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Green Super Rice (*Oryza sativa* L.) Variety Evaluation Under Rain Fed Conditions in Ethiopia

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Abstract

Two different sets of field experiments were conducted from 2016 to2018 main cropping seasons. In experiment I, 15 GSR genotypes including two checks were evaluated in Fogera and Shire-Maitsebri and its objective was to select cold tolerant and high yielding GSR rice varieties. In experiment II, a total of 20 GSR genotypes including one check were evaluated in Pawe and Assosa with the objective of selecting high yielding and disease resistance in the lowland ecosystems of Ethiopia. In both sets of experiments, the trials were laid out in randomized complete block design with three replications. The combined analysis of variance in experiment I revealed significant difference on most of agronomic traits ($P \leq 0.01$). Three genotypes (G2, G6 and G4) showed significant difference than the standard checks on grain yield and gave grain yield advantage of 32.6 %, 27.9 % and 22.3 %, respectively. GGE-bi-plot analysis revealed that G2 and G6 are high yielding and most stable among tested genotypes in both environments. There was no grain sterility problems observed in both genotypes (G2 &G6) and had better panicle exertion which can fit the cold tolerant phenotypic characteristics. G2 has been released in 2020 as variety by giving local name "Selam" which means Peace and recommended for large scale production. In Experiment II, the mean grain yield of the 20 lowland green super rice genotypes ranged from 2730.30kgha^{-1}(G7) to 3683.40 kg ha^{-1} (G13). The combined analysis over the environments revealed that no genotype significantly gave higher yield than the standard check. There was no genotype for wider adaptability. However, the separate location analysis revealed that at Assosa, one genotype (G13) and at Pawe two genotypes (G14 and G1) gave significantly higher yield than the standard check with yield advantage of 26.7%, 21.7% and 20.6%, respectively.

Key words: GSR; Cold; Stability; Rice

Introduction

Green Super Rice (GSR) can be defined as rice varieties that can produce high and stable yields under fewer inputs (water, nutrients, and pesticides) and adverse conditions [1]. It has also become a new brand for achieving sustainable rice production through breeding. The tremendous growth of human population worldwide has increased the demand for rice production [2]. Requiring an improvement of 50% by the year 2025[3-5]. Due to its origin in tropical and subtropical regions, rice is more sensitive to cold stress than other cereals crop such as Wheat and Barley [6, 7]. Therefore, the production of rice is severely limited by cold stress in temperate areas [8, 9]. Cold stress is the major factor affecting rice growth, productivity, its distribution worldwide [10]. Production of rice is affected primary due to its vulnerability to cold stress at seedling stage, as well as reproductive stage leading to spikelet sterility. In Africa, rice also constantly increasing as staple food and there has been increasing demand in Africa in the past three decades from 1999-2018; however, these demands have not been commensurate with the total production and most of African countries are net importer of milled rice, which costs 6.4 billion USD annually [9]. The production, productivity and consumption of rice in Ethiopia are constantly increasing in the country [11]. Ethiopia's geography is noticeable by immense depressions and mountains. Consequently vast arable lands are located at high altitudes more than 1500 meter above sea level. Rice can grow in wide agro climatic zones [12]; however, low temperature stresses are serious challenges for rice farmers at high elevations in the tropics. Lack of cold tolerant rice varieties in the high lands of Ethiopia is the main constraints for the promotion of rice. Therefore, the main objective of this study was to evaluate the performance and stability of introduced lowland green super rice genotypes for their wider or specific adaption in the North-West Ethiopia and similar agro ecologies.

Materials and Methods

Two sets of low land Green Super Rice (GSR) experiments were conducted.

Experiment I

A total of 16 genotypes were introduced from China/CAASin 2014 with cold tolerant and high grain yield genotypes Laboratory and field quarantine/observation for both sets of experiment I and II were conducted in Holeta agricultural Research Center and Andasa, respectively in 2014 main cropping season (Table 1). Both sets of preliminary variety trials were conducted in 2015 in wrote a station. The multi-environment trials for sets of experiments were conducted for 3 years from 2016 to 2018. Fogera, Shire- Maitsebri, Gondar/Dembia and Jima were the testing locations for the first experiment. However the complete data were generated from Fogera and Shire-Maitsebri for the first experiment. The locations where the trials conducted differ in soil types, annual rain fall, altitude and annual temperature (Tables 2 and 3). For multi-environment trials, a total of 15 genotypes including two checks were used (Table 4).

Experiment II

A total of 40 GSR genotypes were introduced from IRRI in 2014 for

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No.	Genotype	Seed Source	No.	Genotype	Seed Source
1	Yungeng 44	CASS/ China	10	P-28	CASS/ China
2	Yungeng 31	CASS/ China	11	P-37	CASS/ China
3	Yungeng 45	CASS/ China	12	P-38	CASS/ China
4	Yungeng 38	CASS/ China	13	P-39	CASS/ China
5	Fengdao 23	CASS/ China	14	Songgeng15	CASS/ China
6	Songgeng20	CASS/ China	15	Li Jing 9	China
7	KB-2	CASS/ China	16	Li jing 11	China
8	Songgeng3	CASS/ China	17	Ediget (check 1)	Fogera/FNRRTC
9	Songgeng9	CASS/ China	18	X-Jigina (Ceck 2)	Fogera/FNRRTC

Table 1: List of genotypes introduced form China/CAAS for exameriment I.

No	Genotype	Seed Source	No	Genotype	Seed Source
1	GSR IR1-5-D1-D1	IRRI	22	GSR IR1-8-Y7-D2-S1	IRRI
2	GSR IR1-5-D7-Y3-S1	IRRI	23	GSR IR1-9-D12-D1-SU1	IRRI
3	GSR IR1-5-D20-D2-D1	IRRI	24	GSR IR1-11-D7-S1-S1	IRRI
4	GSR IR1-5-D20-D3-Y2	IRRI	25	GSR IR1-11-Y10-D3-Y3	IRRI
5	GSR IR1-5-S8-D2-S1	IRRI	26	GSR IR1-12-D10-S1-D1	IRRI
6	GSR IR1-5-S10-D1-D1	IRRI	27	GSR IR1-12-S2-Y3-Y1	IRRI
7	GSR IR1-5-S10-D3-Y2	IRRI	28	GSR IR1-12-S2-Y3-Y2	IRRI
8	GSR IR1-5-S12-D3-Y2	IRRI	29	GSR IR1-12-S8-Y1-S1	IRRI
9	GSR IR1-5-S14-S2-Y1	IRRI	30	GSR IR1-12-S8-Y1-Y2	IRRI
10	GSR IR1-5-S14-S2-Y2	IRRI	31	GSR IR1-12-Y4-D1-Y1	IRRI
11	GSR IR1-5-Y3-S2-SU1	IRRI	32	GSR IR1-12-Y4-D1-Y2	IRRI
12	GSR IR1-5-Y3-Y1-D1	IRRI	33	GSR IR1-12-Y4-D1-Y3	IRRI
13	GSR IR1-5-Y4-S1-Y1	IRRI	34	GSR IR1-12-Y4-Y1-D1	IRRI
14	GSR IR1-5-Y7-Y2-SU1	IRRI	35	GSR IR1-15-D4-D1-Y1	IRRI
15	GSR IR1-8-S6-S3-S1	IRRI	36	GSR IR1-15-D7-S4-S1	IRRI
16	GSR IR1-8-S6-S3-Y1	IRRI	37	GSR IR1-17-D6-Y1-D1	IRRI
17	GSR IR1-8-S6-S3-Y2	IRRI	38	GSR IR1-17-Y16-Y3-S1	IRRI
18	GSR IR1-8-S9-D2-Y2	IRRI	39	GSR IR1-17-Y16-Y3-Y1	IRRI
19	GSR IR1-8-S12-Y2-D1	IRRI	40	GSR IR1-17-Y16-Y3-Y2	IRRI
20	GSR IR1-8-S14-S1-SU1	IRRI	41	Ediget (Check)	Fogera/NRRTC
21	GSR IR1-8-S14-S3-Y2	IRRI	42	Gumera(Check)	Fogera/NRRTC

Table 2: List of genotypes introduced from IRRI and used for observation and preliminary variety trial used for experiment II.

Location	Altitude (m)	Latitude	Longitude	Annual rain fall (mm)	Temperature ^{0}C (Mean)	
					Max	Min
Fogera/Woreta	1810	11^{0}58'N	37^{0}41' E	1300	27.9	11.5
Shire/Mai-tsebri	1350	13^{0}05' N	38^{0}08' E	1296	36.0	15.0
Gondar/Dembiya	NA	NA	NA	NA	NA	NA
Jimma	NA	NA	NA	NA	NA	NA

Table 3: Description of study environment for Lowland GSR experiment for cold tolerant for experiment I.

Location	Altitude (m)	Latitude	Longitude	Annual rain fall (mm)	Temperature ^{0}C (Mean)	
					Max	Min
Pawe	1050	11^{0}9' N	36^{0}3' E	1457	32.8	17.2
Assosa	1590	10^{0}03'N	34^{0}59'E	1120	28.0	14.5
Tepi	NA	NA	NA	NA	NA	NA
Gambella	NA	NA	NA	NA	NA	NA

Table 4: Description of study environment for Lowland GSR experiment for experiment II.

the second experiment (Table 5). Thirty six (36) genotypes including one check were planted as preliminary variety trial in a place where temperature and humidity are high (Pawe). The plot size and type of design for observation and preliminary variety trial were not standard and vary based on the amount of seed and experimental area. For multi environment trials, Pawe, Assosa, Tepi and Gambela were used for the second experiment and 20 genotypes including one check were used for the second experiment (Table 6). However, data were generated only from Pawe and Assosa for the second experiment.

Design and trial management for Experiment I and II

The trials were laid out in randomized complete block design with three replications for both sets of experiments in all locations. Each plot had a size of 7.5 m^2 (Six rows with 5 m long x0.25 m row spacing).

No.	Genotype	Seed Source	No.	Genotype	Seed Source
1	Yungeng 44	CASS/ China	9	P-37	CASS/ China
2	Yungeng 31	CASS/ China	10	P-38	CASS/ China
3	Yungeng 45	CASS/ China	11	P-39	CASS/ China
4	Yungeng 38	CASS/ China	12	Li Jing 9	CASS/ China
5	Fengdao 23	CASS/ China	13	Li jing 11	CASS/ China
6	KB-2	CASS/ China	14	Check1(Ediget)	Fogera/NRRTC
7	Songgeng9	CASS/ China	15	Check (KOMBOKA)	Fogera/NRRTC
8	P-28	CASS/ China			

Table 5: List of genotypes used for national variety trial for cold for experiment I

No	Genotype	Seed Source	No	Genotype	Seed Source
1	GSR IR1-17-Y16-Y3-Y2	IRRI	11	GSR IR1-5-Y3-S2-SU1	IRRI
2	GSR IR1-15-D4-D1-Y1	IRRI	12	GSR IR1-11-Y10-D3-Y3	IRRI
3	GSR IR1-5-D1-D1	IRRI	13	GSR IR1-12-D10-S1-D1	IRRI
4	GSR IR1-12-Y4-Y1-D1	IRRI	14	GSR IR1-12-Y4-D1-Y2	IRRI
5	GSR IR1-8-S9-D2-Y2	IRRI	15	GSR IR1-12-S8-Y1-Y2	IRRI
6	GSR IR1-12-S2-Y3-Y2	IRRI	16	GSR IR1-5-S10-D1-D1	IRRI
7	GSR IR1-5-D20-D2-D1	IRRI	17	GSR IR1-8-S6-S3-S1	IRRI
8	GSR IR1-5-S10-D3-Y2	IRRI	18	GSR IR1-5-S12-D3-Y2	IRRI
9	GSR IR1-12-S8-Y1-S1	IRRI	19	GSR IR1-5-S8-D2-S1	IRRI
10	GSR IR1-8-S14-S1-SU1	IRRI	20	KOMBOKA (Check)-	Fogera/NRTTC

Table 6: List of genotypes used for national variety trial for experiment II

A seed rate of 60 kgha^{-1} was used with direct seeding methods in a row was applied. Fertilizer (UREA and DAP) were applied based on each location recommendation. All DAP was applied at the time of sowing. For UREA, split application was applied; 1/3 at sowing, 1/3 at active tillering and the remaining 1/3 during panicle initiations.

Agronomic data collected

The phenological and agronomic data collected includes days to heading, days to maturity, plant height (cm), Planicle length (cm), number of effective tillers per plant, number of filled grain per panicle, thousand grain weight (g), phenotypic acceptability, grain yield per plot (g).

Statistical data analysis

The data were subjected to the GLM procedure for analysis of variance using SAS software V.9.0. And Genotype x environment and stability analysis were done by using Genstat 18th edition software.

Results and Discussion

Observation and preliminary variety trial

All introduced genotypes for both sets of experiments were free from any quarantine pests and disease during quarantine and observation stages. The preliminary variety trial of the first experiment showed good performance and significant variation among tested genotypes (Figure 1). Whereas the genotypes in the second experiment revealed stunted growth and failed to seed set at Wereta however those genotypes showed a significant difference on grain yield and other traits like number of tillers and plant height in Pawe on station in 2015/16. Following this result, the national variety trials were designed and conducted (Figure 2).

Experiment I

The combined analysis of variance for grain yield, days to maturity, days to heading, panicle length and filled grain per panicle, plant height and thousand grains weight showed significant difference ($P \leq 0.01$). The analysis of environment effect also revealed significant difference ($P \leq 0.01$) for grain yield and other agronomic characters. The genotype x environment interaction effect was significant for all traits ($P \leq 0.01$). The three way interaction of genotypes x location x years showed significant variation ($P \leq 0.01$) for grain yield and other agronomic characters (Table 7). The study revealed that genotypes responded differently for grain yield and other agronomic characters to different environments. This pointed out the advantage of executing multi location trials to explore the response of genotypes for their specific or wider adaptability.

The significant interaction difference of the three way interaction of genotype x location x years revealed that the possibility of getting genotypes which can be adapted widely/or specifically. The mean grain yield of the 15lowland green super rice genotypes ranged from 3108.4 kgha^{-1}(G13) to 4840.3 kg ha^{-1} (G2). Compared to the standard checks (G14 and G15), ten genotypes (G2, G6, G4, G1, G12, G5, G8, G9, G3 and G10) it gave higher yield than the checks. However only the three genotypes viz. G2, G6and G4 showed significant difference than the standard checks for grain yield with grain yield advantage of 32.6 %, 27.9 % and 22.3 %, respectively and other agronomic traits. Moreover, GGE-bi-plot analysis revealed that G2 and G6 are high yielding and most stable among tested genotypes in both environments (Figure 3). There was no grain sterility problems observed in both genotypes (G2 &G6) and had better panicle exertion which can fit the cold tolerant characteristics. G2 gave mean grain yield of 5200 kg ha^{-1}from three on-stations and 4700 kg ha^{-1} from four on-farm sites and had 17.6 % yield advantage over recently released check (*Shaga)*. Furthermore, it was cold tolerant, resistance to major diseases, and has white caryopsis color. Finally, G2has officially released and recommended for commercial production for Fogera, Dembia, Jimma, Shire-Maitsebri and similar agro-ecologies of Ethiopia.

Experiment 2

The combined analysis of variance for grain yield, days to maturity, days to heading, plant height and thousand grains weight showed highly significant difference ($P \leq 0.01$) and for panicle length significant different ($P \leq 0.05$) among the genotypes. There was no significant difference observed among tested genotypes for filled grain per panicle.

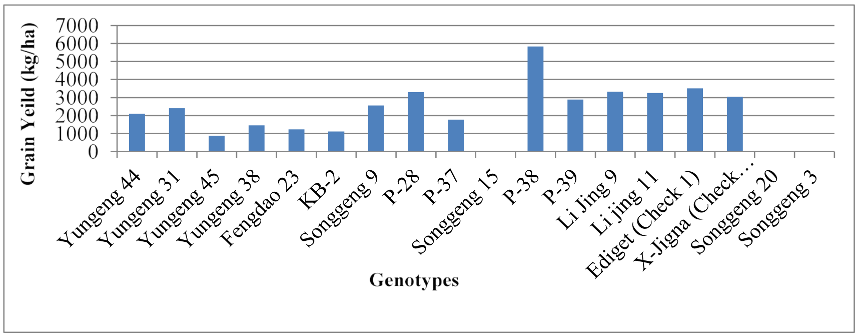

Figure 1: Grain yield performance of 18 lowland GSR cold tolerant genotypes at Wereta in 2015/16.

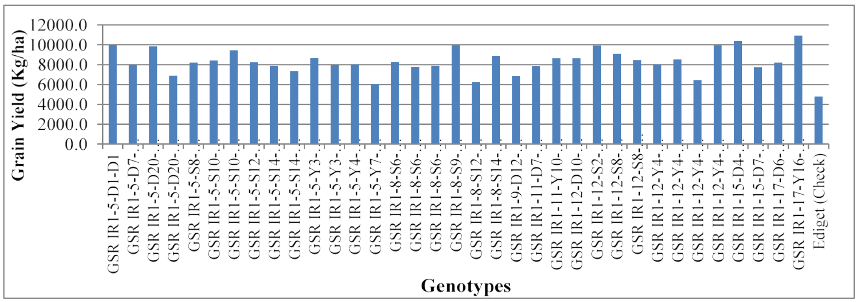

Figure 2: Grain yield performance of 36 lowland GSR genotypes at Pawe in 2015/16.

Genotype	code	DTH	DTM	PL	PH	FTP	FGP	PHA	GY
Yungeng 44	G1	95.3	132.7	17.6	81.4	10.5	114.2	1.2	4233.1
Yungeng 31	G2	91.3	127.4	19.2	87.4	10.6	123.4	1.0	4840.3
Yungeng 45	G3	94.3	134.3	18.5	78.7	11.5	116.4	1.3	3830.6
Yungeng 38	G4	91.8	127.9	19.6	85.5	10.2	124.2	1.2	4464.7
Fengdao 23	G5	92.4	151.1	16.7	74.5	16.6	91.7	1.7	3981.7
KB-2	G6	90.4	127.2	17.4	78.2	11.0	104.3	1.2	4667.8
Songgeng9	G7	84.7	123.8	17.7	75.7	11.7	95.6	2.2	3272.8
P-28	G8	89.4	127.9	16.7	74.6	11.8	99.1	1.5	3898.7
P-37	G9	87.4	122.7	16.7	73.6	12.8	101.7	1.0	3863.8
P-38	G10	100.4	137.4	19.0	80.9	12.4	101.7	2.0	3734.3
P-39	G11	88.1	121.3	17.2	77.4	13.0	96.3	1.7	3309.2
Li Jing 9	G12	86.1	122.8	19.7	86.6	10.8	119.0	1.0	4079.5
Li jing 11	G13	103.6	138.8	16.9	63.0	12.7	89.3	3.0	3108.4
Check -Ediget	G14	89.1	120.2	18.8	85.1	10.9	96.1	1.3	3649.5
Check - Komboka	G15	104.6	116.6	16.8	60.4	13.4	104.3	1.7	3373.2
Mean		92.6	128.9	17.9	77.5	12.0	105.1	1.5	3883.0
CV (%)		5.7	14.3	7.2	5.9	22.9	10.8	34	23.1
Gen. (G)		***	***	***	***	***	***	***	***
Loc. (L)		***	***	***	***	***	***	-	***
Year (Y)		***	NS	***	***	***	***	-	***
G*L		***	***	***	***	***	NS	-	***
G*L*Y		***	***	***	***	***	***	-	***

Table 7: Mean grain yield and other yield related parameters of lowland green super rice genotypes for cold tolerant at Fogera and Shire-Mai-Tsebrifrom2016 to 2018.

Note: *, **, and *** refers to significant at 5%, 1% and 0.1% level, NS=non -significant, CV= coefficient of variation, G*L= genotype by location, G*L*Y= genotype by location by year, DH= days to 50% heading, DM= days to 85% maturity, FGP= filled grains/panicle, PH= plant height (cm), PL= panicle length (cm), PHA=Phenotypic acceptability and Gy= grain yield (kg/ha).

The combined analysis of environment effect also revealed significant difference (P≤0.01) for grain yield and other agronomic characters. Except panicle length and filled grain per panicle, the three way interaction of genotypes x location x year showed significant variation (P≤0.01) for grain yield and other agronomic characters (Table 8).

The significant interaction difference of the three way interaction of genotype x location x years revealed that the possibility of getting genotypes which can be adapted widely/or specifically to all or specific environment. The mean grain yield for the 20 lowland green super rice genotypes ranged from 2730.30 kgha^{-1} (G7) to 3683.40 kg ha^{-1} (G13) with the mean grain yield of 3310.04 kgha^{-1}. Compared to the standard check (G20), seven genotypes (G13, G14, G1, G12, G15, G4, G8,) gave higher yield than the check. However there is no genotype showed significant difference than the standard check on grain yield. This revealed that the tested genotypes failed to give significantly higher grain yield than the standard check (KOMBOKA) and there is no genotype for wider adaptability. However, the separate location combined analysis revealed that there is a significant difference on grain yield and other agronomic characteristics than the standard check. At Assosa, the three years combined analysis for grain yield ranged from1872.5 kgha^{-1} to 3809.7kgha^{-1} and mean grain yield of 2836.23kgha^{-1}. Seven genotypes (G13, G12, G6, G4, G3, G15 and G8) gave higher grain yield than the standard check (Table 9). However, only one genotype (G13) gave statistically significantly higher grain yield than the check and with grain yield advantage of 26.7% as compared to the check.

At Pawe, the combined analysis of variance showed that significant difference (P≤0.01) for grain yield, days to maturity, days to heading and plant height ; and significant different (P≤0.05) for thousand grain weight among the genotypes (Table 10). There was no significant difference for fertile tillers per plant and fertile grain per panicle among tested genotypes. The genotype by year interaction showed that significant difference for plant height (P≤0.01) and grain yield (P≤0.05). The mean grain yield ranges from 3416.7 kgha^{-1}to 4545.8 kgha^{-1}. Two genotypes (G14 and G1) showed significant different than the check and gave yield advantage of 21.7% and 20.6%, respectively.

Conclusion

The present study in the first experiment revealed that significant differences among genotypes and environments for grain yield and related agronomic traits suggesting differential response of genotypes to varied environments. In the first set of experiments, G2 (Yungeng 31) and G6 (KB-2) were proposed for national variety release and G2 released as variety for large scale production. The seed of this variety should be increased, demonstrated and popularized. For the second experiment, the combined analysis over years and locations revealed that there was no genotype which was statistically significant higher than the standard check for grain yield and related agronomic traits. However, site specific analysis at Pawe showed that two genotypes, G14 (GSR IR1-12-Y4-D1-Y2and G1(GSR IR1-17-Y16-Y3-Y2) gave significantly higher grain yield than the check with yield advantage of 21.7% and 20.6%, respectively. Similarly at AssosaG13 (GSR IR1-12-D10-S1-D1) gave significantly higher grain yield than the check with yield advantage of 26.7%.Therefore, further investigation of regional variety trial is necessary for Pawe and Assosa areas to recommend for their specific locations. The first experiment revealed the importance of cold tolerance, high yield and diseases resistance in the evaluation of genotypes. Cold tolerance varieties allow the rice producers to use high elevation areas for rice production. The released variety from the first experiment may have a significant role to boost rice production and productivity in high elevation of rain fed lowland rice in Ethiopia.

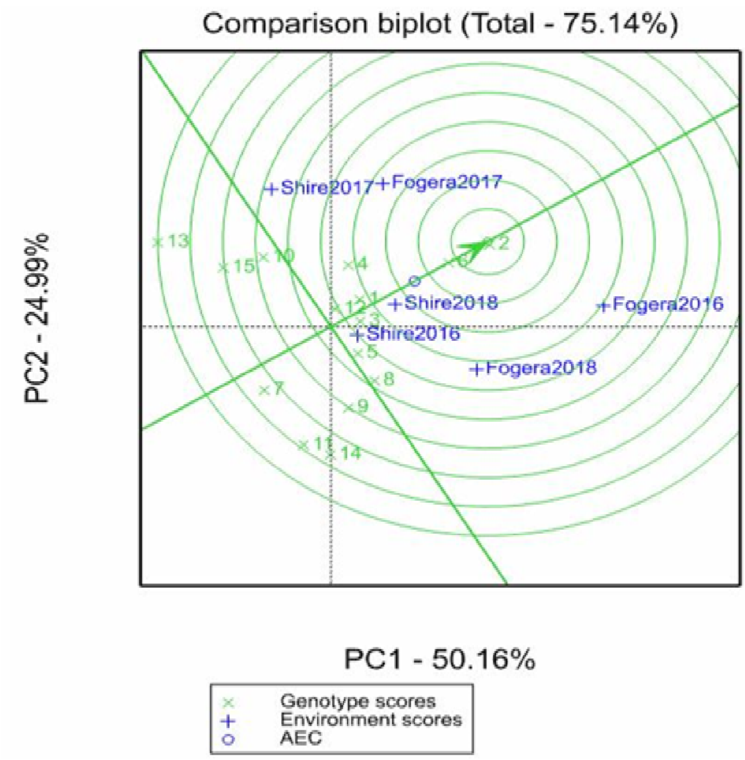

Figure 3: The average-environment coordination (AEC) view of ranking rice genotypes relative to an ideal genotype (center of the concentric circle).

Genotype	Code	DTH	DTM	PL	PH	FTP	FGP	GY
GSR IR1-17-Y16-Y3-Y2	1	104.11	139.22	19.62	77.75	6.40	87.71	3653.70
GSR IR1-15-D4-D1-Y1	2	104.89	140.22	19.93	78.21	6.08	96.84	2929.70
GSR IR1-5-D1-D1	3	105.61	142.72	20.53	78.36	6.57	96.01	3347.10
GSR IR1-12-Y4-Y1-D1	4	105.56	140.17	19.81	78.48	6.37	91.57	3436.40
GSR IR1-8-S9-D2-Y2	5	107.94	142.17	20.41	79.26	6.40	90.35	3307.00
GSR IR1-12-S2-Y3-Y2	6	106.50	142.50	21.23	79.39	5.91	91.98	3351.80
GSR IR1-5-D20-D2-D1	7	107.11	142.00	19.47	79.43	6.71	95.68	2730.30
GSR IR1-5-S10-D3-Y2	8	110.78	144.78	19.95	80.51	5.98	93.27	3409.20
GSR IR1-12-S8-Y1-S1	9	104.17	137.72	20.02	80.87	6.47	86.69	3089.50
GSR IR1-8-S14-S1-SU1	10	104.56	140.00	21.70	81.31	5.68	100.6	3113.80
GSR IR1-5-Y3-S2-SU1	11	106.28	141.67	21.51	81.43	5.92	89.61	3136.40
GSR IR1-11-Y10-D3-Y3	12	103.78	138.61	20.48	81.72	6.12	91.29	3603.30
GSR IR1-12-D10-S1-D1	13	108.44	142.22	19.89	81.91	5.72	90.73	3683.40
GSR IR1-12-Y4-D1-Y2	14	105.72	139.61	19.59	82.22	6.41	91.97	3644.50
GSR IR1-12-S8-Y1-Y2	15	106.89	142.33	19.79	83.28	5.71	92.67	3578.90
GSR IR1-5-S10-D1-D1	16	108.17	142.50	20.06	83.44	5.78	100.8	3211.20
GSR IR1-8-S6-S3-S1	17	105.44	141.00	19.38	83.57	6.19	87.48	3113.90
GSR IR1-5-S12-D3-Y2	18	105.39	141.06	19.69	83.89	6.99	101.9	3284.80
GSR IR1-5-S8-D2-S1	19	104.22	140.28	19.82	85.62	5.42	98.91	3205.00
KOMBOKA (Check)	20	103.89	139.00	20.90	86.09	5.97	97.80	3371.00
Mean		106.00	140.99	20.19	81.34	6.14	93.70	3310.04
CV (%)		3.30	2.50	10.70	7.10	25.60	14.60	18.90
LSD (5 %)		2.32	2.36	1.42	3.81	1.03	8.99	411.09
Gen. (G)		***	***	*	***	NS	***	***
Loc. (**L**)		***	***	***	***	***	***	***
Year (Y)		***	***	NS	***	***	***	***
G***L**		***	***	**	***	NS	*	***
G***L***Y		***	***	NS	***	***	NS	***

Table 8: Mean grain yield and other yield related parameters of 20 lowland green super rice genotypes at Assosa and Pawefrom2016 to 2018.

Genotype	Code	DTH	DTM	PL	PH	FTP	FGP	TGW	GY
GSR IR1-17-Y16-Y3-Y2	1	115.89	153.00	19.61	83.94	4.16	74.22	22.48	2804.20
GSR IR1-15-D4-D1-Y1	2	115.11	152.56	19.90	85.91	4.44	86.07	23.82	2194.50
GSR IR1-5-D1-D1	3	114.67	155.67	20.98	91.96	4.73	84.20	24.42	3265.70
GSR IR1-12-Y4-Y1-D1	4	116.78	153.56	20.02	89.81	5.00	82.56	23.74	3239.60
GSR IR1-8-S9-D2-Y2	5	115.22	153.11	22.09	91.27	4.56	82.87	24.82	2802.70
GSR IR1-12-S2-Y3-Y2	6	115.67	153.22	23.50	85.39	4.78	81.13	23.37	3287.00
GSR IR1-5-D20-D2-D1	7	119.11	155.56	20.70	90.46	4.44	85.29	52.21	1872.50
GSR IR1-5-S10-D3-Y2	8	119.56	156.22	20.83	93.56	4.38	81.91	52.00	3143.20
GSR IR1-12-S8-Y1-S1	9	108.22	143.67	22.20	93.49	5.16	72.20	26.53	2775.00
GSR IR1-8-S14-S1-SU1	10	113.11	150.33	23.56	100.67	4.91	94.71	27.38	2697.90
GSR IR1-5-Y3-S2-SU1	11	116.22	154.78	22.32	93.67	4.02	76.29	25.03	2574.60
GSR IR1-11-Y10-D3-Y3	12	118.00	154.00	20.42	100.32	4.18	83.73	22.93	3440.40
GSR IR1-12-D10-S1-D1	13	119.89	154.78	21.02	91.03	4.51	82.09	25.41	3809.70
GSR IR1-12-Y4-D1-Y2	14	114.00	150.33	19.58	87.72	4.82	76.04	23.50	2743.20
GSR IR1-12-S8-Y1-Y2	15	118.11	155.56	20.80	91.23	4.22	88.36	23.86	3170.80
GSR IR1-5-S10-D1-D1	16	120.00	156.00	20.61	91.96	4.60	95.33	24.02	2449.00
GSR IR1-8-S6-S3-S1	17	114.56	152.22	20.69	97.84	4.40	68.40	25.19	2402.80
GSR IR1-5-S12-D3-Y2	18	115.11	152.89	20.78	94.83	4.62	103.0	24.47	2569.00
GSR IR1-5-S8-D2-S1	19	113.56	151.56	21.04	97.16	4.20	87.33	25.77	2475.10
KOMBOKA (Check)	20	111.44	148.56	21.62	96.29	4.33	85.60	22.58	3007.80
Mean		115.71	152.88	21.11	92.43	4.52	83.57	27.18	2836.23
CV (%)		2.8	2.3	12.9	7.5	18.5	18.5	93.8	20.8
LSD (5 %)		3.05	3.21	2.54	6.44	0.78	14.42	23.79	551.95
Genotype (G)		***	***	NS	***	NS	***	NS	***
Year (Y)		NS	***	**	***	***	***	NS	***
G*Y		NS	NS	NS	NS	NS	NS	NS	NS

Table 9: Mean grain yield and other yield related parameters of 20 lowland green super rice genotypes at **Assosa**from 2016 to 2018.

Note: *, **, and *** refers to significant at 5%, 1% and 0.1% level, NS=non -significant, CV= coefficient of variation, LSD= list significance different, G*E= genotype by environment, DH= days to 50% heading, DM= days to 85% maturity, FGP= filled grains/panicle, PH= plant height (cm), PL= panicle length (cm), TGW=thousand grain weight and GY= grain yield (kg/ha)

Genotype	Code	DTH	DTM	PL	PH	FTP	FGP	TGW	GY
GSR IR1-17-Y16-Y3-Y2	1	92	125	19.62	77.07	8.64	101.20	21.17	4503.20
GSR IR1-15-D4-D1-Y1	2	95	128	19.96	72.60	7.71	107.62	25.94	3664.80
GSR IR1-5-D1-D1	3	97	130	20.09	74.93	8.40	107.82	21.50	3428.40
GSR IR1-12-Y4-Y1-D1	4	94	127	19.60	73.04	7.73	100.58	22.38	3633.10
GSR IR1-8-S9-D2-Y2	5	101	131	18.73	67.51	8.24	97.83	20.06	3811.30
GSR IR1-12-S2-Y3-Y2	6	97	132	18.96	70.11	7.04	102.82	20.89	3416.70
GSR IR1-5-D20-D2-D1	7	95	128	18.24	66.27	8.98	106.07	20.06	3588.20
GSR IR1-5-S10-D3-Y2	8	102	133	19.07	69.89	7.58	104.62	20.22	3675.20
GSR IR1-12-S8-Y1-S1	9	100	132	17.84	70.33	7.78	101.18	19.23	3403.90
GSR IR1-8-S14-S1-SU1	10	96	130	19.84	71.51	6.44	106.64	21.17	3529.70
GSR IR1-5-Y3-S2-SU1	11	96	129	20.69	70.78	7.82	102.93	22.89	3698.20
GSR IR1-11-Y10-D3-Y3	12	90	123	20.53	70.91	8.07	98.84	21.73	3766.10
GSR IR1-12-D10-S1-D1	13	97	130	18.76	65.38	6.93	99.38	19.94	3557.10
GSR IR1-12-Y4-D1-Y2	14	97	129	19.60	69.24	8.00	107.89	21.96	4545.80
GSR IR1-12-S8-Y1-Y2	15	96	129	18.78	67.62	7.20	96.98	20.73	3987.00
GSR IR1-5-S10-D1-D1	16	96	129	19.51	69.78	6.96	106.36	21.28	3973.30
GSR IR1-8-S6-S3-S1	17	96	130	18.07	69.93	7.98	106.56	20.22	3825.00
GSR IR1-5-S12-D3-Y2	18	96	129	18.60	72.31	9.36	100.87	20.56	4000.60
GSR IR1-5-S8-D2-S1	19	95	129	18.60	65.47	6.64	110.49	20.06	3934.90
KOMBOKA (Check)	20	96	129	20.18	70.27	7.60	110.00	19.83	3734.20
Mean		96	129	19.26	70.25	7.76	103.83	21.09	3783.84
CV (%)		3.9	2.9	7.1	6.3	26.7	10.8	14.9	17.2
LSD (5 %)		3.46	3.48	1.28	4.16	1.94	10.51	2.94	608.89
Gen. (G)		***	***	***	***	NS	NS	*	***
Year (Y)		***	***	***	***	***	***	***	***
G*Y		NS	NS	NS	***	NS	NS	NS	*

Table 10: Mean grain yield and other yield related parameters of 20 lowland green super rice genotypes at **Pawe** from 2016 to 2018.

Note: *, **, and *** refers to significant at 5%, 1% and 0.1% level, NS=non -significant, CV= coefficient of variation, LSD= list significance different, G*E= genotype by environment, DH= days to 50% heading, DM= days to 85% maturity, FGP= filled grains/panicle, PH= plant height (cm), PL= panicle length (cm), TGW=thousand grain weight and GY= grain yield (kg/ha)

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