Estimation of Genetic Variability, Heritability and Genetic Advance in Rice (*Oryza sativa* L.) Genotypes

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***Abstract*: A study was conducted on eight rice varieties, planted and crossed using incomplete diallel mating design and 28 hybrids were generated which were evaluated along with the eight parents and two checks at Edozhigi duing the 2017/2018 dry season. Data were collected were subjected to diallel analysis of variance (ANOVA) for both parents and hybrids using Statistical Analysis System (SAS) soft ware package (2002).The ANOVA showed highly significance (P<0.01) difference among the genotypes for all the traits. Results from grain yield of parents ranged from 2830kg/ha for FARO 60 to 8210 kg/ha for FARO 57. Grain yield of the F1 hybrids ranged from 2550 kg/ha for FARO 44 x FARO 61 to 7045 kg/ha for Suakoko- 8 x Ck-21. High estimates of PCV and GCV were recorded for all traits except panicle length and 1000 grain weight. The highest estimates of PCV and GCV were for panicle exertion (pcv =106.5, gcv =101.8), followed by second iron toxicity scores (pcv =74.0, gcv =70.7), first iron toxicity scores (pcv =72.1, gcv =65.6), grain yield (pcv =67.2, gcv =66.8) and moderate estimates were for panicle length (pcv =18.7, gcv =18.2), and 1000 grain weight (pcv =18.4, gcv =17.9). Slight differences between PCV and GCV were observed which indicated evidence that the variability existing in the genotypes was mainly due to their genetic makeup. High heritability in broad sense was estimated for all traits with the highest estimate recorded for grain yield (98.7) followed by plant height (96.0), number of seeds per panicle (95.7), 1000 grain weight (95.3)and least was first iron toxicity scores (82.7). High genetic advance was noticed for number of seeds per panicle (158.34) followed by grain yield (124.23), plant height (82.87), days to 50% flowering (337.76), number tillers (22.86),and number of effective tillers (26.05) whereas, low genetic advance was observed for1000 grain weight (10.20) followed by panicle length (8.74), second iron toxicity scores (6.12), panicle exertion (4.21),first iron toxicity scores (3.81) and number of leaves (2.77) which indicated that these traits are likely to respond better to selection.**

***Keywords:* Rice, genetic variability, heritability, genetic advance and iron toxicity**

I. INTRODUCTION

Rice (*Oryza sativa* Linn) belongs to the family of grass (Poeceae) Chandrasekaran *et al.* (2007). It is one of the world's most important food crops with a total production of around 600 million tons occupying 11% of the world total arable land (Guimaraes, 2009). The crop supplies 2808 calories/person/day, which represents 21% of the total calorie supply consumed by humans. Rice is an important annual crop in Nigeria. It is one of the major staples. The crop is commonly consumed even as a food crop for household food security. The average Nigerian, consumes 24.8l kg of rice per year, representing 9% of annual calorie intake (IRRI, 2001). Rice production in Africa has grown from a yearly average growth rate of (1.76%) in 1991-2001 to more than double (3.96%) in 2002–2013 (FAOSTAT, 2014). Thus, rice is a key cereal crop in sub-Saharan Africa (SSA) (Seck *et al.,* 2012). Although rice production has increased since the 1970s, domestic production meets only 60% of the demand. Annually, Africa imports about 13 million tons of milled rice which is equivalent to about one-third of the world market. In 2008, growing concern about global food security led to a hike in food prices, particularly in rice, that consequently led to social unrest (*Saito et al.,* 2015). As a result of this 'rice crisis', African governments and the international donor community embarked on ambitious rice-development programs to achieve self-sufficiency (Saito *et al*., 2015). In Nigeria, lowland rice is cultivated on an estimated area of 3 million hectares out of which 1.8 million hectares are prone to iron toxicity (NCRI, 2012). One of the areas where rice is commonly grown in Nigeria is Edozhigi village in Bida Local Government Area of Niger State. The people of this environment are predominantly lowland rice farmers. A survey conducted by the West African Rice Development Association (WARDA) in the area showed that average yield of lowland rice at Edozhigi seldom exceeds 1.5 tons ha^{-1} (Narteh and Sahrawat, 1999). Iron toxicity is a major constraint to rice production in some important production areas. Iron toxicity is a nutritional disorder associated with high level of ferrous iron concentration in the soil and is found mainly in waterlogged lowlands (Cherif *et al.*, 2009). The response of rice to iron toxicity varies among different rice varieties. Some varieties have the mechanism to retain high iron levels in their roots or as oxides in the rhizosphere while other varieties are susceptible to iron toxicity, expressed in poor adaptability to iron toxicity stressed environment (Mandal *et al.,* 2004). Fukuda *et al.,* (2012), reported that the surest way to counter iron toxicity is by using tolerant rice varieties. Genetic improvement of iron-toxicity tolerance implies the need of varietal screening to make good use of the existing diversity for iron toxicity tolerance. Lowland soils in Nigeria have high concentrations of iron. This is an impediment to rice production in the lowlands. Rice is mostly grown by small holder farmers in Nigeria who depend on good harvests as their source of income. Since rice is a staple food in Nigeria, a low production due to iron toxicity threatens the country's food security.

Several researches have been carried out on iron toxicity effects on rice production around the world. But in Nigeria, works on iron toxicity in rice have been based on mere selection. Therefore, adequate information has not been clearly understood about the constraint. Understanding of the genetic basis of iron tolerance mechanisms can provide useful information that will guide in designing strategic programme for the breeding of iron toxicity tolerant rice varieties. Consequently, knowing genetic bases of the materials formed the basis of this research. Genetic variability is the basic requirement for crop improvement as this provides wider scope for selection. Thus, effectiveness of selection is dependent upon the nature, extent and magnitude of genetic variability present in material and extent to which it is heritable. According to Wright (1921), knowledge of heritability for different component traits are essential for any crop improvement programme because the heritable component is the consequence of genotype and is inherited from generation to generation.

The objective of the present study was to determine Genetic variability, heritability, genetic advance and genetic advance as percent mean of some agronomic traits for iron toxicity in rice.

II. MATERIALS AND METHODS

The research was conducted at the National Cereals Research Institute (NCRI) research field Edozhigi, Bida in Niger State from November 2017 to February 2018. The experimental field is known to be an iron toxicity hot spot located in the Southern Guinea Savannah region of Nigeria at 09° 05 39.9′N Latitude and 06° 07′E Longitude at an Altitude of 50.57 m above the sea level, (https://sciaiert.net) with the mean annual temperature of 23°C- 37°C and the mean annual rainfall of about 1800-2200 mm, (https://sciaiert.net)

Table 1: Soil Analysis of the Study Area: Edozhigi, Bida, Niger State, 2018

Parameters	0-15cm value	15-30cm value
Sand (%)	84.96	83.24
Silt (%)	10.56	8.28
Clay (%)	4.48	8.48
USDA Textural Class	*Sandy loam*	*Sandy loam*
pH (H_20)	4.64	4.65
Organic Carbon (%)	0.59	0.68
Organic Matter (%)	1.02	1.18
Total Nitrogen (%)	0.15	0.10
Available Phosphorus (mg/kg)	25.00	26.88
Exchangeable Bases (Cmol/kg)		
Calcium (Ca^{2+})	2.48	2.88
Magnesium (Mg^{2+})	4.63	5.90
Sodium (Na^+)	0.17	0.13
Potassium (K^+)	0.15	0.20
Exchangeable Acidity (Cmol/kg)	0.05	0.08
Cation Exchange Capacity (Cmol/kg)	7.48	9.19
Fe ($mgkg^{-1}$)	546	537

The experimental materials comprised of eight genotypes of rice five obtained from the National Cereals Research Institute (NCRI) Badeggi, Niger State and three from West African Rice Centre, Ibadan. The description of the rice genotypes is presented in Table 2. The eight rice genotypes were mated using half diallel mating design method IV model I to generate 28 F_1. Seeds were planted in 128 buckets in four successions at an interval of one week (32 buckets in each succession) to synchronize flowering. Emasculation was carried out between 07.00 am and 09.00 am which involved direct removal of anthers before anthesis. In rice, anthers are enclosed in lemma and palea. Scissors was used to cut the un-matured caryopsis to expose the anthers and carefully removed with forceps without causing damage to the style and stigma. For the hybridization, flowers containing matured pollen grains from the male plants were shed on the emasculated panicles between 10am and 12noon. Pollinated flowers were covered with envelops sizeable enough to avoid contaminations and damages, (Mohanan, 2010).

Field Evaluation of the F_1 Genotypes and their Parents

The eight parents, 28 F_1 hybrids and two checks making a total of 38 entries were evaluated at an iron toxicity spot in-situ at Edozhigi, Niger State. Plots were laid in a randomized complete block design with three replications. The genotypes were randomly planted with five stands per plot at 20 cm x 20 cm inter and intra row spacing respectively. All cultural practices for rice production were carried out in accordance with the recommendations of the NCRI, Badeggi.

Table 2: Description of the Genetic Materials used for the Study

Genotypes/Variety	Source	Potential Yield (kg/ha)	Plant height (cm)	Days to maturity	Reaction to Iron Toxicity
FARO 44 (P_1)	NCRI	6442	115	95-105	S
FARO52 (P_2)	NCRI	6710	129	125-135	T
FARO 60(P_3)	NCRI	6754	120	100-115	S
FARO 57 (P_4)	NCRI	7954	124	120 - 135	T
FARO61(P_5)	NCRI	6312	115	100-110	S
SUAKOKO 8 (P6)	WARDA	5500	141	115 - 120	T
CK-21 (P7)	WARDA	5000	130	120 - 130	T
CK- 43 (P_8)	WARDA	5000	75-80	80 – 90	T

Source: NCRI/ WARDA 2017, S: Susceptible, T: Tolerant

Coefficient of Variation

The coefficient of variation for different characters was estimated using the formula suggested by Singh and Chaudhary (1985)

$$GCV = \frac{\sqrt{\sigma_g^2}}{\bar{x}} \text{ x } 100\%$$

Where: GCV = genotypic coefficient of variation, σ_g^2 = estimate of genetic variance,

$\bar{x}$ = grand mean of the respective character

$$\text{Phenotypic coefficient of variation PCV} = \frac{\sqrt{\sigma_{ph}^2}}{\bar{x}} \text{ x } 100\%$$

Where: PCV = Phenotypic coefficient of variation, σ_{ph}^2 = estimate of phenotypic variance,

$\bar{x}$ = grand mean of the respected character.

The PCV and GCV values were categorized as low, moderate and high as suggested by Sivasubramanian and Madhavamenon (1973). <0-10%=(low), 10-20% (moderate), >20% (High).

Heritability in broad sense (h^2_{bs}) and genetic advance as percentage of the mean

Heritability in broad sense (h^2_{bs}) is defined as the proportion of the genotypic variance to the total phenotypic variance and estimated using the formula suggested by (Johnson *et al*., 1955).

$$H_b\% = \frac{\sigma_g^2}{\sigma_{ph}^2} \times 100$$

Where: $\sigma_{ph}^2 = \sigma_g^2 + \sigma_{e/r}^2$

For the purpose of estimating heritability, random model was assumed.

The heritability estimates were categorized according to (Robinson *et al*., 1949) as 0-30% (low), 30-60% (moderate), 60 % and above (high).

Genetic advance (GA) was calculated with the method suggested by Allard (1960) and Singh and Chaudhury (1985): GA= K.h2 where: K- constant = 2.06 at 5% selection intensity, σ 2ph - phenotypic variance, h2 - heritability in broad sense.

Data Collection

Data were collected on the followings traits: Plant height at maturity (cm), Number of tillers, Number of leaves, Days to 50% flowering, Panicle length (cm), Number of seeds per panicle, Iron toxicity score: *This was recorded on the scale 1 to 9. Where 1.0= highly resistance, 3.0= resistance, 5.0 = moderately susceptible, 7.0= susceptible and 9.0=highly susceptible IRRI$_{SES,}$ (2001),* Grain Yield after harvest (g), Number of effective tillers, One thousand (1000) grain weight (g) and Panicle Exertion.

Statistical Analysis

The data collected were subjected to analysis of variance (ANOVA) using general linear model procedure of Statistical Analysis System (SAS) package (2002). Significant difference between treatments means were compared using least significant difference (LSD) using linear model as shown below:

$$Y_{ijk} = \mu + \alpha_i + r_j + \ell_{ijk}$$

Where: Y_{ijk} is the observation in treatment i and block j and k, μ is the overall mean, α_i is the effect of treatment, ℓ_{ijk} is the random error

III. RESULTS

The results of the analysis of variance showed highly significant (P<0.01) difference among the genotypes for all traits measured under iron toxicity hotspot (Table 3). The highest mean performance for grain yield among parents was observed in FARO 57 (8210 kg/ha) with the first and second iron toxicity scores of 3.0 and 5.0, respectively, while the lowest mean performance for grain yield was observed in FARO 60 (2830 kg/ha) with first and second iron toxicity scores of 4.3 and 7.0, respectively with a mean value of 4429 kg, (Table 4).

Days to 50% flowering varied among the parents between 57days for FARO 61 to 93 days for CK-21 with an average value of 77days. The number of tillers per plant varied between 20 tillers for FARO 44 to 47 tillers for CK-43 with the mean value of 32 tillers. Number of leaves per plant ranged from 4 leaves for Suakoko 8 to 8 leaves for CK-43 with the mean value of 6.0 leaves. Plant height varied from 53.1cm for FARO 60 to 138.6cm for CK-21 with a mean value of 95.6 cm. Panicle length varied considerably among the parents between 17cm for FARO 60 to 28cm FARO 57 with an average value of 23.7 cm. Number of seeds per panicle differed among parents between 76 for FARO 44 to 254 for FARO 57 with a mean value of 159 seeds. Panicle exertion among the genotypes ranged from 1.0cm each for FARO 52, FARO 57, Suakoko 8, CK-21 and CK-43 to 5.0cm for FARO 60 with an average value of 2.1cm. Highest number of effective tillers was recorded for CK-43 (41.0) while 14 were observed for Faro 44 as he lowest with the mean value of 28.

Table 3: Analysis of variance (ANOVA) for grain yield and other agronomic traits under iron toxicity at Edozhigi in 2018

Source of variation	Replication	Genotype	Error
Df	2	37	70
Grain yield (kg/ha)	23.36	3733.03**	93.73
Days to flowering	8.18	383.48**	49.28
Number of tiller	19.27	139.89**	17.36
Number of leaves	0.62	2.18**	0.42
plant height (cm)	97.47	1755.86**	138.96
panicle length (cm)	3.59	20.05**	2.11
Number of seed per panicle	32.11	6450.62**	550.35
Panicle exertion (cm)	0.48	4.99**	0.86
Number of effective tillers	13.01	195.61**	37.53
1000 grain weight (g)	0.03	27.03**	2.55
1st iron score (ses)	2.11	4.99**	1.73
2nd iron score (ses)	2.81	10.59**	1.86

****=** Significant at 0.01 probability level; df=Degree of Freedom.

Table 4: Mean performance for Parents and F_1 genotypes of rice under iron toxicity condition at Edozhigi in 2018

Genotype	Grain yield (kg/ha)	Days to flowering	Number of tillers	Number of leaves	plant height (cm)	panicle length (cm)	Number of seeds per panicle	Panicle exertion (cm)	Number of effective tillers	1000 grain weight (g)	1st iron score (ses)	2nd iron score (ses)
Parents												
Faro 44	3020	84.0	21.0	6.0	61.9	20.9	76.0	3.7	14.0	27.2	5.0	7.0
Faro 52	7560	89.0	36.0	6.0	85.7	26.2	158.0	1.0	32.0	26.2	2.3	3.0
Faro 60	2830	69.0	27.0	6.0	53.1	17.4	95.0	5.0	17.0	27.3	4.3	7.0
Faro 57	8210	89.0	42.0	5.0	72.5	28.3	254.0	1.0	40.0	29.2	3.0	5.0
Faro 61	2955	57.0	28.0	7.0	65.7	21.5	85.0	3.0	18.0	26.6	4.3	6.3
Suakoko 8	6105	77.0	34.0	5.0	119	26.3	175.0	1.0	31.0	36.2	1.0	2.3
CK-21	7355	93.0	33.0	4.0	138.6	27.2	235.0	1.0	31.0	31.2	1.7	1.7
CK-43	6225	69.0	47.0	8.0	101.3	20.3	114.0	1.0	41.0	36.8	1.7	2.3
Hybrids												
Faro 44 x Faro 52	3025	76.0	27.0	6.0	68.4	21.4	124.0	3.0	21.0	27.3	5.0	7.0
Faro 44 x Faro 60	2590	57.0	26.0	6.0	65.9	22.3	94.0	5.0	17.0	26.5	5.7	7.0
Faro 44 x Faro 57	3675	88.0	33.0	6.0	78.3	23.1	204.0	1.0	27.0	28.6	3.7	6.3
Faro 44 x Faro 61	2550	77.0	22.0	6.0	67.4	19.5	109.0	4.3	16.0	26.8	4.3	7.0
Faro 44 x Suakoko 8	3240	89.0	27.0	5.0	103.3	24.4	133.0	2.3	23.0	30.2	3.0	3.7
Faro 44 x CK- 21	3855	75.0	36.0	6.0	105.7	24.3	181.0	1.0.	33.0	27.4	3.0	5.0
Faro 44 x CK- 43	3890	59.0	34.0	7.0	98.6	23.9	125.0	1.7	31.0	29.9	3.0	4.3
Faro 52 x Faro 60	3575	69.0	32.0	5.0	111.0	25.9	166.0	1.7	29.0	24.6	1.7	3.0
Faro 52 x Faro 57	5595	76.0	27.0	6.0	68.4	22.9	124.0	3.0	21.0	27.3	4.3	7.0
Faro 52 x Faro 61	3940	68.0	32.0	7.0	83.9	25.8	244.0	1.0	29.0	28.6	3.0	5.0
Faro 52 x Suakoko 8	6010	88.0	44.0	5.0	104.7	27.1	217.0	1.0	41.0	25.9	2.3	2.3
Faro 52 x CK- 21	6870	67.0	37.0	5.0	106.4	24.7	143.0	1.0	28.0	23.9	1.0	1.7
Faro 52 x CK- 43	6525	74.0	30.0	5.0	109.3	25.7	153.0	2.3	26.0	26.1	4.3	4.3

Table 4: Cont'd

Genotype	Grain yield (kg/ha)	Days to flowering	Number of tillers	Number of leaves	plant height (cm)	panicle length (cm)	Number of seeds per panicle	Panicle exertion (cm)	Number of effective tillers	1000 grain weight (g)	1st iron score (ses)	2nd iron score (ses)
Faro 60 x Faro 57	3290	56.0	34.0	7.0	85.4	23.0	173.0	3.7	30.0	29.2	3.7	7.0
Faro 60 x Faro 61	2640	82.0	23.0	7.0	68.8	17.9	101.0	4.3	15.0	26.2	5.7	7.0
Faro 60 x Suakoko 8	3140	56.0	34.0	5.0	101.2	27.7	165.0	2.3	35.0	28.9	1.7	3.7
Faro 60 x CK-21	3455	86.0	34.0	5.0	91.8	23.9	188.0	1.0	31.0	30.3	2.3	2.3
Faro 60 x CK- 43	3315	57.0	30.0	6.0	117.1	25.0	163.0	1.0	30.0	27.9	3.0	3.0
Faro 57 x Faro 61	3070	85.0	31.0	7.0	77.5	24.3	191.0	1.7	27.0	24.9	3.7	4.3
Faro 57 x Suakoko 8	3760	79.0	31.0	5.0	97.5	24.5	177.0	2.3	26.0	28.9	3.0	3.0
Faro 57 x CK- 21	5905	79.0	41.0	5.0	133.5	25.0	217	1.0	36.0	28.0	2.3	4.3
Faro 57 x CK- 43	6675	68.0	30.0	6.0	127.5	26.3	184.0	1.0	27.0	28.9	3.7	4.3
Faro 61 x Suakoko 8	3050	68.0	30.0	6.0	71.3	23.0	127.0	3.0	22.0	26.9	3.7	5.0
Faro 61 x CK- 21	2860	76.0	36.0	6.0	124.1	26.1	199.0	1.0	33.0	29.0	1.7	3.0
Faro 61 x CK- 43	3585	56.0	33.0	7.0	104.7	23.9	181.0	1.0	30.0	27.9	3.0	3.0
Suakoko 8 x CK-21	7045	77.0	29.0	4.0	121.8	25.9	162.0	1.0	24.0	30.3	1.7	2.3
Suakoko 8 x CK- 43	6725	68.0	41.0	4.0	130.8	25.5	124.0	1.0	36.0	37.0	2.3	2.3
CK- 21 x CK- 43	5960	68.0	53.0	6.0	136.6	23.8	216.0	1.0	50.0	28.2	1.0	1.7
Check 1(Alh Baba)	4225	67.0	27.0	5.0	74.2	19.1	157.0	4.3	21.0	24.0	3.7	6.3
Check 2 (Ewodufagi)	4435	76.0	23.0	4.0	98.8	22.6	122.0	3.0	19.0	26.4	3.7	4.3
MEAN	4429	77.0	32.0	6.0	95.6	23.9	159.0	2.1	28.0	28.3	3.1	4.4
CV(%)	10.6	10.0	13.0	11.0	12.3	6.1	15.0	26.9	22.0	5.6	23.1	21.8
LSD (0.05%)	15.8	11.0	6.80	1.0	19.2	2.4	38.0	1.5	10.0	2.6	2.1	2.2

One thousand (1000) grain weight varied from 26.2g for FARO 52 to 36.8g for CK-43 with an average value of 28.3g. First iron toxicity score ranged from 1.0 for Suakoko 8 to 5.0 for FARO 44 with a mean value of 3.1, while second iron toxicity score also varied from 1.7 for CK-21 to 7.0 each for FARO 44 and FARO 60 with an average value of 4.4.

Among the F_1crosses, highest grain yield 7045 kg/ha was recorded for Suakoko 8 x CK-21 with first and second iron toxicity scores of 1.7 and 2.3, respectively, while the lowest mean performance for grain yield 2550 kg/ha was recorded for FARO 44 x FARO 61 with first and second iron toxicity scores of 4.3 and 7.0, respectively, with the mean value of 4429 kg/ha.

The earliest days to 50% flowering was recorded 56 days each for FARO 60 x FARO 57, FARO 60 x Suakoko 8 and FARO 61 x CK-43 and 89 days each for FARO 44 x FARO 57and FARO 52 x Suakoko 8 and FARO 44 x Suakok 8 as the latest with a mean value of 77. The number of tillers varied between 22 tillers for FARO44 x FARO 61 to 53 tillers for CK-21 x CK43 with the mean value of 32.0. Number of leaves per plant ranged from 4 leaves for Suakoko 8 x CK43 to 7 leaves for FARO61 x CK43 with a mean value of 6.

Plant height varied between 65.9cm for FARO 44 x FARO 60 to 136.6 cm for CK21 x CK43 with a mean value of 95.6. Panicle length varied between 17.9 cm for FARO 60 x FARO 61 to 27.7cm for FARO 60 x Suakoko 8 with an average value of 23.9. Number of seeds per panicle ranged from 94 seeds for FARO 44 x FARO 60 to 244 seeds for F_1 FARO 52 x FARO 61 with mean value of 159. Panicle exertion ranged from 1 cm to 5 cm with mean value of 2.1cm. Number of effective tillers was recorded highest 50 tillers for CK-21 x CK-43 and recorded lowest 15 tillers for FARO 60 x FARO 61 with an average value of 28. The mean value of 1000 seeds weight was 28.3g, the weight varied from 26.2g for FARO 60 x FARO 61 to 37.0g for Suakoko 8 x CK-43. The first iron toxicity score ranged from 1.0 each for FARO 52 x CK-21 and CK-21 x CK-43 to 5.7 each for FARO 44 x FARO 60 and FARO 60 x FARO 61 with an average value of 3.1. The second iron toxicity score ranged from 1.7 each for FARO 52 x CK- 21 and CK-21 x CK 43 to 7.0 each for FARO 44 x FARO 52, FARO 44 x FARO 60, FARO44 x FARO 61, FARO 52 x FARO57, FARO 60 x FARO 57 and FARO 60 x FARO 61 with an average value of 4.4.

The PCV values were slightly higher than the corresponding GCV values (Table 5). High PCV and GCV (106.5 and

101.8), respectively, were recorded for panicle exertion and moderate PCV and GCV were recorded for panicle length (18.7 and 18.2) as well as for 1000 grain weight (18.4 and 17.9), respectively. High broad sense

High broad sense heritability was observed for all traits under iron toxicity hotspot condition. The results ranged from (82.7%) for first iron score to (98.7%) for grain yield followed by (96.0%) for plant height, (95.7%) for number of seeds per panicle and (95.3%) for 1000 grain weight. High genetic advance were observed in case of number of seeds per panicle (158.34), followed by grain yield (124.23), plant height (82.87), days to 50% flowering (37.76), number of effective tillers (26.05) and number of tillers (22.86). While low genetic advance were observed in the following traits 1000 grain weight (10.20), panicle length (8.74), second iron toxicity score (6.12), panicle exertion (4.21), first iron toxicity score (3.81) and number of leaves (2.77).

Table 5: Variance components for iron toxicity and agronomic traits of rice F_{1S} at Edozhigi in 2018

Traits	σ^2_g	σ^2_e	σ^2_{ph}	H_b (%)	PCV(%)	GCV(%)	GA%	GAM
Grain yield	3686.1	46.87	3733	98.7	67.2	66.8	124.23	2.81
Days to flowering	358.9	24.64	383.5	93.6	27.4	26.5	37.76	49.04
Number of tillers	131.2	8.68	139.9	93.8	36.5	35.4	22.86	71.42
Number of leaves	2.0	0.21	2.2	90.5	26.5	25.2	2.77	7.68
Number of seed per panicle	6175.8	275.18	6451	95.7	50.5	49.4	158.34	99.59
Panicle exertion	4.6	0.43	5.0	91.4	106.5	101.8	4.21	200.48
panicle length	19.0	1.06	20.05	94.7	18.7	18.2	8.74	36.55
plant height	1686.4	69.48	1755.9	96.0	43.8	430	82.87	86.68
Number of effective tillers	176.8	18.77	195.6	90.4	50.3	47.8	26.05	93.02
1000 grain weight	25.7	1.28	27.0	95.3	18.4	17.9	10.20	36.05
1st iron score	4.1	0.87	5.0	82.7	72.1	65.6	3.81	122.88
2nd iron score	9.7	0.93	10.6	91.2	74.0	70.7	6.12	139.02

σ^2_g =Genotypic variance, σ^2_e =Environmental variance, σ^2_{ph} =Phenotypic variance, PCV= Phenotypic coefficient of variation, GCV= Genotypic coefficient of variation, H_b %=Broad sense heritability.

IV. DISCUSSION

The analysis of variance showed highly significant difference among the genotypes for all the traits measured. This suggested that there was an inherent genetic difference among the genotypes. The genetic variability in breeding is very important especially for desirable traits. The more variability in a population is the more opportunity for crop improvement for desirable traits in that population. Harsha, *et al*. (2017) pointed out that the source of any kind of selection depends on the existence of the genetic variability. Significant variability for various traits in different sets of genotypes were also reported by rice researchers in their experimental materials Abdul Fiyaz, *et al*. (2011), Abdourasmane *et al*. (2016) and Bhatt *et al.* (2016) in rice genotypes. Significant differences for characters in the present set of genotypes suggested a positive scope for improvement of various traits through simple selection which is in agreement with Painkra, (2014).

A wide range in mean performance was observed for grain yield, days to 50% flowering, number of effective tillers, number of leaves, plant height and other traits. This signified that there is high contribution of both positive and negative genes among the genotypes studied. This is in conformity with Bhatt *et al.* (2016). Wide range in mean performance among the genotypes also indicated the presence of significant amount of genetic variability for the most traits studied. This is in conformity with the results reported by Mulugeta *et al.* (2012), on mean performance and ranges for the measured traits among rice genotypes. Similar results had been reported that crosses of unrelated lines of rice yielded better than crosses of related lines, (Ismaila 2012). And Bhatt *et al*, (2016), also confirmed that the cross between distance genotypes may be expected to exhibit high heterosis through desirable segregation in later generation of hybridization. Mean performance of the cross between tolerant varieties tended to yield higher; FARO 52 x FARO 57 (5595 kg/ha), FARO 52 x Ck-21 (6870 kg/ha) than those between tolerance and susceptible genotypes; FARO 57 x FARO 44 (3675 kg/ha), FARO 44s x Ck-21 (3855 kg/ha) and those between susceptible genotypes; FARO 44 x FARO 60 (2590 kg/ha) and FARO 60 x FARO 61 (2640 kg/ha).This is in conformity with results reported by Ismaila *et al.* (2015). Mean performance of some varieties as well as some hybrids with high iron toxicity/ leaf bronzing scores had low grain yield, low number of tillers, stunted plant height, low number of seeds per panicles and low number of effective of tillers. Devi *et al*, (2018), reported that for each increase in leaf bronzing symptom score, yield reduction occurs approximately by 400 kg/ha. Based on the leaf bronzing score, FARO 44, FARO 60 and hybrid FARO 44 x FARO 61 had low mean performance of grain yield and other traits which could indicate that these varieties are susceptible to iron toxicity or have little or no adaptation mechanism as reported by Jiang *et al.*(2004) or are less capable of oxidizing large amount of iron translocated to the shoot Devi *et al*, (2018). Choosing breeding populations with a high mean performance is straight forward.

Coefficient of variation provides the relative measure of variability among the different traits. Genotypic coefficient of variation (GCV) gives the implication of genetic potential of traits under study in crop improvement through selection (Johnson *et al.*, 1955). The GCV was high for most of the traits measured except for panicle length and 1000 grain weight that measured moderate GCV. Similar trend was observed for phenotypic coefficient of variation (PCV), but close relationship between GCV and PCV was found in all the traits. However, PCV values were slightly greater than GCV values, revealing very little influence of environment and predominance of genetic factors for their expression of the traits. This implies that there is a good scope for yield improvement through phenotypic selection for grain yield. In addition, it indicates the presence of sufficient genetic variability for observed traits and may facilitate the success of the selection process. This present study is similar to findings reported by Abdul Fiyaz *et a.* (2011), Dutta and Borua (2013), Aditya (2013), Konate *et al*. (2016) and Abayneh (2018). Considering the amount of genetic variation alone will not be of much use to the breeder unless supplemented with the information on heritability estimate that gives a measure of the heritable portion of the total variation. It was suggested by Abdul Fiyaz *et al*, (2011) that the GCV along with heritability estimate could provide a better picture of the amount of genetic advance to be expected by phenotypic selection. Since heritability is dependent on phenotypic variability and in addition to selection intensity, the heritability estimates will be effective and reliable in predicting response to selection Johnson *et al.* (1955). Heritability in broad sense includes both additive and non-additive gene effects Hanson *et al.* (1956). In the present study, broad sense heritability was estimated. Nevertheless, high broad sense heritability estimates were recorded for all the traits studied. This indicated high breeding value which has additive genetic effects which is important for crop improvement. It also indicated that large proportion of phenotypic variance was attributed to the genotypic variance and slightly influenced by the environment. This present study is in conformity with the findings reported by Mulugeta *et al.* (2012) and Ismaila *et al.* (2012) who observed high broad sense heritability in all traits studied in rice genotypes. High heritability accompanied with high genetic advance in case of grain yield, days to 50% flowering, number of tillers, number of seeds per panicle, plant height and number of effective tillers indicate that most likely the heritability due to additive gene effects and selection may be effective in early generations for these traits. While high heritability coupled with low genetic advance in case of number of leaves, panicle exertion, panicle length, 1000 grain weight and first and second iron toxicity scores indicate non-additive gene effects. This therefore, means that there is a limited scope for improvement in these traits. Similar findings have been reported by Sharma and Garg (2002) which support the present study.

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