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Article

Morphological characterization and assessment of genetic parameters of NERICA mutant rice lines under rainfed condition

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Abstract: An experiment was conducted to evaluate thirty one NERICA mutant rice genotypes (twenty eight NERICA mutant lines along with three parental lines) of advanced (M_4 and M_5)generations for morphological characters and genetic parameters assessment in aus season, 2014 at the experimental field of Biotechnology division, BINA, BAU Campus, Mymensingh-2202 following Randomized Complete Block Design (RCBD) with three replications. The genotypes differed significantly for all the traits *viz.*, days to flowering (1^{st}, 50%, 80%), days to maturity, plant height, total tillers and effective tillers hill^{-1}, filled and unfilled grains panicle^{-1}, 100-seed weight (g) and yield plant^{-1}(g).N_1/300/P-9-5 had maximum yield plant^{-1} and N_4 parent had minimum yield plant^{-1}. All the parental lines showed less yield compared to other mutant lines. The phenotypic co-efficient of variations (PCV) were higher than genotypic co-efficient of variations (GCV) for all the traits studied indicating that they all interacted with the environment to some extent. All the traits studied expressed moderate to high heritability estimates ranging from 43.68 to 92.87%. High heritability along with high genetic advance was noticed for the traits, number of filled grains panicle^{-1}, number of unfilled grains panicle^{-1} and plant height.

Keywords: NERICA; mutant lines; morphological characters; genetic parameters

1. Introduction

NERICA is a new drought tolerant rice variety introduced by the ministry of agriculture for growing in drought prone areas of Bangladesh. The term NERICA stands for New Rice for Africa, an extended family of some 3000 siblings. NERICA is the product of interspecific hybridization between the cultivated rice species of Africa *(O. glaberrima)* and Asia *(Oryza sativa)*. Rice grain yield is a quantitative polygenic character and highly influenced by environment. Extent and significance of association of yield with yield components should be considered, while determining the selection criteria of germplasm on the basis of available genetic variation. The success of breeding program also depends on the amount of genetic variability present in the population and extent to which the desirable traits are heritable. Different morphological traits play very important role for more rice production with new plant type characteristics associated with the plant yield. Phenologicalproperities of rice also associated with the yield potential of the different rice varieties that further involved in rice breeding program (Shahidullah *et al.*, 2009). Study of genetic divergence among the plant materials is an important tool to the plant breeders for an efficient selection of the diverse parents for their potential use in a rice breeding program for the improvement of the rice production.The term rainfed is used to describe farming practises that rely on rainfall for water without any artificial irrigation. Development of improved rice varieties with stress tolerance traits from introduced varieties could significantly increase productivity (Mzengeza, 2010). NERICA varieties have 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, to 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). 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 produce 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^{-1} 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).

Therefore, the present experiment was conducted to evaluate thirty one mutant rice lines for morphological traits and to assess the genetic parameters of the NERICA lines to screen out best performing lines and traits with high heritability and genetic advance for developing high yielding new rice varieties.

2. Materials and Methods

2.1. Experimental materials

Thirty one NERICA rice genotypes (twenty eight mutant lines along with three parents) of advanced generations (M_4 and M_5) were used. Seeds of the rice genotypes were obtained from Bangladesh Institute of Nuclear Agriculture (BINA), BAU Campus, Mymensingh-2202. The experiment was conducted in aus season 2014. The list of the genotypes is present in the Table 1.

2.2. Field experimentation and management

2.2.1. Seedbed preparation and sowing of pre-germinated seeds

Seed bed was prepared by raising soil up to 5-10 cm from the field surfaces followed by puddling. Before puddling cow dung was applied @ 2kgm^{-2}. The entire seed bed was than divided into three seed beds and small plots (50 cm X 50 cm) were prepared considering the 31 rice genotypes. Between the plots 10 cm distance was maintained. Drainage channels (30 cm) were prepared between seed beds to drain out excess water whenever needed. The seeds were soaked into water for 24 hours and incubated in moist cloth sacks for 48 hours for quick germination. The pre-germinated seeds were sown in seedbed on 29th March, 2014.

2.2.2. Experimental design

Field experiments were conducted following randomized complete block design (RCBD) with three replications. Row to row and plant to plant distance were 20 cm and 15 cm respectively.

2.2.3. Transplanting

One seedling per hill was transplanted to the main plot on the 18th April, 2014. Row to row and plant to plant distance were 20cm and 15cm respectively.

2.2.4. Intercultural operations

Gap filling was done within seven days after transplanting with the seedlings from same source to obtain uniform plant population. Drainage and weeding were done as and when required. Insecticides and fungicides were sprayed only once. No artificial irrigation was given.

2.2.5. Harvesting

Different genotypes were matured at different times. Harvesting was done when 90% of the plant populations of each plot reached to maturity.

2.2.6. Recording of data

Data were recorded on the following traits-Days to flowering, Days to maturity, Plant height, Total tillers hill$^{-1,}$ Effective tillers hill^{-1}, Non effective tillers hill^{-1}, Panicle length, Filled grains panicle^{-1}, Unfilled grains panicle^{-1}, 100-Seed weight (g), Yield plant^{-1}.

2.3. Estimation of genetic parameters

2.3.1. Estimation of genotypic and phenotypic variances

Genotypic and phenotypic variances were estimated according to the formula given by Johnson *et al*., (1995).

$$\text{Genotypic variance}, \sigma_g^2 = \frac{\text{GMS} - \text{EMS}}{\text{r}}$$

Where, GMS = Genotypic mean square, EMS = Error mean square and r = Number of replication.
Phenotypic variance, $\sigma^2_p = \sigma^2_g$ + EMS
Where, σ^2_g = Genotypic variance and EMS = Error mean square

2.3.2. Estimation of heritability

Heritability in broad sense (h^2_b) was estimated according to the formula suggested by Johnson *et al.*, (1955) and Hanson *et al*., (1956).

Heritability, $h^2_b = \frac{\sigma^2{}_g}{\sigma^2{}_p} \times 100$

Where, h^2_b=Heritability in broad sense, σ^2_g= Genotypic variance; andσ^2_p = Phenotypic variance.

2.3.3. Estimation of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV)

Genotypic and phenotypic coefficient of variations were estimated according to Burton (1952) and Singh and Chaudhury (1985).

$$\text{Genotypic coefficient of variations}, \text{GCV} = \frac{\sqrt{\sigma_g^2}}{\bar{X}} \times 100$$

Where, σ^2_g= Genotypic variance and $\bar{X}$= Population mean

$$\text{Phenotypic coefficient of variations}, \text{PCV} = \frac{\sqrt{\sigma_P^2}}{\bar{X}} \times 100$$

Where, σ^2_p = Phenotypic variance and $\bar{X}$= Population mean

2.3.4. Estimation of genetic advance

Estimation of genetic advance was done following formula given by Johnson *et al.*, (1955) and Allard (1960).
Genetic advance, GA = $h^2_b.K.\sigma_p$
Where, h^2_b = Heritability in broad sense, K= Selection differential, the value of which is 2.06 at 5% selection intensity and σ_p = Phenotypic standard deviation.

2.3.5. Estimation of genetic advance in percentage of mean, GA (%)

Genetic advance in per cent of mean was calculated by the formula of Comstock and Robinson (1952) as follows:

$$\text{Genetic advance in percentage of mean}, \text{GA}\ (\%) = \frac{\text{GA}}{\bar{X}} \times 100$$

Where, GA = Genetic advance and $\bar{X}$= Population mean

3. Results and Discussion

The analyses of variance of different NERICA mutant lines indicated that the difference among genotypes for all the quantitativetraits under study *viz.*, days to flowering (1^{st}, 50%, 80%), days to maturity, plant height (cm), total tillers hill^{-1}, panicle length (cm), effective tillers hill^{-1}, filled and unfilled grains panicle^{-1},100 seed weight (g) and yield plant^{-1} (g) were highly significant (Table.2).Yaqoob *et al.* (2012) observed significant variation among genotypes for days to maturity, total tillers hill^{-1}, effective tillers hill^{-1}, plant height, panicle length, 100-grain weight and yield plant^{-1}. Tiwari *et al.* (2011) also observed significant variation among genotypes for days to 50% flowering, effective tillers plant^{-1}, panicle length, and grain yield plant^{-1}. These results suggest that all the genotypes under study had significant variation with each other.The mean performances of 31 rice genotypes for their morphological characters are shown in Table 3.

3.1. Days to flowering (1^{st}, 50% and 80%)

Being an important character to assess early maturity, days to flowering was taken to an account for the genotypes. Days to 1^{st} flowering among the genotypes ranged from 61.33 to 90.56 days with a mean value of

77.67 days. N_4/250/P-9-5-3 took the lowest days to 1^{st} flowering (61.33 days) and N_1 parent took the highest days to 1^{st} flowering (90.56 days). The average range of days to50% flowering among the genotypes was 65.61 to 95.27days with a mean value of 82.96 days.N_4/250/P-9-5-3 took the lowest days to 50% flowering (65.61 days) and N_1 parent took the highest days to 50% flowering (95.27days). Days to80% flowering among the genotypes ranged from 70.43 to 101.7 days with a mean value of 88.53 days. N_4/250/P-9-5-3 took the lowest days to 80% flowering (70.43 days) and N_1 parent took the highest days to 80% flowering (101.7 days).

3.2. Days to maturity

Early maturity is the most desirable character of rice variety in present situation. Days tomaturity among the genotypes ranged from 104.6 to 126.67 days with a mean value of 110.46 days.N_1/250/P-7-3 took the lowest days to maturity (104.6 days) which was followed by N_4/350/P-2(1)-32-11, N_4/250/P-2(5)-11-13 and N_1/300/P-9-5 and N_1 parent took the highest days to maturity (126.70 days) which was followed by N_4 parent and N_1/250/P-7-3-12.

3.3. Plant height (cm)

Lower plant height is desirable in rice breeding. The average range of plant height among the genotypes was 73.43cm to 114.77cm with a mean value of 97.12cm. N_4 parent had the lowest plant height(73.43 cm) and N_1/300/P-9-5-12 had the highest plant height(114.77 cm).Plant height in rice is a complex character and is the end product of several genetically controlled factors (Cheema *et al.*, 1987). Reduction in plant height may improve their resistance to lodging and reduce substantial yield losses associated with this trait (Abbasi *et al*. 1995).

3.4. Number of total tillers hill^{-1}

The higher number of tillers hill^{-1} is preferable for achieving high yield. In this study, the average number of tiller hill^{-1} ranged from6.33 to 19.0 with a mean value of 10.49.N_{14}/350/P-2(1)-32-11 had the maximum number of tillers hill^{-1} (19.0) andN_1/250/P-7-13-12 had the minimum number of tillers hill^{-1}(6.33) which was followed byN_{10}/300/P-3-7-3.

3.5. Number of effective tillershill^{-1}

The number of effective tillers hill^{-1} is directly related to grain yield. In this study the number of effective tillers hill^{-1} ranged from 5.00 to 14.00 with a mean value of 833.N_4/350/P-2(1)-32-11 had maximum number of effective tillers hill^{-1} (14.0) and N_{10}/300/P-3-7-3had minimum number of effective tillers hill^{-1}(5.0).

3.6. Panicle length (cm)

Panicle length is also an important yield contributing character since higher panicle length could provide higher grain numbers. Panicle length among the genotypes ranged from 20.60 to 31.13 cm with a mean value of 25.05 cm. N_1/250/P-7-3-11 had the longest panicle (31.13 cm) and N_4 parent had the lowest panicle length (20.60 cm).

3.7. Number of filled grains panicle^{-1}

The yield of the plant is related to number of filled grains panicle^{-1} and it differed significantly among the lines. In this study the number of filled grain panicle^{-1} ranged from 61.0 to 127.0 with a mean value of 95.91.N_4/350/P-2 (1)-32-11 had the highest number of filled grain panicle^{-1} (127.0) and N_1/350/P-2-2-4 had the lowest number filled grain panicle^{-1}(61.0).

3.8. Number of unfilled grains panicle^{-1}

Less number of unfilled grains panicle^{-1} is a positive attribute towards higher yield. The number of unfilled grain panicle^{-1} ranged from 17.0 to 42.33 with a mean value of 30.77.N_{10}/300/P-3-7-1 had the highest number of unfilled grain panicle^{-1} (42.33) and N_1/250/P-7-13-15 had the lowest number of unfilled grain panicle^{-1}(17.0).

3.9. 100 seed weight (g)

There was a significant difference in 100 seed weight among the lines depending on the size and shape of grains. 100 seed weight ranged from 1.73g to 3.03 g with a mean value of 2.47g. The highest 100 seed weight was recorded in N_1/250/P-7-3-12 (3.03 g) andN_1/350/P-2-2-4 had minimum 100 seed weight (1.73g).

3.10. Yield plant^{-1}(g)

There was significant difference in yield plant^{-1} among the studied lines. Yield plant^{-1} (g) ranged from 6.15g to 33.02g with a mean value of 18.73g. N_1/350/P-9-5 had maximum yield plant^{-1} (33.02g) andN_1 parent and N_4 parent had minimum yield plant^{-1} (6.15g).

3.11. Estimation of genetic parameters of NERICA mutant lines along with their parents

Genotypic variances, phenotypic variances, heritability, genotypic co-efficient of variation (GCV), phenotypic co-efficient of variation (PCV), genetic advance and genetic advance as percent of mean, GA (%) for all the yield contributing traits are presented in Table 4.

Table 1. List of the genotypes used in the experiment.

Sl. No	Symbol	Genotypes
1	G1	N_4/350/P-2(1)-32-11
2	G2	N_1/300/P-9-9-13
3	G3	N_{10}/300/P-2(1)-11-(1)
4	G4	N_1/350/P-2-2-4
5	G5	N_1/250/P-7-2-1
6	G6	N_{10}/300/P-2(1)-6-11
7	G7	N_4/250/P-2(5)-11-13
8	G8	N_{10}/300/P-3-7-1
9	G9	N_{10}/300/P-3-7-3
10	G10	N_{10}/300/P-5-7-5
11	G11	N_4/250/P-2(6)-26(1,3,4)
12	G12	N_4/300/P-3(4)-10-9
13	G13	N_1/250/P-7-3-12
14	G14	N_{10}/300/P-2-3-5
15	G15	N_1/300/P-9-5-12
16	G16	N_{10}/300/P-2(1)-8
17	G17	N_4/250/P-2(5)-11-10
18	G18	N_4/250/P-9-5-3
19	G19	N_1/250/P-7-3-11
20	G20	N_1/250/P-7-3-15
21	G21	N_1/250/P-7-3-12
22	G22	N_1/350/P-2-3
23	G23	N_1/300/P-9-5
24	G24	N_{10}/300/P-3-7-6
25	G25	N_1/300/P-8-3-3
26	G26	N_1/250/P-6-2-8
27	G27	N_1/250/P-7-3
28	G28	N_1/300/P-9-5-6
29	G29	N_1 Parent
30	G30	N_4 Parent
31	G31	N_{10} Parent

3.11.1. Variability parameters

A wide range of variation was observed among thirty one rice genotypes for eleven yield contributing traits. The perusal of data revealed that variance due to treatment was highly significant for all the traits (Table 2). This suggested that there were inherent genetic differences among the genotypes. Coefficient of variation studied indicated that phenotypic coefficient of variation (PCV) were higher than the corresponding genotypic coefficient of variation (GCV) for all the traits (Table 3) indicating that they all interacted with the environment to some extent. That means the studied traits are influenced by the environment. Among the all traits total tillers hill^{-1} (26.20% and 28.64%) exhibited high estimates of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) respectively. On the other hand, Days to 1st flowering (8.13% and 8.46%), days to 50% flowering (7.67% and 7.99%), days to 80% flowering (7.34% and 7.62%), days to maturity (4.20% and 5.12%) and plant height (10.48% and 11.68%) exhibited low genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV).

Table 2. Analysis of variance for different morphological plant characters of 31 NERICA mutant lines.

Characters	d.f	Days to 1st flowering	Days to 50% flowering	Days to 80% flowering	Days to maturity	Plant height (cm)	Total tillers hill^{-1}	Effective tillers hill^{-1}	Panicle Length (cm)	Filled grain panicle^{-1}	Unfilled grain panicle^{-1}	100 Seed weight (g)	Yield plant^{-1} (g)
Genotypes	30	122.95**	124.86**	129.93**	74.97**	335.62**	24.15**	13.68**	23.29**	769.68**	129.56**	0.335**	154.29**
Replication	2	36.633	37.113	61.277	69.384	91.409	0.140	0.103	15.936	121.043	2.065	0.004	2.89
Error	60	3.263	3.442	3.244	10.423	25.043	1.473	0.649	7.001	63.176	4.720	0.018	1.64

Here,
d.f = Degree of freedom
** indicates significant at 0.01 probability level.
NS= Not significant

Table 3. Mean performance of 31 rice genotypes on different morphological traits related to yield.

Genotypes	Days to 1st flowering	Days to 50% flowering	Days to 80% flowering	Days to maturity	Plant height (cm)	Total tiller hill^{-1}	Effective tillers hill^{-1}	Panicle length (cm)	Filled grain panicle^{-1}	Unfilled grain panicle^{-1}	100 Seed weight (g)	Yield plant^{-1} (g)
N4/350/P-2(1)-32-11	73.57gh	78.17jkl	84.51hi	105.5f	103.3bcde	19.00a	14.00a	25.67cdefghi	127.0a	39.00abc	2.43fghi	31.46a
N1/300/P-9-9-13	75.33efg	80.66hijk	86.33fgh	107.7def	93.67fghij	16.67b	12.67b	26.00bcdefgh	90.00fghijkl	26.67hi	2.24hijk	25.09d
N10/300/P-2(1)-11-(1)	67.52i	72.34m	78.38k	107.7def	105.6abcd	16.00b	10.33c	24.00defghi	96.00efghijk	24.33ijk	1.89lm	20.85fg
N1/350/P-2-2-4	71.43h	76.53l	80.43jk	109.3cdef	84.47jk	10.00defghi	7.67efg	21.00hi	61.00n	33.67ef	1.73m	12.36jk
N1/250/P-7-2-1	79.07cd	84.62efg	90.60cde	108.2def	86.50ijk	10.67defgh	8.33def	21.30ghi	85.67ijklm	37.33bcde	2.92ab	19.01g
N10/300/P-2(1)-6-11	66.70i	71.70m	77.95k	109.7cdef	88.70ij	11.67de	9.67cd	23.70defghi	114.3abc	22.00jkl	1.77m	16.44h
N4/250/P-2(5)-11-13	80.20cd	86.70de	93.00bc	105.7f	106.7abcd	10.33defghi	8.33def	20.77hi	85.00ijklm	38.00bcd	2.59defg	16.26h
N10/300/P-3-7-1	74.26fgh	80.60hijk	86.33fgh	110.3cdef	93.63fghij	11.00defg	9.00cde	26.60abcdefg	111.7bcd	42.33a	2.31hij	29.30b
N10/300/P-3-7-3	72.43gh	77.33kl	82.50ij	109.6cdef	89.63ij	6.67kl	5.00j	25.30defghi	101.3cdefgh	31.33fg	2.02kl	12.47jk
N10/300/P-5-7-5	78.37cde	82.66fgh	88.27defg	108.8def	91.63ghij	9.00fghijk	7.00fgh	25.00defghi	102.7cdefg	26.33hi	2.28hij	13.65ijk
N4/250/P-2(6)-26(1,3,4)	80.24cd	85.35ef	90.33cde	107.3def	109.5abc	11.33def	9.67cd	22.33efghi	104.0cdef	27.33ghi	2.12jkl	21.07fg
N4/300/P-3(4)-10-9	80.58cd	85.30ef	92.73bc	110.5cdef	104.6bcde	11.00defg	8.33def	24.70defghi	103.0cdefg	25.00ijk	2.73bcde	27.42bc
N1/250/P-7-3-12	78.40cde	83.46efgh	89.67cdef	115.4bc	101.0cdefg	9.00fghijk	7.00fgh	26.80abcdef	84.33jklm	31.33fg	3.03a	20.34fg
N10/300/P-2-3-5	75.28efg	81.50ghij	86.33fgh	113.6bcd	95.33efghi	8.67ghijkl	7.00fgh	26.03bcdefgh	118.7ab	34.00def	2.50efgh	20.57fg
N1/300/P-9-5-12	77.33def	82.38fghi	87.25efgh	107.0ef	114.8a	7.33jkl	6.00hij	24.70defghi	103.7cdef	30.00fgh	2.81abcd	12.48jk
N10/300/P-2(1)-8	79.42cd	84.67efg	89.05defg	112.6bcde	109.3abc	8.00ijkl	6.000hij	30.87ab	74.33mn	37.67bcde	2.35ghij	12.85jk
N4/250/P-2(5)-11-10	78.17cde	84.57efg	90.33cde	108.5def	111.9ab	9.33efghij	6.67ghi	25.23defghi	126.3a	19.00lm	2.85abc	23.96de
N4/250/P-9-5-3	61.33j	65.61n	70.43l	109.4cdef	88.13ij	8.00ijkl	7.33fgh	25.70cdefghi	119.7ab	36.33cde	2.44fgh	13.16ijk

Genotypes	Days to 1st flowering	Days to 50% flowering	Days to 80% flowering	Days to maturity	Plant height (cm)	Total tiller hill^{-1}	Effective tillers hill^{-1}	Panicle length (cm)	Filled grain panicle^{-1}	Unfilled grain panicle^{-1}	100 Seed weight (g)	Yield plant^{-1} (g)
N1/250/P-7-3-11	81.23c	86.47de	90.33cde	108.6def	107.7abcd	8.67ghijkl	7.33fgh	31.13a	81.00klm	30.67fg	2.33ghij	13.10ijk
N1/250/P-7-13-15	74.33fgh	79.00ijkl	84.61hi	107.8def	105.0bcde	8.33hijkl	6.00hij	24.97defghi	78.67lm	17.00m	2.72bcde	14.36hij
N1/250/P-7-13-12	85.34b	89.53cd	95.67b	112.6bcde	88.50ij	6.33l	5.33ij	26.77abcdef	84.67ijklm	31.33fg	2.69bcde	11.80kl
N1/350/P-2-3	75.40efg	80.67hijk	86.50fgh	110.6cdef	95.37efghi	12.33cd	9.33cd	23.73defghi	87.00hijklm	21.33kl	2.72bcde	21.39f
N1/300/P-9-5	84.37b	90.69bc	95.27b	105.9f	104.8bcde	14.00c	12.33b	24.93defghi	99.00defghij	25.67ij	2.80abcd	33.02a
N10/300/P-3-7-6	80.41cd	86.33de	91.48cd	107.6def	104.5bcde	10.00defghi	8.33def	30.43abc	92.33fghijkl	32.33f	2.38ghij	15.26hi
N1/300/P-8-3-3	75.33efg	82.73fgh	88.27defg	110.8cdef	102.3bcdef	11.33def	9.67cd	24.83defghi	100.0cdefghi	30.67fg	2.75bcde	21.99ef
N1/250/P-6-2-8	74.58fgh	80.00hijk	85.67ghi	109.3cdef	103.0bcdef	11.00defg	9.00cde	28.87abcd	97.00defghij	38.00bcd	2.66bcdef	23.60de
N1/250/P-7-3	80.17cd	85.60ef	90.33cde	104.6f	91.37hij	10.67defgh	9.67cd	27.23abcde	110.0bcde	31.67f	2.77bcd	28.73b
N1/300/P-9-5-6	90.48a	94.67a	99.85a	110.5cdef	99.27defgh	11.67de	10.33c	22.90efghi	94.33fghijk	37.00bcde	2.64cdef	25.85cd
N1 parent	90.56a	95.27a	101.7a	126.7a	79.00kl	8.33hijkl	7.33fgh	21.67fghi	88.00ghijklm	32.33f	2.28hij	6.640m
N4 parent	88.33a	93.60ab	99.83a	125.3a	73.43l	10.33defghi	7.33fgh	20.60i	74.00mn	23.33ijk	2.17ijk	6.153m
N10 parent	77.65def	83.17efgh	90.67cde	117.3b	78.13kl	8.67ghijkl	6.33ghij	22.70efghi	78.67lm	41.00ab	2.42fghi	9.970l
CV (%)	2.33	2.24	2.03	2.92	5.15	11.57	9.67	10.56	8.29	7.06	5.45	6.84
Maximum	90.56	95.27	101.67	126.67	114.77	19.00	14.00	31.13	127.00	42.33	3.03	33.02
Minimum	61.33	65.61	70.43	104.60	73.43	6.33	5.00	20.60	61.00	17.00	1.73	6.15
Mean	**77.67**	**82.96**	**88.53**	**110.46**	**97.12**	**10.49**	8.33	25.05	95.91	30.77	2.47	18.73
$LSD_{(0.05)}$	2.95	3.03	2.94	5.27	8.17	1.98	1.32	4.32	12.98	3.55	0.219	2.09

Notes: Genotypes with the different letter(s) are significantly different.

Table 4. Estimation of genetic parameters for morphological characters related to yield.

SL. No.	Characters	Phenotypic variance (σ^2_p)	Genotypic variance (σ^2_g)	PCV (%)	GCV (%)	Heritability (%)	GA	GA (%)
1	**Days to 1st flowering**	43.16	39.90	8.46	8.13	92.44	12.51	16.11
2	**Days to 50% flowering**	43.92	40.47	7.99	7.67	92.16	12.58	15.16
3	**Days to 80% flowering**	45.47	42.33	7.62	7.34	92.87	12.90	14.57
4	**Days to maturity**	31.94	21.52	5.12	4.20	67.37	7.84	7.10
5	**Plant height(cm)**	128.57	103.53	11.68	10.48	80.52	18.81	19.37
6	**Total tillers hill^{-1}**	9.03	7.56	28.64	26.20	83.69	5.18	49.37
7	**Effective tillers hill^{-1}**	5.00	4.35	26.82	25.02	87.01	4.01	48.07
8	**Panicle length(cm)**	12.43	5.43	14.08	9.30	43.68	3.17	12.67
9	**Filled grain panicle^{-1}**	298.68	235.50	18.02	16.00	78.85	28.07	29.27
10	**Unfilled grain panicle^{-1}**	46.33	41.61	22.12	20.96	89.81	12.59	40.92
11	**100 Seed weight (g)**	0.124	0.106	14.26	13.19	85.44	0.61	25.11

Notes: PCV= Phenotypic coefficient of variation, GCV= Genotypic coefficient of variation, GA= Genetic advance, GA (%) = Genetic advance as percent of mean

The high values of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) for these traits suggested the possibility of yield improvement through selection of these traits. Tiwari *et al.* (2011) also observed the higher magnitude of PCV and GCV for grain yield plant^{-1}, number of fertile spikelets, effective tillers hill^{-1}, panicle length and number of spikelets panicle^{-1}.

3.11.2. Heritability

The estimates of heritability act as predictive instrument in expressing the reliability of phenotypic value. Therefore, high heritability helps in effective selection for a particular trait. Heritability was classified as low (below 30%), medium (30-60%) and high (above 60%) as suggested by Johnson *et al.* (1955). The traits expressed moderate to high heritability estimates ranging from 43.68% to 92.87%. Among the traits, high heritability was recorded by days to 80% flowering (92.87%), days to 1st flowering (92.44%), days to 50% flowering (92.16%), unfilled grain panicle^{-1} (89.81%), effective tillers hill^{-1} (87.01%), 100 seed weight (85.44%), total tillers hill^{-1} (83.69%), plant height (80.52%), filled grain panicle^{-1} (78.85%) and days to maturity (67.37%), and moderate heritability value was recorded bypanicle length (43.68%) (Table4).High heritability values indicate that the traits under study are less influenced by environment in their expression and have greater possibility of genetic improvement through selection methods. Patel *et al.* (2012) observed highest heritability for days to 50%flowering, plant height, total tillers, panicle length, total number of spikelets panicle^{-1}, number of filled spikelets panicle^{-1}, number of unfilled spikelets panicle^{-1} and grain yield m^{-2}.

3.11.3. Genetic advance

The genetic advance is a useful indicator of the progress that can be expected as result of exercising selection on the pertinent population. Heritability in conjunction with genetic advance would give a more reliable index of selection value (Johnson *et al.*, 1955). In the present study genetic advance was highest for number of filled grains panicle^{-1} (28.07) and lowest for 100 seed weight (0.619) among yield contributing traits (Table 4).The genetic advance as percent of mean was highest in case of number of total tillers hill^{-1} (49.37%), while lowest recorded by days to maturity (7.10%). Babu *et al*. (2012) also found highest genetic advance for number of filled grains panicle^{-1}and highest genetic advance as per cent of mean in case of number of unfilled grains panicle^{-1}.

4. Conclusions

A total of 31 NERICA rice genotypes were evaluated for morphological characters and various genetic parameters were assessed. Considering the traits days to flowering and days to maturity, the genotype N_4/250/P-9-5-3 was earliest (104.6 days) and N_1 parent took highest days (126.7 days). All parents took the highest days to maturity than different lines. In terms of yield plant^{-1} genotypeN_1/300/P-9-5 was superior (33.02g) and N_4 parent had minimum yield plant^{-1} (6.15g).All the traits are highly influenced by the environment as PCV were higher than GCV and a little scope for genetic improvement. Days to 80%, days to 1st flowering, days to 50% flowering, number of unfilled grain panicle^{-1} and 100 seed weight are less influenced by environment in their expression. The lowest heritability value was recorded for panicle length. In the present study, high heritability along with high genetic advance was noticed for the traits, number of filled grain per panicle, plant height and days to 50% flowering. These traits can be improved through simple or progeny selection methods. Other traits showed high heritability along with moderate or low genetic advance which can be improved by inter mating superior genotypes of segregating population developed from combination breeding. So, while taking breeding program using this genotype, higher emphasize should be given to environmental factors as well as agronomic practices.

Conflict of interest

None to declare.

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