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Evaluation of NERICA rice mutant in Jhum cultivation

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Abstract

Jhum cultivation of rice is an ancient practice of the tribal people living in the hill tracts of Bangladesh. They can grow rice only once a year in the Aus season. Most of the varieties are traditional which are low yielding and long duration (140-160 days). Considering this situation, an experiment was carried out to evaluate the performance of NERICA rice *(Oryza sativa* L.*)* mutant- N_4/350/P-4(5) with check variety BRRI dhan48 and parent NERICA-4 for their growth, yield and duration in Aus season at jhum cultivation in Panchariupazila of Khagrachari hill tract. RCB design was followed for experimentation and data was collected during harvest. From the result it was observed that, maximum plant height (132.7 cm), percent unfilled grains/hill (45.02) and 1000 seed weight (33.69) was obtained from NERICA-4. Days to 50% flowering (78.33), days to maturity (95.33 DAD) and HI (15.35%) was also found to be lowest by NERICA-4. BRRI dhan48 exhibited lightest 1000 seed weight (26.91 g), maximum days to maturity (106 DAD) and similar percent of unfilled grains/panicle (42.87)as that of NERICA-4. NERICA mutant- N_4/350/P-4(5) had lowest percentage of unfilled grains/hill (17.62), earlier maturity (101 DAD) than BRRI dhan48 and highest HI (47.77%). Straw (11.70 t/ha) and biological yield (13.80 t/ha) was most at NERICA-4 and least at NERICA mutant (straw-4.80 t/ha and biological yield-9.10 t/ha). Grain yield (4.3 t/ha) was highest observed in NERICA mutant followed by BRRI dhan48 (4.0 t/ha) and NERICA-4 (2.30 t/ha). Being a short duration, high yielding and less pest infestation line; NERICA mutant-N_4/350/P-4(5) can be recommended for variety of aus season in the Jhum cultivation of hill tracts.

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Introduction

Rice (*Oryza sativa* L.) is the most extensively cultivated cereal crop in Bangladesh, which covers about 74% of the total cropped area (BBS, 2015). In respect of area and production of rice, Bangladesh ranks fourth following China, India and Indonesia (FAO, 2014).Bangladesh has three districts in Chittagong Hill Tracts (CHT) viz. Bandarban, Rangamati and Khagrachhari. The CHT region comprises about one tenth of the total area of Bangladesh. The area covers 13,295 sq. km consisting of about 77% upland (hill), 20% undulating bumpy land and 3% plain with high potential for agriculture development. Indigenous hill people are generally very poor, not enough educated and their livelihood depends mostly on wage earnings and Jhum cultivation. Jhum or shifting cultivation which is defined as a primitive system of agriculture, the first step in transition from food gathering and hunting to food production which is nearly 9000 years old in the world. A large number of CHT farmers still depend on the Jhum/Shifting cultivation which they have been practicing by generations. This traditional cultivation practice has been the only way of subsistence agriculture practice for many of the CHT people specially who are living in remote places. It is estimated that about 40,000 households are engaged with Jhum cultivation in CHT. Now a days, the shrinkage of Jhum fields and reducing yields has created a challenge for the Jumia families (Ullah *et al.,* 2012). Jhum cultivation is commonly practiced with rice, chilli, maize, wheat, yard long bean etc. For the well-being of human life, food security as well as livelihood security is a matter of concern. Proper utilization of hilly lands and human assets can contribute a lot to reduce household food insecurity in this region. Rice is the most common crop in Jhum farming and cultivated in rainfed condition and it is on aus season when first rain fall at the beginning of rainy season commonly the sowing time at March – May. Chorui, Bobboi, Company, Horinbinni, Kamarangdhan, Gallongbinni, Lanka poradhan, Uttosebinni, Binnidhan, Kamarangbinni, Laxmibinni, Dopchodaidhan, Guridhan, Torkeedhan, Angudhan, Koborockdhan, Marry dhan, Patti dhan, Pattiya dhan, Madhu maloti dhan, Mon angedhan, Amedhan, Badheiadhan, Longurdhan, China IRRI etc. are the local rice varieties commonly used for jhum cultivation in Khagrachari district (Chakma and Ando, 2008; Ullah *et al.,* 2012). But, these varieties are low yielded. In, 2016aus rice was cultivated in 4,428 hectares and average rice production (de-husked) of local cultivars were 1.44 t/ha and HYV were2.55 t/ha (DAE, 2016). Whereas, national average production of Aus rice is 2.23 t/ha (BBS, 2015). Due to low yield, more pest abundance and lack of appropriate variety farmers are unable to achieve higher yield. Two modern rice varieties (BRRI dhan43 and BRRI dhan27) and recently introduced variety NERICA was cultivated in Jhum condition but they could not perform better yield under the farmers' low inputs. As there has been very limited intervention on adaptive research on Jhum crops; there's more scope for research and development of high yielding cultivar for this region.

Different morphological traits play very important role for more rice production with new plant type characteristics associated with the plant yield (Shahidullah *et al.,* 2009). NERICA varieties were high yield potential and short growth cycle. Several of them possess early vigor during the vegetative growth phase and this is a potentially useful trait for weed competitiveness. Likewise, a number of them are resistant to African pests and diseases, such as the devastating blast, rice stem borers and termites. They also have higher protein content and amino acid balance than most of the imported rice varieties (WARDA, 2008). Though its cause of low productivity in Bangladesh is still unrevealed, the farmers found low tiller number, weak and fragile stem could be the important morphological characters that compromised the yield (reported in a discussion meeting organized by UBINIG, 28 September 2012). Yield potential of variety is determined by the genetic constituent (Roy *et al.,* 2014) which is manifested in the field under provided environmental conditions. Environment is the second most important factor that determines the gene expression and yield of crops.

Moreover, the scientists in the discussion meeting assumed that the low productivity could be due to climatic change and soil variation compared to its origin. For this reason mutation is applied to develop mutant lines to improve yield of NERICA lines in Bangladesh. Mutants have made it possible to identify critical elements for developing high yield potential varieties exhibiting desirable traits such as semi-dwarfism, early maturity, greater number of panicles/plant and increased fertility. The technique has been successfully utilized by Bangladesh Institute of Nuclear Agriculture (BINA) and many other research institutes on different crops (Das *et al.,* 1999; Azad *et al.,* 2012).

NERICA (New Rice for Africa) is an introduced rice variety from Uganda. It was created by crossing *Oryza glaberrima* and *Oryza sativa*. NERICA was well adapted to drought conditions in Africa. The yield potential of this variety is low ~5 t/ha. Bangladesh is one of the most climate vulnerable countries in the world. The climate change and variability is posing serious threat to agricultural productivity including rice production, the main food crop. Because, the rainfall patterns has been changed in the last couple of decades (Sultana, 2015). Consequently, it is predicted that drought would be one of the serious challenges to produce rice in rainfed condition areas. Thus, to develop a drought tolerant, short duration and high yielding rice variety NERICA can be an important breeding material. Considering the above situation field performance of NERICA mutant N_4/350/P-4(5) in the Jhum cultivation was evaluated to verify its yield potential and suitability in Jhum environment along with its parent NERICA-4 and check variety BRRI dhan48.

Materials and methods

The field experiment was conducted during Aus season (April-July) 2016 at the Moratila of Panchhari upazila under Khagracharihill district. It was laid out in a Randomized Complete Block Design (RCBD) with three replications. Unit plot size of the experiment was 6m ×5m, replication to replication distance 1m, spacing 20 cm × 15 cm; Which comprised of three rice variety/line viz. NERICA-4 (parent), N_4/350/P-4(5) (mutant) and BRRI dhan48 (check). Among them N_4/350/P-4(5) is a mutant line obtained from induced mutation of 350 Gyirradiation through Co 60gamma irradiator onNERICA-4 seed.

The total process of induced mutation and growth of mutant population were maintained at Bangladesh Institute of Nuclear Agriculture (BINA) head quarter located at Mymensingh. Among the mutant lines N_4/350/P-4(5) was selected for its drought tolerant, yield and yield contributing characters and finally set for evaluation in Jhum condition.

The seeds of those varieties were directly seeded by dibbling in Jhum cultivation. Urea, Triple super phosphates, muriate of potash, gypsum was applied @210-140-110-110 kg ha^{-1}. The whole dose of triple superphosphate, muriate of potash, gypsum and one third of nitrogen were applied at 20DAD (days after dibbling) and the remaining doses of nitrogen were applied in two splits at 40 DAD and 55 DAD.

Data collection

Randomly 10 hill were selected from unit plot and plant data were recorded after final harvest on-plant height, days to 50% flowering (day), no. of effective tillers/hill, no. of panicles/plant, panicle length (cm), no. of filled grains/panicle, no. of unfilled grains/panicle, 1000 seed weight (g), unfilled grain/hill (%), root length/plant, days to maturity (day), grain yield (t/ha), straw yield (t/ha) and biological yield (t/ha). Harvest index was calculated on the basis of adjusted grain and straw weight using the following formula (Munshi *et al.,* 2016)-

$$\text{Harvest index (\%)} = \frac{\text{Grain yield}}{\text{Grains yield + straw yield}} \times 100$$

Statistical analyses

The collected data were statistically analyzed using "Analysis of variance technique" with the help of computer package program MSTAT and the significance of mean difference was adjudged by Duncan's Multiple Range Test (Gomez and Gomez, 1984).

Results and discussion

The performance of different rice genotypes for grain yield and different yield contributing characters were evaluated (Table 1). Days to 50% flower initiation was earlier in NERICA-4 (78.33 days) followed by N_4/350/P-4(5) (83 days) and late in BRRI dhan48 (86 days)(Table1). Due to irradiative mutation floral biology was changed in the mutant, thus it took more days than its parent (NERICA-4). Nuruzzaman *et al.* (2016) reported days to fifty and eighty percent flowering of N_4/350/P-2(1)-32-11 rice mutant was 78.17 DAD and 84.51 DAD. Hasan (2014) recorded 81 to 82 days to fifty percent flowering in two NERICA-4 rice mutants under drought condition.

Table 1. Growth and yield components of Aus cultivars and NERICA mutant grown at Panchari, Khagrachari during Aus season (2015-16).

Variety	Days to 50% flowering	Plant height (cm)	No. of effective tillers/ hill	No. of panicle/ plant	Panicle length (cm)	No. of filled grains/ panicle	No. of Unfilled grains/ panicle	% Unfilled grains/ hill	1000 seed weight (g)	Root length/ plant (cm)	Days to maturity	HI (%)
NERICA-4	78.33 b	132.7 a	8.400 a	8.067 a	25.03 a	82.53 a	67.41 a	45.02 a	33.69 a	14.70 a	95.33 c	15.35 c
N_4/350/P-4(5)	83.00 a	116.6 b	10.73 a	9.733 a	24.00 a	56.86 a	11.89 b	17.62 b	29.26 b	11.16 a	101.0 b	47.77 a
BRRI dhan48	86.00 a	118.7 b	10.37 a	9.333 a	25.50 a	51.05 a	38.07 ab	42.87 a	26.91 c	10.59 a	106.0 a	35.25 b
LSD value	3.023	8.896	2.315	2.083	2.898	35.46	34.46	11.63	2.206	4.823	3.294	7.382
CV	1.62%	3.20%	10.39%	10.16%	5.15%	24.64%	19.43%	14.59%	3.25%	17.51%	1.44%	9.93%

Means bearing same letter(s) in a column do not differ significantly at 5% level of probability by DMRT.

Lower plant height is desirable in rice breeding. Considering plant height BRRI dhan 48 and N_4/350/P-4(5) had found statistically identical which are shorter than NERICA-4(132.7 cm) (Table1) (Fig. 2). Generally plant height is shortened in drought condition but longer height of NERICA-4 was may be due to its wild and genetic character. On the other hand the mutant N_4/350/P-4(5) and BRRI dhan48exhibited drought tolerance through reduced plant height. Nuruzzaman *et al.,* (2016) reported that the average range of plant height among the NERICA mutants were 73.43cm to 114.77cm.

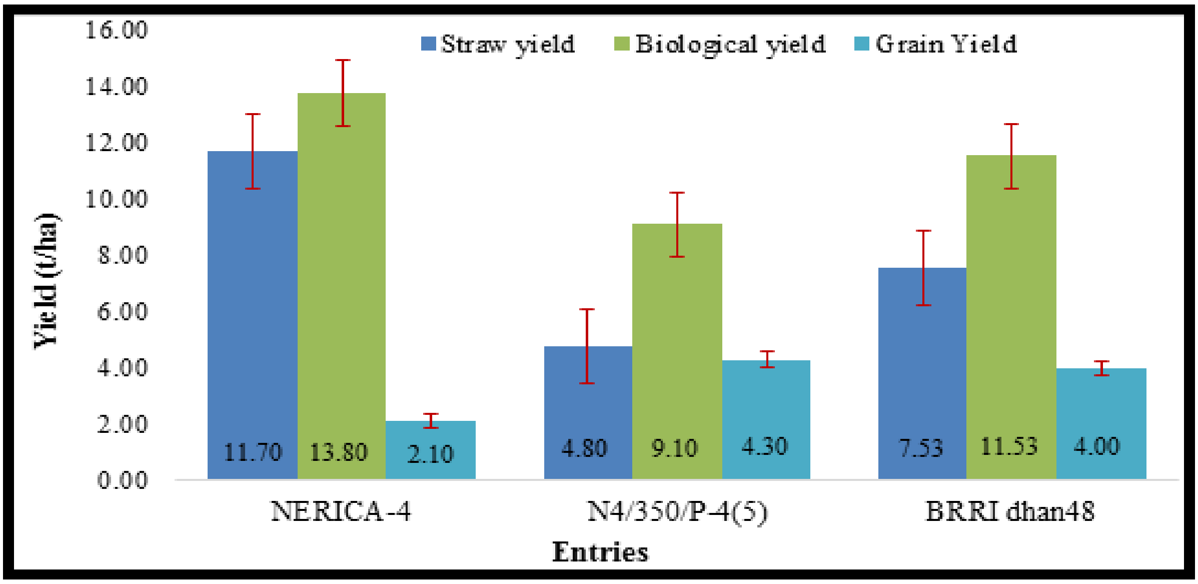

Fig. 1. Yield of NERICA mutant, it's parent and check variety.

There were no statistical differences among the studied variety/line in case of effective number of tillers per hill, number of panicles per plant, panicle length (Fig.3), number of filled grains per panicle and root length of individual plant (Table1)(Fig.2). Deshmukh (2012), reported that average number of tillers per plant across the genotypes was 5.4 under rainfed and 7.0 under irrigated conditions. Nuruzzaman *et al.,* (2016) found that under rainfed condition, average effective tillers/hill of NERICA-4 was 7.33, panicle length was 20.60 cm and effective tillers/hill of N_4/350/P-2(1)-32-11 was 14 in the Aus season.

Hasan (2014) found that, effective number of tillers varied from 6.67 to 10.00 and panicle length varied from 23.67 to 24.33 among two NERICA-4 mutants.

Number and percent of unfilled grains was the highest in NERICA-4 (67.41 and 45.02%) and the lowest in N_4/350/P-4(5) (11.89 and 17.62%) (Table1). BRRI dhan48 gave statistically identical results as NERICA parent. NERICA-4may have genetic character to produce unfilled grains due its wild type nature. On the other hand, NERICA mutant may have high pollen viability than its parent and thus produced less unfilled grains. Increased number of unfilled grains/panicle usually gives fewer yields. Unfilled grain is higher at drought or stress condition. There was significant difference in thousand seed weight (Table1). NERICA-4 had the highest weight (33.69g) followed by NERICA mutant N_4/350/P-4(5) (29.26g) and BRRI dhan48 (26.91g). Seed coat of NERICA-4 is hard, bold; seed length and diameter is greater than the others thus weighing more.

Fig. 2. Plant height and root length of NERICA-4 (A), N_4/350/P-4(5) (B) and BRRI dhan48 (C).

Root length variation was non-significant in the three entries (Table 1). It is the indication of nutrient availability of the top soil's horizon which is higher than the other depth horizon; for this reason the rooting depth may be lower in these three entries. Rice varieties which avoid drought usually have deep, coarse roots with a high ability in branching and penetration (Wang *et al.,* 2006).

Considering days to maturity there were significant differences was found among the genotypes (Table 1). NERICA-4 matured earlier (95.33 days) than the mutant N_4/350/P-4(5) (101 days) followed by BRRI dhan48 (106 days). To escape drought NERICA-4 may have matured earlier to shorten its lifecycle. On the other hand, N_4/350/P-4(5) took more days to maturity than its parent to gain more grain yield. BRRI dhan48 took more days to maturity due to its own genetic makeup. Nuruzzaman *et al.,* (2016) concluded that NERICA rice mutants required 105.5 to 107.3 days to gain maturity. Flowering time is an important trait related to drought adaptation, where a short life cycle can lead to drought escape (Araus and Royo, 2002).

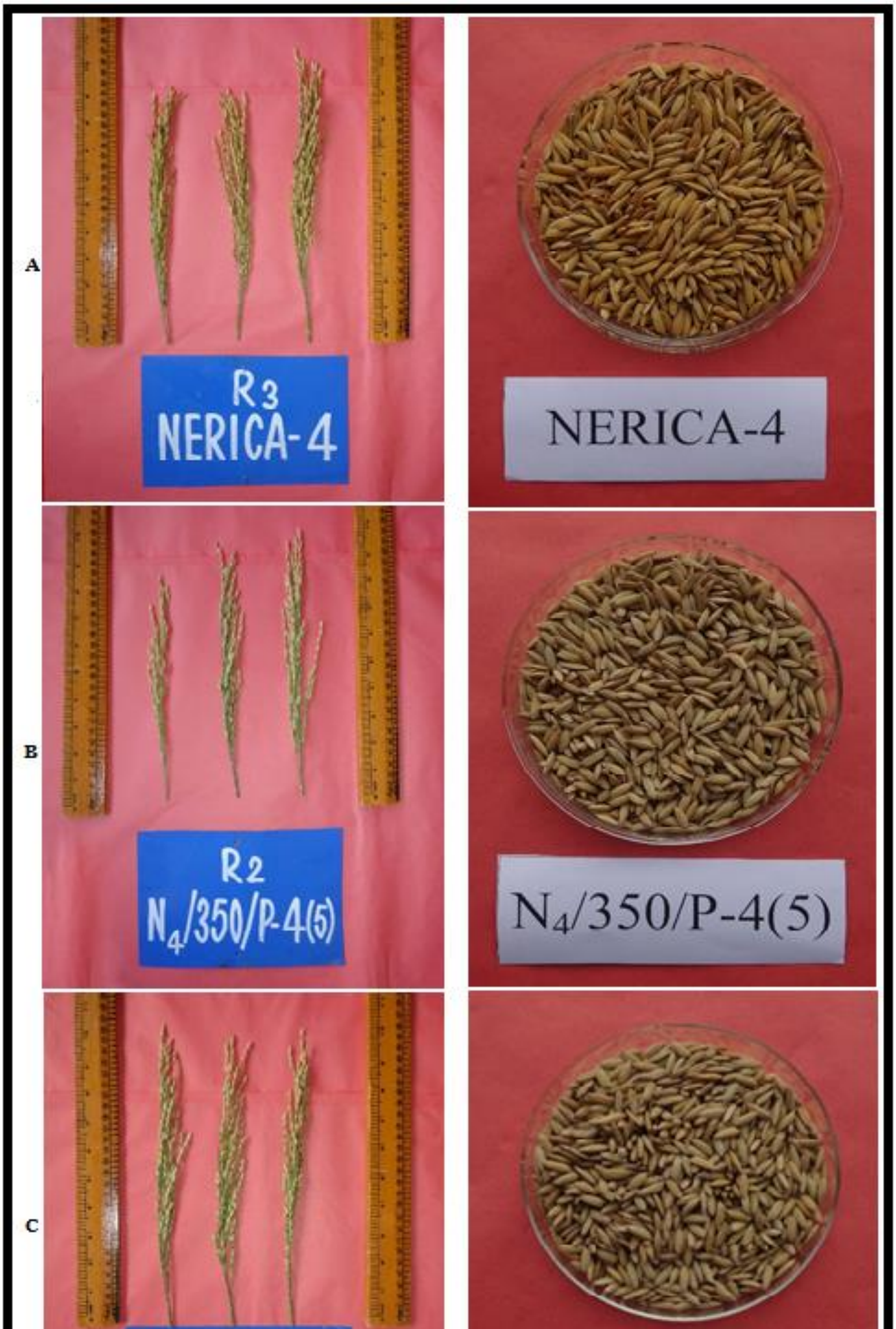

Fig. 3. Panicle length and seed morphology of NERICA-4 (A), N_4/350/P-4(5) (B) and BRRI dhan48 (C).

Maximum straw (11.70 t/ha) and biological yield (13.80 t/ha) was obtained from NERICA-4 followed by BRRI dhan48 (7.53 t/ha and 11.53 t/ha) and N_4/350/P-4(5) (4.80 t/ha and 9.10 t/ha) (Fig. 1).

Being a low yielding, short duration, wild vigorous bushy type nature and over all genetic characteristics to gain more vegetative growth rather than grain yield may have caused to produce more straw and biological yield in NERICA-4. Contrary, N_4/350/P-4(5) utilized available resources to store food materials in sink (grain) and thus giving less emphasis for vegetative growth.

Grain yield and harvest index is a vital character having physiological importance. Considering grain yield and HI the mutant line N_4/350/P-4(5) showed highest grain yield and HI 4.30 t/ha and 47.77%respectively than the BRRI dhan48 4.0 t/ha and35.35% (Table 1 and Fig. 1).

Lowest HI (15.35%) and yield (2.10 t/ha) was found in NERICA parent NERICA-4. Cui *et al.,* (2000) highlighted the contribution of high harvest index to yields. High yield is determined by physiological process leading to a high net accumulation of photosynthates and their partitioning (Miah *et al.,* 1991).

Conclusion

From the result of this experiment it can be concluded that NERICA mutant N_4/350/P-4(5) can be recommended for variety of Ausseason in jhum cultivation because of its higher yield, shorter duration and drought tolerance than BRRI dhan48, NERICA-4 and other local traditional cultivars used by the tribal farmers during Aus season.

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