Agronomic Performance of Premium Quality Advanced Breeding Lines of Indica Rice

ABSTRACT

An experiment was conducted at the Research field in the west byed of Bangladesh Rice Research Institute (BRRI), Gazipur-1701 during the rabi season (December 2023 to May 2024) to assess the advanced breeding lines concerning yield and other agronomic characteristics of select premium quality rice. The experiment was laid out using a Randomized Complete Block Design (RCBD), comprising eight treatments (five advanced breeding lines and three controls) in three replications. The total numbers of plots were 24. All treatments received full of the recommended doses of N, P, K, S & Zn fertilizers. BRRI dhan104, BRRI dhan107 and BINA dhan25 were used as Check variety. Crops were harvested at 80% maturity, and the data on the growth parameters and grain and straw yields were recorded. All statistical analyses were conducted with the PB Tools v 1.4. (Version 1.4) package. Results indicated that considering the various agronomic parameters of the advanced lines, the treatment T3 = BR10648-12-1-3-4-1 and T4 =Zira (Nachol) yielded significantly higher than any other varieties of the experiment. It possesses a superior quality long and slender grain, an excellent 1000 grain weight, and a growth duration of 138 days. These advanced lines can be included in the variety development pipeline to release a variety.

Keywords: Rice; premium quality; treatment; yields; slender grain; variety.

1. INTRODUCTION

Rice is the staple food of Bangladesh and plays a central role in the nation's culture, economy, and nutrition. The country is one of the largest rice producers in the world, with rice cultivation occupying around 75% of the total arable land. In fact, rice is not just a dietary staple, but a symbol of livelihood for millions of rural families in Bangladesh, where it forms the backbone of both agricultural activity and food security. Bangladesh is the fourth largest producer and consumer of rice in the world with an annual production ranging from 52 to 53 million tons (FAO, 2018). It occupies 77% of total cropped areas and it alone constitutes about 92% of the total food grains produced annually in the country (Karim et al., 2007). A modest estimate suggests that the demand for rice in Bangladesh will increase by over 80% in the next 20 years to feed the growing population (Hasan et al., 2011). The introduction of modern rice varieties took place in the mid-1960s, prompting the establishment of the Bangladesh Rice Research Institute (BRRI) in 1970. BRRI was founded with the aim of developing improved rice varieties tailored to the specific growing conditions prevalent in Bangladesh (Islam *et al*., 2019). The quality of rice grains is a multifaceted characteristic encompassing aroma, flavor, milling properties, visual appearance, and the overall experience of cooking and consuming the rice (Anacleto *et al*., 2015 & Custodio *et al*., 2019). The eating and cooking quality (ECQ) of rice plays a crucial role in determining its economic worth in the market and fostering consumer satisfaction. As such, it has been a primary focus in rice breeding initiatives due to its significance (Sreenivasulu *et al*., 2022). Assessment of rice quality can also be based on specific characteristics or Variability attributes, which are categorized as either intrinsic or extrinsic factors (Demont & Ndour, 2015). This involves collaboration with local experts and the examination of the physico-chemical properties of the grain (Calingacion *et al*., 2014). Premium quality rice refers to the superior varieties of rice that are known for their excellent texture, flavor, appearance, and overall quality, making them highly sought after in both domestic and international markets. In Bangladesh, premium rice varieties are prized not only for their taste but also for their agricultural value, as they require specific growing conditions, care in cultivation, and meticulous processing methods. Quality serves as a significant driver in enhancing the value chain of food in developing nations. Nonetheless, defining "rice quality" is complex and lacks a universally applicable definition, particularly in the rice sector. Furthermore, there is a lack of consensus on the appropriate methods for measuring it. Unlike agronomic traits, which can be quantified by their impact on yields or stress tolerance, assessing quality attributes is more intricate as it is subjective and varies depending on the context (Fitzgerald *et al*., 2009). It is difficult to evaluate rice grain quality preferences from a global perspective because rice quality differs between countries and target zones (Custodio *et al*., 2019). For instance, consumers in Southern China, India, Bangladesh, Sri Lanka, and Pakistan show a preference for long, slender grains with varying textures ranging from fluffy to firmer. To cater to these preferences, breeders focus on developing varieties with intermediate to high amylose content. On the other hand, consumers in Northern China, Japan, and South Korea prefer medium grains with a softer texture, leading to the development of varieties with lower amylose content. The productivity and quality of rice depend on the genetic characteristics of cultivars, as well as environmental factors and management practices. Selecting the appropriate variety is crucial for increasing rice production. Rice yield fluctuates due to various growing conditions such as different geographical locations, seasonal variations, and varying planting dates (Sarker, 2002). It is, therefore, to evaluate the performance of rice varieties through appropriate cultural practices to get maximum yield and quality in multi-locations trial is very important. Development of rice cultivars with a high yielding ability is one of the most fundamental approaches for dealing with the expected increase in the world demand (IRRI, 1993). While there is ample research data available on individual rice varieties, there is a scarcity of documented comparative studies focusing on the morpho-physiological characteristics of rice cultivars specifically during the Boro season in Bangladesh. This research work gives an account of growth and yield performance of some premium quality advanced breeding lines to meet up the demand of the nations. This study describes the breeding procedures, agro morphological characters and grain quality of some premium quality advanced breeding lines.

2. MATERIALS AND METHODS

The experiment was conducted at the research field of Bangladesh Rice Research Institute (BRRI), Gazipur-1701 during the winter (Rabi) season (December 2023 to May 2024). Geographically, the experimental site is located at 23.99 N latitude and 90.40° E longitude at an elevation of 15 m above the mean sea level. The soil belongs to the Agro-Ecological Zone of Madhupur Tract (AEZ-28). The land is moderately well drained above the flood level with a silty clay loam texture, and sufficient sunshine is available through the experimental period. Seeds were collected from Bangladesh Rice Research Institute (BRRI), Gazipur, Bangladesh. The experiment was laid out in a Randomized Complete Block Design with eight treatments and three replications. The total numbers of plots were 24. The unit plot size was (5 m × 4 m) =20 m^2 the whole experimental plot was divided into 3 blocks; the blocks were treated as replications. There were 8 treatments including five advanced breeding lines and three control in the plots. The treatments were as follows: T_1 = BR10645-6-4-8-1-2, T_2 = BR10646-3-2-2-4-3, T_3 = BR10648-12-1-3-4-1, T_4 = Zira, Nachol, T_5 = Katari, Shibganj, T_6 = BRRI dhan104 (Check variety), T_7 = BRRI dhan107 (Check variety) and T_8 = BINA dhan25 (Check variety). A piece of high land was selected for raising seedlings. The land was prepared by repeated ploughing with a power tiller. Well decomposed cow dung (10kg) was applied in the seedbed before 30 days ago. Weeds were removed and stubbles were uprooted. The pre-germinated seeds were broadcasted uniformly in the seedbed on 10^{th} December, 2023. Land preparation was started on 7^{th} December 2023. At first, the main land was prepared by ploughing and cross ploughing and subsequently leveled by laddering. Thereafter, the land was ploughed and deep ploughing was obtained for good tilth, which was necessary to get better yield. Laddering was done in order to break the soil clods into small pieces followed by each ploughing. The amount of nitrogen (N), phosphorus (P), potassium (K), sulphur (S) and zinc (Zn) required for each plot were calculated and were applied by following the Fertilizer Recommendation Guide (FRG, 2018). According to the Fertilizer Recommendation Guide (FRG, 2018), the rate of Urea, TSP, MP, Gypsum and $ZnSo_4$ for rice were 138 (300 kg), 20 (100 kg), 83 (165 kg), 20 (112 kg) and 4 (11 kg), respectively. The full doses of chemical fertilizers except urea were applied before sowing as basal dose to all the experimental plots. Urea fertilizer was applied in three splits such as 15 DAT, 30 DAT, and 45 DAT, respectively. Seedlings were uprooted carefully from the nursery bed. Before uprooting the seedlings, nursery bed was slightly irrigated for easier uprooting. The uprooted seedlings were transplanted in the unit plots on 13^{th} January, 2024 respectively maintaining spacing of 20 cm × 20 cm (Row to Row and Plant to Plant distance) at the rate of 2-3 seedlings/hill. Intercultural operations such as weeding, gap filling, insect and pest control, irrigation and water management were done in order to ensure and maintain the normal growth of the crop. The crops were harvested at 80% maturity on 3^{rd} May 2024. From each plot 12 randomly selected hills were collected and then plants of each plot were harvested separately. The data of plant growth (plant height, panicle length, grain length, grain breadth, grain length-breadth ratio) and yield components (grain yield, effective and non-effective tillers hill^{-1}, spikelet's panicle^{-1} and 1000-grain weight) were determined. Statistical analyses were done using the PB Tools v 1.4. (Version 1.4) package. The effects of NPKSZn fertilizers on grain yield, straw yield, yield components were determined using a two-way analysis of variance (ANOVA) model. The least significant difference (LSD) test at the 95% level of confidence was performed to differentiate the means. The graphs were prepared using MS Excel 2019.

3. RESULTS AND DISCUSSION

The agronomic performance of eight premium quality rice was observed at BRRI farm, Gazipur. All the observed data recorded was found significant at 1% level except for straw yield (t/ha) which was found significant at 5% level with not significant harvest index. The observed findings are described below:

3.1 Plant height (cm)

The highest plant height was recorded for BINA dhan25 (Ck) (137 cm) whereas lowest was recorded for BRRI dhan107 (Ck) (110 cm). The plant height of the tested genotypes ranged from 112-123 cm. Lsd value (0.05) indicated that there was significant difference found for all the genotypes with check variety BINA dhan25. There was not significant variation among the plant heights of Zira (Nachol), Katari (Shibgonj), BRRI dhan104 (Ck) and BRRI dhan107 (Ck).

Significant difference was found for BR10645-6-4-8-1-2, BR10646-3-2-2-4-3 and BR10648-12-1-3-4-1 with check variety BRRI dhan104 (Ck) and BRRI dhan107 (Ck). Heritability of plant height was found 0.96 which indicated high precision of the experiment. Moderate plant height ranged from 100-115 cm for selecting plant would be desirable to avoid lodging of the plants in unfavorable weather. Liu et al. (2018) also emphasized on semi-dwarf plant height in his review article.

3.2 Days to 50% flowering

The highest days to 50% flowering was recorded for BRRI dhan104 (Ck) (130 days) whereas lowest was recorded for Zira (Nachol) (114 days). The days to 50% flowering of the tested genotypes ranged from 114-125 days. There was significant difference found for all the genotypes for days to 50% flowering with BRRI dhan104 (Ck), BRRI dhan107 (Ck) and BINA dhan25 (Ck). Heritability of days to 50% flowering was found 0.97. BR10648-12-1-3-4-1 and Zira (Nachol) might be selected and used in the hybridization program due to their lowest days to 50% flowering. This finding was also supported by Roy and Roy (2021).

3.3 Growth duration (days)

The highest growth duration was recorded for BRRI dhan104 (Ck) and BRRI dhan107 (Ck) (148 days) whereas lowest was recorded for BR10648-12-1-3-4-1 and Zira (Nachol) (138 days). There was significant difference found for all the genotypes for growth duration with the check varieties except for BR10646-3-2-2-4-3 and BINA dhan25 (Ck). High heritability 0.89 was found for the experiment. BR10648-12-1-3-4-1 and Zira (Nachol) had the lowest growth duration. Selection based on growth duration coupled with grain yield is the best selection criteria for forwarding a genotype into the varietal release pipeline. BRRI (2020) suggested this kind of findings in the experiments.

3.4 Tiller no./hill

The highest tiller no./hill was recorded for Zira (Nachol) (14.72) followed by Katari (Shibganj) (13.25) and lowest was recorded for BR10645-6-4-8-1-2 (12.27). High heritability (0.81) was found for the trait. Moderate tiller no./hill is good for successful selection of any breeding trial. All the tested genotypes had a moderate no. of tillers per hill.

3.5 Panicle no./hill

The highest panicle no. /hill was recorded for Zira (Nachol) (13.56) followed by BINA dhan25 (11.48) and lowest was recorded for BR10645-6-4-8-1-2 (11.08). High heritability (0.88) was found for the trait. All the other tested genotypes produced similar nos. of panicles per hill in the experiment. Moderate panicle no./hill is good for successful selection for any breeding trial. This study was also found similar to that of Roy and Roy (2021).

3.6 Panicle length (cm)

The highest panicle length (cm) was recorded for BRRI dhan107 (Ck) (31.0 cm) followed by BRRI dhan104 (Ck) (30.67 cm) whereas lowest was recorded for Zira (Nachol) (26.39). There was significant difference found for almost all the genotypes for panicle length except for BR10646-3-2-2-4-3. High heritability (0.98) was found for the trait. A long panicle length with less no. of empty grain is a good selection criterion in the hybridization as well as breeding trial. All the genotypes in this experiment had long panicle. So, the genotypes could be forwarded based on panicle length, growth duration and grain yield performance. Roy and Roy (2021) also found genotypes which 15.8-30.6 cm long panicle in Boro season.

3.7 Grain length (mm)

The highest grain length (cm) was recorded for BRRI dhan104 (Ck) (11.10 cm) followed by BRRI dhan107 (Ck) (10.95 cm) and BINA dhan25 (Ck) (9.92) whereas lowest was recorded for Katari (Shibganj) (9.35). The grain length as a selection criterion is very effective for premium quality rice in the hybridization program. High heritability (0.98) was found for the trait.

3.8 Grain breadth (mm)

The highest grain breadth (cm) was recorded for BRRI dhan104 (Ck) (1.98 cm) followed by BRRI dhan107 (Ck) (1.87 cm) and BR10646-3-2-2-4-3 (1.77 cm) whereas lowest was recorded for Katari (Shibganj) (1.67 cm). The grain breadth of all the genotypes represented the beauty of the grains of the genotypes were slender. Further experiments could be done to know the physico-chemical properties of the grain to be used in the breeding programs. High heritability (0.93) was found for the trait.

3.9 Filled spikelet/ panicle (nos.)

The highest filled spikelet no. of the panicles was recorded for Katari (Shibganj) (143) followed by BR10645-6-4-8-1-2 (133) and BINA dhan25 (Ck) (129) whereas lowest was recorded for BRRI dhan104 and BRRI dhan107 with 86 grains per panicle. High heritability (0.99) was found for the trait. The filled spikelet no. per panicles as a selection criterion is very effective for rice in the hybridization program.

3.10 Unfilled spikelet/ panicle (nos.)

The highest unfilled spikelet no. of the panicles was recorded for BINA dhan25 (Ck) (44) followed by BRRI dhan107 (32) and BRRI dhan104 (Ck) (29) whereas lowest was recorded for BR10648-12-1-3-4-1 (12). The less the no. of unfilled grains per panicle the higher the grain yield of the genotypes. High heritability (0.99) was found for the trait. The less chaffy grains as a selection criterion are very effective for rice in the hybridization program.

3.11 Total Spikelet/ panicle (nos.)

The highest spikelet no. per panicle was recorded for BINA dhan25 (Ck) (173) followed by Katari (Shibganj) (162) and BR10645-6-4-8-1-2 (157) whereas lowest was recorded for BRRI dhan104 (115). High heritability (0.99) was found for the trait. The more the no. of spikelet per panicles the more the grain yield of the genotypes.

3.12 Spikelet fertility (%)

The highest spikelet fertility (%) was recorded for BR10648-12-1-3-4-1 (91.23) followed by Katari (Shibganj) (88.17) and BR10645-6-4-8-1-2 (85.03) whereas lowest was recorded for BRRI dhan107 (Ck) (72.97). There was significant difference found for almost all the genotypes for spikelet fertility (%). High heritability (1.00) was found for the trait. Roy and Roy (2021) found a maximum of 91.97% spikelet fertility for rice varieties. Sultana et al. (2020) also studied 65.55% fertility in CN_6 rice genotype.

3.13 1000 grain weight (g)

The highest grain weight (g) was recorded for BRRI dhan107 (Ck) (26.71 g) followed by BRRI dhan104 (Ck) (25.68 g) and BR10646-3-2-2-4-3 (20.33 g) and whereas lowest was recorded for BINA dhan25 (19.08). Heritability was recorded 0.95 for 1000 grain weight. BR10646-3-2-2-4-3, BR10648-12-1-3-4-1 and Zira (Nachol) could be used as parent as the 1000 grain weight is higher in the hybridization program. Khatoon et al. (2021) found the 1000 grain weight of the rice genotypes ranged from 19.97-24.30 g in her study.

3.14 Straw yield (t/ha)

The highest straw yield (t/ha) was recorded for Zira (Nachol) (8.07 t/ha) followed by BR10648-12-1-3-4-1 (7.80 t/ha) and BR10645-6-4-8-1-2 (6.39 t/ha) and whereas lowest was recorded for Katari (Shibganj) (6.91 t/ha). Heritability was recorded 0.71 for straw yield (t/ha).

3.15 Grain yield (t/ha)

The highest grain yield (t/ha) was recorded for Zira (Nachol) (7.40 t/ha) followed by BR10648-12-1-3-4-1 (7.12 t/ha) and BR10645-6-4-8-1-2 (6.64 t/ha) and whereas lowest was recorded for BINA dhan25 (6.23 t/ha). The grain yield of BR10648-12-1-3-4-1 and Zira (Nachol) was recorded significant higher yield from the check varieties BRRI dhan104, BRRI dhan107 and BINA dhan25. Grain yield of other varieties were more or less similar with the check varieties. These two genotypes could be forwarded with varietal development pipeline to release as a variety. High heritability (0.81) was found for grain yield. The heat map of the experimental plot is shown in Fig. 1. The Fig. 1 represented that the grain yield variation of the genotypes in three blocks. The different blocks also showed the variability of grain yield among different blocks.

3.16 Harvest Index (HI)

Harvest index was ranged from 0.46 to 0.48 for the genotypes. All the genotypes had similar HI. The grain yield of the genotypes could be increased with the increased HI. Du et al. 2022 also supported HI with this range in his finding.

3.17 Physicochemical Properties

BR10648-12-1-3-4-1 and Zira, Nachol both have a long slender grain. The milling outturn of the two lines are 69% and 70% with the head rice recovery 61% in both lines (Table 1). BR10648-12-1-3-4-1 and Zira, Nachol both are straight and could be milled in any kind of milling machine. This result revealed that BR10648-12-1-3-4-1 and Zira, Nachol both will get high market price because of high protein (8.0% in BR10648-12-1-3-4-1 and 7.7% in Zira, Nachol), long slender type grain. The amylose percentage of BR10648-12-1-3-4-1 and Zira, Nachol are 25.4%.

4. CONCLUSIONS

To achieve food security and grain yield has to be targeted leading to self-sufficiency of the country, the people of Bangladesh are also focusing on the grain quality of rice. The premium quality rice is a very good for table rice as well as it can earn foreign currency by exporting due to its high demand in the world. In the current study, five premium quality rice was tested along with three existing premium quality rice. Considering the different agronomic parameters, it was concluded that the premium quality T_3 = BR10648-12-1-3-4-1 and T_4 = Zira (Nachol) yielded significantly higher than any other varieties of the experiment. It has a premium quality long and slender grain, good 1000 grain weight with 138 days growth duration. This varieties can be included in the variety development pipeline to release a variety. The tested genotypes in the experiment were premium quality type. Further study is recommended to confirm the grain yield and other agronomic data. Grain quality parameters including the head rice yield, milling outturn and other physicochemical study must be conducted to confirm the quality of the rice of the genotypes. The eating quality must be tasted to perceive the experience of the flavor of rice.

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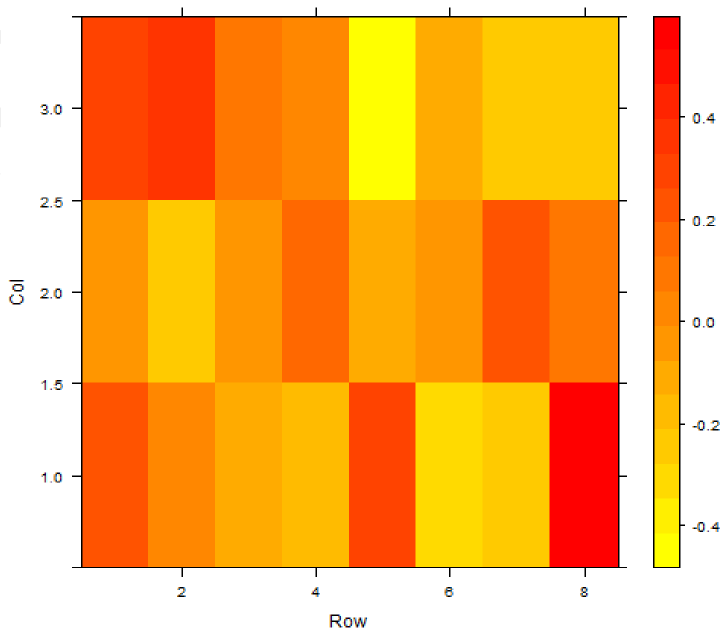

Fig: 1 The heat map of the rice experimental field in response to grain yield (t/ha) at BRRI, Gazipur

Table 1: Physico-chemical properties of some advanced breeding lines

Designation	Milling outturn (%)	Head rice yield (%)	Milled Rice length (mm)	Milled Rice breadth (mm)	L-B ratio	Size & Shape	Amylose (%)	1000 grain weight (g)	Protein (%)	ER	IR	Chalkiness (%)
BR10645-6-4-8-1-2	70	57	6.5	2.0	3.3	LS	25.7	19.4	8.1	1.5	3.9	72
BR10646-3-2-2-4-3	70	56	6.3	1.9	3.3	LS	25.0	19.4	8.1	1.5	4.8	71
BR10648-12-1-3-4-1	**69**	**61**	**6.3**	**1.9**	**3.4**	**LS**	**25.4**	**18.3**	**8.0**	**1.7**	**4.5**	**81**
Zira, Nachol	**70**	**61**	**6.1**	**2.0**	**3.1**	**LS**	**25.4**	**17.8**	**7.7**	**1.4**	**4.3**	**50**
Katari, Shibganj	62	60	4.9	1.8	2.8	SB	25.0	13.5	8.1	1.6	4.8	64
BRRI dhan104(Ck)	66	49	7.2	1.7	4.2	LS	24.0	26.3	8.5	1.3	4.0	-
BRRI dhan107(Ck)	70	56	7.9	1.7	4.5	ELS	27.4	27.1	8.6	1.4	3.9	-
BINA dhan25(Ck)	65	60	8.0	1.7	4.7	ELS	25.1	19.7	6.6	1.4	-	-

Table 2: Agronomic performance of some premium quality indica rice genotypes, Boro 2023-24, BRRI, Gazipur

Entry	Designation	Plant height (cm)	Days to 50% flowering	Growth duration (days)	Tiller no./hill	Panicle no./hill	Panicle length (cm)	Grain length (mm)	Grain breadth (mm)	Filled spikelet/ panicle (nos.)	Unfilled spikelet/ panicle (nos.)	Total Spikelet/ panicle (nos.)	Spikelet fertility (%)	1000 grain weight (g)	Straw yield (t/ha)	Grain yield (t/ha)	Harvest Index (HI)
1	BR10645-6-4-8-1-2	117	124	145	12.27	11.08	29.36	9.49	1.72	133	23	157	85.03	18.99	7.39	6.64	0.47
2	BR10646-3-2-2-4-3	123	125	143	13.05	11.28	30.21	9.81	1.77	114	26	141	81.39	20.33	7.03	6.40	0.48
3	BR10648-12-1-3-4-1	120	118	138	12.42	11.30	29.67	9.89	1.74	126	12	138	91.23	19.56	7.80	7.12	0.48
4	Zira (Nachol)	112	114	138	14.72	13.56	26.39	9.35	1.76	111	26	138	80.98	19.25	8.07	7.40	0.48
5	Katari (Shibganj)	115	125	144	13.25	11.44	29.93	8.92	1.67	143	19	162	88.17	17.37	6.91	6.45	0.48
6	BRRI dhan104 (Ck)	111	130	148	12.91	11.30	30.67	11.10	1.98	86	29	115	75.04	25.68	7.02	6.42	0.48
7	BRRI dhan107 (Ck)	110	128	148	13.02	11.41	31.00	10.95	1.87	86	32	117	72.97	26.71	7.35	6.62	0.47
8	BINA dhan25 (Ck)	137	122	142	12.86	11.88	30.08	9.92	1.74	129	44	173	74.84	19.08	7.35	6.23	0.46
	$LSD_{0.05}$	4.8	2.4	3.6	0.897	0.770	0.751	0.263	0.071	4.7	2.1	6.6	0.866	2.114	0.601	0.484	0.029
	Level of significance	**	**	**	**	**	**	**	**	**	**	**	**	**	*	**	NS
	Heritability (h^2b)	0.96	0.97	0.89	0.81	0.88	0.96	0.98	0.93	0.99	0.99	0.99	1.00	0.95	0.71	0.81	

* Significant at 5% level, ** Significant at 1% level, NS: Not Significant