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**Research Article**

# IDENTIFICATION OF NITROGEN USE EFFICIENT LOCAL RICE GENOTYPES UNDER LOW SOIL NITROGEN CONDITIONS

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**Abstract-** Rice is an important staple food crop in most of Asian countries and feeding more than half world population. India is having rich source of rice germplasm and the local rice genotypes are reservoirs of valuable traits. Unscientific nitrogen application at different crop growth stages mainly influences grain yield and environmental quality. The increase nitrogen application directly and indirectly affects emission of methane gas, finally leads to global warming. Hence, an attempt was made to identify high nitrogen use efficient genotypes by studying genetic variability parameters for nitrogen use efficiency and yield component traits in a set of 55 local rice genotypes under low soil nitrogen conditions. Analysis of variance revealed highly significant genotypic differences for all the traits studied. High Genotypic coefficient of variability (GCV) and Phenotypic coefficient of variability (PCV) values with less difference observed for nitrogen use efficiency, yield related traits indicating less influence of environment factors on their expression. High heritability coupled with high genetic advance was recorded for plant height, number of productive tillers, panicle length, number of spikelets per panicle, grain yield per plant and nitrogen use efficiency at low nitrogen conditions. This indicated that these traits were predominantly controlled by additive gene action and more amenable for selection. Significant positive correlation was observed for nitrogen use efficiency with grain and straw yield in low nitrogen conditions. The SSR marker RM20 was found to be associated with nitrogen use efficiency in local rice genotypes studied. The genotypes Parimalakalavi, Mosaleputtabatta, Mundoni, Bilihasudiand Bolumallige were found to be high nitrogen use efficient.

**Keywords**- Local rice genotypes, Nitrogen use efficiency, Heritability, Genetic advance and SSR markers

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## Introduction

Rice is an important staple food crop in most of Asian countries and feeding more than half world population and it is an important part of nutritious healthy diet as it contains more than 15 vitamins and minerals that help in protecting against diseases and ensure healthy growth during pregnancy and childhood. Currently rice yields were increasing rapidly with time due to improved cultivars and higher application of fertilizers especially nitrogenous fertilizers. Production of rice itself accounts 20% global nitrogen consumption and it will be increased drastically to meet the projected demand of growing population .Nitrogen uptake efficiency under low land rice cultivation is very low due to volatilization, denitrification, surface runoff, and leaching. These losses much higher in excessive nitrogen application at beyond the need of crop growth and development and also cause environmental hazards such as ground water, eutrophication of lakes and rivers, apart from the excessive application of nitrogen fertilizers stimulates growth and activity of methanogens in soil ecosystem; cause to emission of methane gas and lead to global warming.

Strategies has been developed to synchronize available soil nitrogen and nitrogen supply by fertilizers through proper timing of placement, rate and use of modified forms of fertilizers [6]. Rice genotypes reported to differ significantly in relation to nitrogen uptake, grain yield, nitrogen translocation efficiency and nitrogen use efficiency. Nitrogen use efficient rice genotypes could be used in breeding programme to improve rice production in poor soils, which would be useful for resource poor farmers who have limited access to the use of nitrogenous fertilizer.

Continuous increase in rice production has to be achieved with less nitrogen fertilizer by improving Nitrogen Use Efficiency (NUE) through better nitrogen fertilizer management and development of new nitrogen use efficient rice varieties. Some efforts were made to improve rice germplasm for NUE. The genotypic variation in NUE has been realized and however, plant traits that are associated with high grain yield and high Nitrogen use efficient lines should be developed, then breeders are as selection parameters in the breeding programme to develop nitrogen efficient varieties without the scare of playing with rice yield potential.

Identification and validation of SSR (Simple Sequence Repeats) markers linked to nitrogen use efficiency helpful to map QTLs and better understanding about genetic basis of nitrogen use efficiency and related traits. There is a need to validate SSR markers linked to NUE in local rice genotypes to initiate the marker assisted selection programme to breed high yielding with nitrogen use efficient rice varieties. Hence, this study was under taken to evaluate local rice genotypes in respect of nitrogen use efficiency in terms of yield related traits under low nitrogen conditions (lower than recommended dose of nitrogen fertilizer).

## Materials and Methods

The material for the present study consisted of 55 local rice genotypes and nine standard checks drawn from the rice germplasm maintained at the Marker Assisted Selection Laboratory, Department of Genetics and Plant Breeding, UAS, GKVK, Bangalore. The investigation was carried out at the Department of

Genetics and Plant Breeding, College of Agriculture, V. C. Farm, Mandya, University of Agricultural sciences, Bangalore, India.

**(a)Experimental design and layout:**

This experiment design was laid out in puddled field by following 8 X 8 simple lattice design with two replications and in two treatment conditions i. e., low nitrogen condition and available soil nitrogen condition(No nitrogen condition) as separate plots. The spacing maintained was 30 cm between rows and 10 cm between plants within the row. Before experiment was laid out, soil sample were collected from the experiment sites and analyzed for nutrient status including soil chemical properties. Based on the results observed from soil analysis data, quantities of nitrogen application at low nitrogen condition was decided. About 23 days old seedlings were transplanted to main field at the rate of one seedling/hill. The soil analysis results depict low soil available nitrogen in experimental plots [Table-1]. The required quantity of N: P: K applied for low nitrogen condition (50% of recommended Nitrogen in irrigated condition) in area of 268 $m^2$ is 1.34 Kg of Nitrogen, 8.4 kg of Phosphorous and 2.24 kg of Potassium. Nitrogen in low nitrogen condition applied in two split at basal dose and at the time of flowering with full dose Phosphorous and Potassium. Under No nitrogen condition, only full dose phosphorous and potassium were applied and no nitrogen fertilizer was applied to this plot. The growth and yield traits observations *viz*., Plant height (cm) at 35 days, Number of tillers at 35 days, Chlorophyll meter reading at 45 days, 50 % flowering, Days to maturity, Plant height at maturity (cm), Number of tillers at harvest, Number of productive tillers per plant, Panicle length (cm), Panicle weight (g), Number of spikelet's per panicle, Panicle fertility (%), Grain yield per plant (g) and straw yield per plant (g) and Test weight (g) were recorded in both conditions to identify nitrogen use efficient genotypes.

**(b) Nitrogen use efficiency**

Nitrogen use efficiency calculated in terms of yield is grain yield divided by unit quantity of nitrogen applied. Agronomic nitrogen use efficiency is obtained through dividing of total quantity of grain or biomass by total nitrogen fertilizer applied. It is calculated by $(GY_F\text{-}GY_O) \times 0.86 / N_F$.

Where, $GY_F$ is grain yield (14% moisture content) with Nitrogen fertilizer application $GY_O$ is grain yield (14% moisture content) without Nitrogen fertilizer application. NF is Nitrogen fertilizer applied.

**Table-1** *Physical and Chemical soil properties of experimental site*

| Soil Properties | Before Transplanting | | After Harvest | |
|---|---|---|---|---|
| | Low nitrogen condition | No nitrogen Condition | Low nitrogen condition | No nitrogen condition |
| PH | 6.11 | 7.21 | 6.5 | 6.8 |
| Electrical Conductivity (ds/m) | 0.25 | 0.18 | 0.26 | 0.2 |
| Organic carbon (%) | 0.57 | 0.44 | 0.58 | 0.46 |
| Available Nitrogen Kg/ha | 194.2 | 180.72 | 183.52 | 153.25 |
| Available Phosphorous K /ha | 18.06 | 16.6 | 15.23 | 13.54 |
| Available Potassium Kg/ha | 158.08 | 173.28 | 138.5 | 154.2 |

**(c)Validation of SSR markers linked to Nitrogen use efficiency**

In this study 10 SSR markers distributed on all 12 chromosomes of rice were selected from database ( McCouch *et al.,* 2002; www.gramene.org) mentioned in [Table-2] for studying association of Nitrogen use efficiency among 55 local rice genotypes and nine standard checks. Leaf samples were collected from young seedlings of testing material and DNA was isolated as per [5].

**(d) Statistical Analysis for yield related traits and nitrogen use efficiency**

The data of mean value for all the characters were analyzed for their variance following simple lattice design outlined by [4]. Analysis was done using SAS 9.2 statistical software. Phenotypic and genotypic variances were estimated according to the formula given by [10]. Phenotypic and genotypic coefficients of variability were computed according to the Method suggested by [2]. Heritability in broad sense was calculated as per the Formula given by [10]. Range of heritability was categorized as suggested by [9]. Genetic advance was expressed as per cent of mean by using the formula suggested by [9]. Traits were classified as having high, moderate or low genetic advance as per the method suggested by [9]. Single marker analysis was performed to tag and confirm potential SSR markers linked to the trait based on phenotypic and genotypic data pertaining to the local rice genotypes, which is based on simple linear regression method [8]. Single marker analysis was done with the help of Students t-distribution and one way analysis of variance [7].

**Results and Discussion**

In the present investigation, the means of 17 characters were high in 50 kg/ha treatment compared to available soil nitrogen condition (No Nitrogen). All genotypes displayed considerable amount of difference in their mean performance with respect to all characters studied [Table-3]. This indicates genotypes under study were study genetically variable. The analysis of variance for nitrogen use efficiency and various yield related traits under both conditions were statically tested and found to be significant for all the characters evaluated under low and no nitrogen conditions [Table-4] and [Table-5].

Under low nitrogen condition(50 kg N /ha treatment), high phenotypic coefficient of variability and genotypic coefficient of variability were obtained for number of tillers at 35 days, number of tillers at harvest, number of productive tillers, panicle weight, number of spikelets per panicle, grain yield, straw yield, test weight, harvest index and nitrogen use efficiency [Table-6]. The findings were in accordance with [19,14,15]. Moderate phenotypic coefficients of variability and genotypic coefficients of variability was shown by days to 50% flowering, plant height at maturity, panicle length and biomass. Number of spikelets per panicle, days to maturity showed low phenotypic coefficient of variability and genotypic coefficient of variability values. While, low phenotypic coefficient of variability values for number of spikelets per panicle was agree with the observations of [12]. The low genotypic coefficient of variability values for days to maturity was reported [17]. Those Characters having high phenotypic coefficient of variability and genotypic coefficient of variability indicate large scope for selection and improvement in the present set of local rice genotypes and less difference between phenotypic coefficient of variability and genotypic coefficient of variability indicating that less influence of environment on expression of traits.

**Table-2** *List of SSR markers used for validation of Nitrogen use efficiency in local rice genotypes*

| Sl. No. | Markers | Chromosome Number | Probability | $R^2$ Value | Forward sequence | Reverse sequence |
|---|---|---|---|---|---|---|
| 1 | RM20 | 11 | 0.02 | 44.21 | ATCTTGTCCCTGCAGGTCAT | GAAACAGAGGCACATTTCATTG |
| 2 | RM2 | 11 | 0.03 | 37.89 | ACGTGTCACCGCTTCCT | ATGTCCGGGATCTCATCG |
| 3 | RM202 | 11 | 0.03 | 27.05 | CAGATTGGAGATGAAGTCCTCC | CCAGCAAGCATGTCAATGTA |
| 4 | RM215 | 9 | 0.01 | 39.15 | CAAAATGGAGCAGCAAGAGC | TGAGCACCTCCTTCTCTGTAG |
| 5 | RM225 | 6 | 0.01 | 68.34 | TGCCCATATGGTCTGGATG | GAAAGTGGATCAGGAAGGC |
| 6 | RM245 | 9 | 0.03 | 26.23 | ATGCCGCCAGTGAATAGC | CTGAGAATCCAATTATCTGGGG |
| 7 | RM340 | 6 | 0.01 | 45.2 | GGTAAATGGACAATCCTATGGC | GACAAATATAAGGGCAGTGTGC |
| 8 | RM525 | 2 | 0.01 | 59.74 | GGCCCGTCCAAGAAATATTG | CGGTGAGACAGAATCCTTACG |
| 9 | RM1111 | 8 | 0.05 | 14.85 | CCTCCTGTCGGATCTGGTAG | CTTATCCACTTGCCCTCTCG |
| 10 | RM4085 | 8 | 0.03 | 20.22 | ACGAAACTACTCATGTGTAA | CGAGTCTAGAATCCATATAA |

**Table-3** *Mean performance of local rice genotypes under low and available soil nitrogen conditionfor nitrogen use efficiency and yield related traits*

| Characters | Mean | | Range | | | |
|---|---|---|---|---|---|---|
| | | | Minimum | | Maximum | |
| | Low N | No N | Low N | No N | Low N | No N |
| Plant height at 35 days (cm) | 51.00 | 47.62 | 41.40 | 35.20 | 67.00 | 64.40 |
| Number of tillers at 35 days | 14.67 | 8.13 | 6.40 | 4.50 | 36.40 | 15.45 |
| SPAD value | 39.28 | 37.42 | 32.90 | 33.20 | 46.60 | 44.49 |
| Days to 50% flowering | 97.24 | 93.80 | 73.00 | 82.00 | 126.00 | 122.00 |
| Days to maturity | 134.95 | 131.38 | 120.00 | 122.00 | 154.00 | 151.00 |
| Plant height at maturity (cm) | 104.56 | 100.25 | 65.90 | 66.30 | 144.30 | 135.50 |
| Number of tillers at harvest | 14.74 | 10.98 | 6.00 | 5.40 | 35.50 | 22.10 |
| Number of productive tillers | 11.02 | 9.23 | 5.20 | 3.35 | 18.90 | 15.18 |
| Panicle length (cm) | 21.70 | 21.48 | 14.20 | 14.90 | 24.80 | 27.80 |
| Panicle weight (g) | 3.15 | 2.96 | 0.90 | 1.44 | 5.52 | 6.84 |
| Number of Spikelet's/panicle | 118.38 | 117.08 | 40.67 | 33.85 | 262.50 | 209.00 |
| Panicle fertility (%) | 92.82 | 92.04 | 79.40 | 48.07 | 98.80 | 97.84 |
| Grain yield /plant (g) | 25.85 | 18.55 | 13.30 | 9.48 | 46.10 | 36.56 |
| Straw yield /plant (g) | 22.69 | 16.41 | 14.30 | 7.06 | 35.80 | 32.22 |
| Test weight (g) | 22.61 | 22.76 | 10.50 | 11.45 | 31.70 | 31.65 |
| Biomass /plant (g) | 48.52 | 41.29 | 28.40 | 24.26 | 69.60 | 61.54 |
| Nitrogen use efficiency | 34.42 | 33.74 | 18.40 | 17.27 | 60.70 | 59.92 |

**Table-4** *Analysis of variance for yield related characters and Nitrogen use efficiency in rice genotypes under low nitrogen condition during Kharif2014*

| Source | DF | Plant height at 35 days (cm) | Number of tillers at 35 days | SPAD value | Days to 50 % flowering | Days to maturity | Plant height at maturity | Number of tillers at harvest | Number of productive tillers/plant | Panicle length (cm) |
|---|---|---|---|---|---|---|---|---|---|---|
| Replications | 1 | 1.350 | 5.360 | 0.018 | 2.258 | 0.281 | 0.081 | 0.08 | 0.998 | 0.106 |
| Blocks within Replications (Adjusted) | 14 | 0.370 | 4.940 | 2.81 | 0.865 | 0.121 | 8.05 | 0.05 | 2.989 | 0.17 |
| Genotypes (Unadjusted) | 63 | 74.78** | 35.68** | 18.25** | 234.71** | 74.805** | 653.82** | 36.14** | 15.08** | 14.18** |
| Intra Block Error | 49 | 0.40 | 2.750 | 1.423 | 0.656 | 0.184 | 8.801 | 0.04 | 1.808 | 0.352 |
| LSD @ 5% | | 1.180 | 4.650 | 2.52 | 1.618 | 0.858 | 5.928 | 0.433 | 2.818 | 1.185 |
| S.Em | | 0.530 | 0.380 | 0.278 | 0.955 | 0.539 | 1.602 | 0.37 | 0.2579 | 0.237 |

**Table-4** *contd……*

| Source | DF | Panicle weight (g) | Number of spikelets / panicle | Panicle Fertility (%) | Grain yield / plant (g) | Straw yield / plant (g) | Test weight (g) | Biomass / plant (g) | Nitrogen use efficiency |
|---|---|---|---|---|---|---|---|---|---|
| Replications | 1 | 0.072 | 76.076 | 0.290 | 0.41 | 0.001 | 0.272 | 0.123 | 0.858 |
| Blocks within Replications (Adjusted) | 14 | 0.034 | 79.076 | 0.059 | 0.362 | 0.512 | 0.078 | 0.968 | 2.764 |
| Genotypes (Unadjusted) | 63 | 1.978** | 3177.74** | 31.231** | 100.03** | 54.465** | 50.23** | 173.88** | 165.92** |
| Intra Block Error | 49 | 0.015 | 75.945 | 0.084 | 0.221 | 0.933 | 0.103 | 1.169 | 3.752 |
| LSD @ 5% | | 0.264 | 17.415 | 0.58 | 0.985 | 1.93 | 0.641 | 2.161 | 3.871 |
| S.Em | | 0.08 | 3.552 | 0.3483 | 0.6234 | 0.4629 | 0.441 | 0.8235 | 0.8104 |

* and **- Significant at 5% and 1% levels.

**Table-5** *Analysis of variance for yield related characters and Nitrogen use efficiency in rice genotypes under no nitrogen (available soil nitrogen) condition during Kharif 2014*

| Source | DF | Plant height at 35 days (cm) | Number of tillers at 35 days | SPAD value | Days to 50 % flowering | Days to maturity | Plant height at maturity | Number of tillers at harvest | Number of productive tillers | Panicle length (cm) |
|---|---|---|---|---|---|---|---|---|---|---|
| Replications | 1 | 0.649 | 0.195 | 2.140 | 0.383 | 1.125 | 44.888 | 0.861 | 0.475 | 0.366 |
| Blocks within Replications (Adjusted) | 14 | 0.092 | 0.400 | 4.539 | 2.481 | 0.795 | 13.028 | 0.29 | 1.935 | 0.102 |
| Genotypes (Unadjusted) | 63 | 74.48** | 10.138** | 16.22** | 170.44** | 67.841** | 600.03** | 17.210** | 11.736** | 12.027** |
| Intra Block Error | 49 | 0.389 | 0.374 | 3.433 | 1.947 | 0.730 | 14.675 | 0.271 | 1.17 | 0.162 |
| LSD @ 5% | | 1.240 | 1.222 | 3.703 | 2.788 | 1.707 | 7.655 | 1.04 | 2.267 | 0.803 |
| S.Em | | 0.538 | 0.202 | 0.278 | 0.818 | 0.516 | 1.543 | 0.26 | 0.225 | 0.217 |

**Table-5** *Contd….*

| Source | DF | Panicle weight (g) | Number of spikelets/plant | Panicle fertility (%) | Grain yield/ plant (g) | Straw yield / plant (g) | Test weight (g) | Biomass/ plant (g) | Nitrogen use efficiency |
|---|---|---|---|---|---|---|---|---|---|
| Replications | 1 | 0.013 | 77.346 | 0.002 | 0.13 | 3.618 | 3.781 | 0.245 | 1.721 |
| Blocks within Replications (Adjusted) | 14 | 0.032 | 46.614 | 0.778 | 2.476 | 1.438 | 2.018 | 2.438 | 13.844 |
| Genotypes (Unadjusted) | 63 | 1.733** | 2914.49** | 105.900** | 56.195** | 34.084** | 56.264** | 113.980** | 171.050** |
| Intra Block Error | 49 | 0.030 | 41.611 | 0.675 | 1.908 | 1.039 | 1.886 | 1.575 | 7.335 |
| LSD@ 5% | | 0.345 | 12.891 | 1.642 | 2.760 | 2.037 | 2.744 | 2.508 | 5.720 |
| S.Em | | 0.083 | 3.386 | 0.643 | 0.475 | 0.37 | 0.475 | 0.67 | 0.835 |

** and **-Significant at 5% and 1% levels*

**Table-6** *Estimation of genetic variability parameters for yield related traits and nitrogen use efficiency in local rice genotypes under low and available soil nitrogen condition*

| Characters | Coefficients of Variability | | | | Heritability % (Broad Sense) | | GAM (%) | |
|---|---|---|---|---|---|---|---|---|
| | PCV (%) | | GCV (%) | | | | | |
| | Low N | No N | Low N | No N | Low N | No N | Low N | No N |
| Plant height at 35 days (cm) | 12.98 | 13.33 | 11.92 | 12.58 | 98.90 | 89.01 | 26.62 | 29.34 |
| Number of tillers at 35 days | 29.88 | 28.18 | 27.65 | 27.15 | 85.70 | 92.88 | 67.39 | 69.45 |
| SPAD value | 7.98 | 8.38 | 7.39 | 6.76 | 85.60 | 65.07 | 18.63 | 19.00 |
| Days to 50% flowering | 11.16 | 9.90 | 11.13 | 9.79 | 99.40 | 97.74 | 24.01 | 21.43 |
| Days to maturity | 4.54 | 4.46 | 4.53 | 4.41 | 99.50 | 97.87 | 10.08 | 9.93 |
| Plant height at maturity (cm) | 17.41 | 17.49 | 17.17 | 17.07 | 97.30 | 95.22 | 36.79 | 36.98 |
| Number of tillers at harvest | 5.65 | 26.93 | 5.48 | 26.51 | 94.20 | 96.91 | 18.03 | 64.29 |
| Number of productive tillers | 25.2 | 27.51 | 24.63 | 24.89 | 95.50 | 81.87 | 60.58 | 65.55 |
| Panicle length (cm) | 12.79 | 11.49 | 12.47 | 11.35 | 95.20 | 97.54 | 30.86 | 28.20 |
| Panicle weight (g) | 29.66 | 31.68 | 29.4 | 31.13 | 98.30 | 96.60 | 92.32 | 97.84 |
| Number of Spikelet's/panicle | 34.07 | 32.84 | 33.27 | 32.37 | 95.30 | 97.19 | 70.99 | 68.47 |
| Panicle fertility (%) | 4.26 | 7.93 | 4.25 | 7.88 | 99.50 | 98.72 | 9.85 | 17.41 |
| Grain yield /plant (g) | 27.39 | 29.05 | 27.33 | 28.08 | 99.60 | 93.43 | 60.27 | 64.88 |
| Straw yield /plant (g) | 23.19 | 25.54 | 22.8 | 24.78 | 96.60 | 94.08 | 52.04 | 58.35 |
| Test weight (g) | 22.19 | 23.70 | 22.14 | 22.91 | 99.60 | 93.50 | 50.11 | 52.92 |
| Biomass /plant (g) | 19.28 | 18.41 | 19.15 | 18.16 | 98.70 | 97.27 | 41.75 | 40.28 |
| Nitrogen use efficiency | 26.76 | 27.99 | 26.16 | 26.81 | 95.60 | 91.78 | 57.90 | 60.37 |

High heritability coupled with genetic advance as per cent mean for the traits were plant height at 35 days, number of tillers at 35 days, days to 50% flowering, plant height at maturity, number of tillers at harvest, number of productive tillers, panicle length, panicle weight, number of spikelets per panicle, grain yield per plant, straw yield per plant, test weight, biomass per plant, and nitrogen use efficiency. These results agrees with the findings of [20,15,18,1]. But high heritability with moderate and low genetic advance as percent mean observed for SPAD value, number of tillers at harvest and panicle fertility respectively. High heritability and genetic advance as percent mean of these traits depicting that variation obtained is mainly due to genetic factors and also moderate role of environmental factors. It clearly indicates that the improvement of the above traits can be obtained by simple selection in the present set of material. Moderate and low heritability indicates simple selection not sufficient to improvement of traits like SPAD value, number of tillers at harvest and panicle fertility.

In no nitrogen condition, High values of genotypic coefficient of variability and phenotypic coefficient of variability were observed for number of tillers at 35 days, number of tillers at harvest, number of productive tillers, panicle weight, number of spikelets per panicle, grain yield per plant, straw yield per plant, test weight and nitrogen use efficiency [Table-6]. A moderate value of phenotypic coefficient of variability and genotypic coefficient of variability was observed for panicle length and biomass per plant. A low value of phenotypic coefficient of variability and genotypic coefficient of variability obtained for SPAD value, days to 50% flowering, days to maturity and spikelets fertility. High values of phenotypic coefficient of variability and genotypic coefficient of variability with less difference for those traits revealed that less influence of environmental factors and simple selection is sufficient for improvement.

Plant height at 35 days, number of tillers at 35 days, days to 50 % flowering, plant height at maturity, number of productive tillers, panicle length, panicle weight, grain and straw yield per plant, test weight, biomass per plant and nitrogen use efficiency had high heritability and genetic advance as per cent mean. Similar findings reported by [13,14]. Presence of high heritability with high genetic advance indicate simple selection is sufficient to improve the traits like plant height at 35 days, number of tillers at 35 days, days to 50% flowering, plant height at maturity, number of productive tillers ,panicle length ,panicle weight, grain yield, straw yield per plant, test weight, biomass per plant and nitrogen use efficiency A high heritability with moderate genetic advance as per cent mean observed for SPAD value and panicle fertility. Low genetic advance for days to maturity was observed.

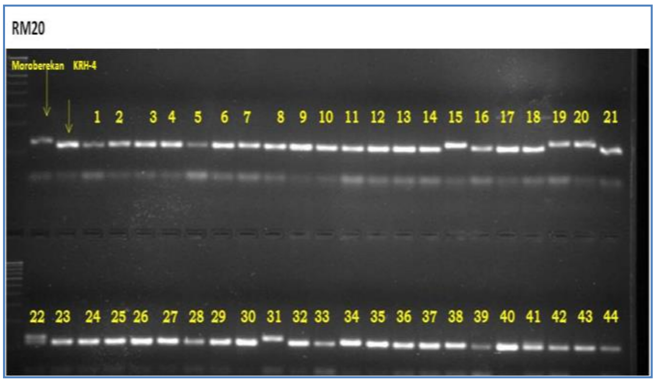
**Agronomic nitrogen use efficiency (ANUE) of local rice genotypes:**

The local rice genotypes Parimalkalvi, Mosale putt batta, SKAU-98, SKAU-334 and P. Doddi having negative values of ANUE and remaining some genotype having higher values of ANUE [Table-7]. This indicates local rice genotypes were highly efficient in utilization of available soil nitrogen and could withstand nitrogen deficient conditions.

Validation of SSR markers determines reliability and practical uses of markers for predicting particular phenotype for specific trait. About ten markers chosen for validating across fifty-five local rice genotypes, only one marker RM20 found significant association with nitrogen use efficiency. Similar results were obtained by [16]. The percent contribution of the significantly associated marker to total phenotypic variance was 9.62 and with a p-value of 0.01 and located on chromosome number 11. Low $R^2$ values indicates large environmental component of variations for the particular trait. This indicates nitrogen use efficiency highly influenced by changing environmental factors. SSR markers linked to nitrogen use efficiency, yield and quality parameters in rice was reported by [21-23]. The agarose gel images depicting the banding pattern of 44 local rice genotypes by SSR marker RM20 associated with NUE were presented in the [Fig-1].

**Table-7** *Agronomic nitrogen use efficiency of local rice genotypes*:

| Sl.No. | Name of Genotype | ANUE value | Sl.No. | Name of Genotype | ANUE value | Sl.No. | Name of Genotype | ANUE value |
|---|---|---|---|---|---|---|---|---|
| 1 | KARISIDDI | 5.97 | 21 | P. KIRWANA | 5.21 | 41 | KADUVAKALONGI | 0.96 |
| 2 | PARIMALA KALAVI | -1.01 | 22 | BKB | 6.95 | 42 | NAVALI | -3.72 |
| 3 | KAGISALE | 0.65 | 23 | BOLUMALLIGE | 0.45 | 43 | MADILAI SAMBA | 7.00 |
| 4 | SK -339 | 1.24 | 24 | AKKALU | 15.96 | 44 | KARI BASUMATHI | -2.10 |
| 5 | HUGGIBATTA | 9.03 | 25 | BETTA SANNA | 14.17 | 45 | SKAU -98 | -12.79 |
| 6 | JADDU BATTA | 5.28 | 26 | RATHNA CHUDI | 6.16 | 46 | SIDDIGIRI | -6.39 |
| 7 | NEERGOTIGA | 5.66 | 27 | SKAU -23 | 8.39 | 47 | KIRWANA | 10.86 |
| 8 | SKAU- 334 | 1.19 | 28 | YALAKISALI | 8.33 | 48 | BALGODU SELECTION | 4.51 |
| 9 | GANDHASALE | 3.21 | 29 | EDUKUNI | 4.24 | 49 | P.DODDI | -1.44 |
| 10 | JEERIGEBATTA | 6.56 | 30 | SHARAWATHI | 11.04 | 50 | BABBADAYAM | 4.75 |
| 11 | BANAVASI SELECTION | 6.88 | 31 | NATI BATTA | 6.10 | 51 | DEPPANAYA BELE JADDU | 3.02 |
| 12 | MUNDONI | 11.15 | 32 | BILIHASUDI | 4.93 | 52 | BAVATHNA CHOODI | 8.28 |
| 13 | ELATAGYGIDDA | -1.48 | 33 | KUMUD | 3.00 | 53 | WALUL KEER | 6.02 |
| 14 | KESARI | 8.25 | 34 | BADASHABOG | 8.41 | 54 | K- 336 | 4.19 |
| 15 | BILIKANHEGME | 3.06 | 35 | KEMPU KAARU | 4.27 | 55 | MALGUDI SANNA | 1.65 |
| 16 | GANDASALAI | -0.30 | 36 | SOLAN BATTI BARA | 4.65 | | | |
| 17 | TOGRASI | 8.15 | 37 | SIDDASALE | 5.44 | | | |
| 18 | HOLABATTA | 12.21 | 38 | AMBEMOHAR | 3.26 | | | |
| 19 | NANDI BATTA | -0.74 | 39 | MOSALE PUTTA BATTA | -5.98 | | | |
| 20 | HASUDI | 5.25 | 40 | DAPPA BATTA | 2.73 | | | |

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|---|---|---|---|---|---|---|---|
| **1** | Karisiddi | **13** | Elatagyagidda | **25** | Bettasanna | **37** | SKAU-98 |
| **2** | Parimala Kalavi | **14** | Bilikanhegme | **26** | Rathna Chudi | **38** | Ambemohar |
| **3** | Kagisale | **15** | Kesarl | **27** | SKAU-23 | **39** | Mosale Putta Batta |
| **4** | SK -339 | **16** | Gandasali | **28** | Yalakisali | **40** | Dappabatta |
| **5** | Huggibatta | **17** | Tograsi | **29** | Edukuni | **41** | Kaduvakalongi |
| **6** | Jaddu Batta | **18** | Holabatta | **30** | Sharawathi | **42** | Navali |
| **7** | Neergotiga | **19** | Nandi Batta | **31** | Natibatta | **43** | Madilai Samba |
| **8** | SKAU -334 | **20** | Hasudi | **32** | Bilihasudl | **44** | Kari Basumathi |
| **9** | Gandhasale | **21** | P. Kirwana | **33** | Kumud | | **Standard checks** |
| **10** | Jeerigebatta | **22** | BKB | **34** | Badashabog | | KRH 4 |
| **11** | Banavasi Selection | **23** | Bolumallige | **35** | Kempu Kaaru | | Moroberekan |
| **12** | Mundoni | **24** | Akkalu | **36** | Solan Batti Bara | | |

**Fig-1 Validation of SSR marker RM20 linked to nitrogen use efficiency of local rice genotypes**

**Table-8** *Single marker analysis for validation of SSR markers linked to nitrogen use efficiency in local rice genotypes*

| Sl. No. | Trait | Marker | Chromosome Number | Probability | R2 Value |
|---|---|---|---|---|---|
| 1 | NUE | RM525 | 2 | 0.14 | 3.97 |
| 2 | NUE | RM340 | 6 | 0.51 | 0.79 |
| 3 | NUE | RM20 | 11 | 0.01* | 9.62 |

## Conclusion

The present investigation to be concluded as, it has identified some of the promising local genotypes of rice which had higher yield with nitrogen use efficiency under low nitrogen conditions than check varieties The local rice genotypes SKAU-98, SKAU-334, Mosale Putta Batta Bolumallige, Parimala Kalavi, Holabatta, Mundoni, Sharawathi, Bilihasudi were performed better for grain yield and nitrogen use efficiency under available soil nitrogen and low nitrogen conditions. Genetic parameters studied were inferred that selection can be made on those characters for their utilization in crop improvement. Among these, some of the local rice genotypes found more efficient in utilization of available soil nitrogen and withstand nitrogen deficiency condition. Hence, these can be genotypes recommended for the conditions with high rainfall areas combined with more soil nutrition leaching condition and other majority of farmers not amenable to high cost nitrogenous fertilizers.

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