR was recorded in RD-2586 (48.33 mg $g^{-1}day^{-1}$) which was statistically similar to TNDB-100 (49.26 mg $g^{-1}day^{-1}$). During 50 to 65 DAT, the highest RGR was recorded in Binadhan 4 which was statistically similar to RNR-381 (27.11 mg $g^{-1}day^{-1}$) and the lowest RGR recorded in RD-2586 (22.15 mg $g^{-1}day^{-1}$) which was statistically similar to TNDB-100 (23.18 mg $g^{-1}day^{-1}$) (Table 3). Results of the present study was in agreement with Khan (1981) who stated that maximum RGR observed during vegetative stage.

Table 3. Leaf area index (LAI), crop growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR) of different advanced rice lines/variety during the growth period 35 to 65 DAT in Aman season, 2004

Treatments	LAI			CGR (g m^{-2} day^{-1})		RGR (mg g^{-1} day^{-1})		NAR (g m^{-2} day^{-1})	
	35 DAT	50 DAT	65 DAT	50-35 DAT	65-50 DAT	50-35 DAT	65-50 DAT	50-35 DAT	65-50 DAT
PNR- 381	1.3 bc	2.7 ab	4.4 a	16.6 b	11.1 b	62.5 a	27.1 a	8.1 a	3.7 a
RD-2586	1.4 b	2.2 b	3.0 b	12.3 d	6.8 d	48.3 c	22.2 c	6.0 b	3.4 c
PR-26305-M-2	1.8 a	3.1 a	4.9 a	19.0 a	13.0 a	59.4 ab	25.2 b	8.6 a	3.6 b
TNDB-100	1.4 b	2.2 b	3.1 b	12.5 cd	10.3 c	49.3 c	23.2 c	5.8 b	3.4 c
DM-25	1.5 b	2.5 ab	3.6 b	12.6 cd	10.6 c	53.2 bc	26.1 ab	6.0 b	3.6 a
Binadhan 4	1.0 c	2.2 b	3.5 b	13.4 c	9.9 c	63.2 a	27.3 a	7.9 a	3.7 a
Level of significance	**	*	**	**	**	**	**	**	**
CV(%)	9.32	9.74	8.75	4.10	7.68	4.79	5.47	5.88	4.95

Figures in the same column having similar letters do not differ significantly whereas dissimilar letters differ significantly as per DMRT; * = Significant at 5% level of probability; ** = Significant at 1% level of probability; DAT = Days after transplanting

Net assimilation rate: At 35 to 50 DAT, the highest NAR (8.55 g $m^{-2}day^{-1}$) was recorded in PR-26305-M-2 which was statistically similar to PNR-381 (8.09 g $m^{-2}day^{-1}$) and Binadhan 4 (7.92 g $m^{-2}day^{-1}$). The lowest NAR (5.84 g $m^{-2}day^{-1}$) was recorded for TNDB-100 which was statistically similar to RD-2586 (5.95 g $m^{-2}day^{-1}$) and DM-25 (5.99 g $m^{-2}day^{-1}$) (Table 3). During 50 to 65 DAT, the highest NAR was recorded in check variety Binadhan 4 (3.73 g $m^{-2}day^{-1}$) which was statistically similar to PNR-381 (3.68 g $m^{-2}day^{-1}$) and DM-25 (3.64 g $m^{-2}day^{-1}$). The lowest NAR was recorded in RD-2586 (3.37 g $m^{-2}day^{-1}$) which was statistically similar to TNDB-100 (3.41 g $m^{-2}day^{-1}$). Higher NAR at early growth stages manifested the higher photosynthetic efficiency. The decrease of NAR later growth stage might be possibly due to mutual shading and increased number of old leaves, which could have lowered photosynthetic efficiency (Reddy et al., 1995).

Grain yield: Results presented in Table 4 shows that the highest grain yield was produced by RD-2586 (5.18 t ha^{-1}) which was statistically similar to check variety Binadha-4 (5.07 t ha^{-1}). The lowest grain yield was produced by DM-25 (3.54 t ha^{-1}) which was followed by PNR-381 (3.91 t ha^{-1}). The RD-2586 showed the high productivity in grain among the advanced rice lines/variety and it was mainly due to its heaviest grains. On the other hand, DM-25 was produced lower grain yield among the advanced rice lines/variety mainly for its lowest grain weight although it had the highest spikelets $panicle^{-1}$. Differences in grain yield of rice due to varieties were also reported by Cheng and Cheng (1989), Suprithatno and Sutaryo (1992), Leenakumari et al. (1993), Biswas et al. (1998) and Guowei et al. (1998).

Straw yield: The highest straw yield was produced by RD-2586 (6.73 t ha^{-1}) which was statistically similar to check variety Biandhan-4 (6.58 t ha^{-1}) and TNDB-100 (6.49 t ha^{-1}). The lowest straw yield was produced by PNR-381 (5.13 t ha^{-1}) (Table 4).

In conclusion, it could be said that the advanced rice lines RD-2586, PR-26305-M-2 and TNDB-100 produced statistically same yields (5.18, 4.86 and 4.47 t ha^{-1}, respectively) as that of the check variety Binadhan 4 (5.07 t ha^{-1}). But the advanced lines required less crop duration, so they may be further evaluated for confirmation of yield and release as variety.

Table 4. Yield contributing characters of different advanced rice lines

Treatments	No. of spikelets panicle^{-1}	No. of grains panicle^{-1}	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
PNR- 381	116.5 ab	92.0 cd	22.37 c	3.91 bc	5.13 c	9.04 c	43.3 b
RD-2586	113.1 b	90.9 d	28.47 a	5.18 a	6.73 a	11.91 a	43.5 b
PR-26305-M-2	117.6 ab	95.1 bc	23.43 c	4.86 ab	5.86 b	10.72 b	45.3 a
TNDB-100	109.6 c	87.7 e	26.04 b	4.47 ab	6.49 a	10.96 b	40. 8 c
DM-25	122.2 a	96.5 ab	21.83 c	3.54 c	5.57 b	9.11 c	38.9 d
Binadhan 4	120.5 a	99.4 a	27.44 b	5.07 a	6.58 a	11.65 a	43.5 b
Level of significance	**	**	**	**	**	**	**
CV(%)	3.08	3.91	3.84	6.83	3.71	4.85	3.92

Figures in the same column having similar letters do not differ significantly whereas dissimilar letters differ significantly as per DMRT; * = Significant at 5% level of probability; ** = Significant at 1% level of probability

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