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Stability Analysis of Panicle and Grain Traits of Rainfed Upland Rice in Two Tropical Ecologies of Nigeria

Nassir, Adesola L.* and Alawode, Yetunde O.

Department of Crop Production, College of Agricultural Sciences, Olabisi Onabanjo University, Yewa Campus, Ayetoro, Nigeria

ABSTRACT

Stability of grain yield in upland rice due to the unpredictability of environmental indices is of important consideration in the development of cultivars adapted to fairly wide cultivation zone. A study was conducted with fifteen upland rice varieties in two locations in South-Western Nigeria to evaluate the contribution of panicle and grain characters to stable grain production. Data collection spanned five environments and was subjected to stability analyses. The effects of genotype, environment and their interaction were significant for all the panicle and grain characters. Broad sense heritability estimate (HB) was moderate for hundred grain weight (62.4) and grain length (58.9) but was generally low for other grain yield traits, particularly grain weight per panicle (11.6) and grain weight per plant (5.6), respectively. Stability variance identified different genotypes as stable for most of the characters. The crossover attribute of AMMI PC 1 however complimented the significant verdict returned by the stability variance though the former also specified the direction of instability. The Yield Stability index (YSi) harnessed the advantages of the two statistics to identify different genotypes as stable for different characters. Thus, there is a need to constitute a pool of genotypes for the evolution of superior synthetic but stable cultivars.

Keywords: AMMI, genotype x environment interaction, grain yield, *Oryza sativa*, yield-stability index.

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E-mail addresses:
solanassir@hotmail.com (Nassir, Adesola L.),
yalawode@noun.edu.ng (Alawode, Yetunde O.)
* Corresponding author

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INTRODUCTION

Genotype by environment (GE) interaction is an important issue in crop improvement efforts, especially considering its importance in the evolution of varieties with appreciably high and stable grain yield across seasons and specific target regions. Plant breeders are constantly guided by this to define breeding strategies and direction (Ouk et al., 2007; Acuña et al., 2008; Nassir & Ariyo, 2011). For a genotype to be commercially successful, it must perform well across the range of environment likely to be encountered in a target region over the entire array of years in which the genotype could be in use. Beyond seasonal and location differences, however, cultivation conditions within season do transit from one condition to the other, as dictated by variability in moisture and other environmental indices. This, as affirmed by Acuña et al. (2008), makes the evaluation of genotypes with respect to dominant traits necessary in different environments to guide in efforts aimed at evolving varieties with reasonably stable yield. Stability implies that both yield and quality remain somewhat constant, and this draws from holding in steady state some aspects of morphology and physiology of the crop in question even when other cultivation factors change. This homoeostatic condition must necessarily derive from the stability of the characters that cumulatively determine grain yield.

Naturally, however, the presence of GE interaction makes it difficult to fully realise the potential of a genotype for a region in which weather varies from year to year. When the GE interaction is significant, the plant and environmental factors that play a major role in causing differential performance, and their significance in determining desirable breeding strategies, must be carefully considered (Kang & Martin 1987; Yan & Hunt, 2001). A number of approaches have been used overtime for various crops to evaluate interaction between genotype and environment and hence, stability. This included the computation of stability variance (Shukla, 1972; Kang & Pham, 1991), yield/stability biplots (Kempton, 1984), the Additive Main effect and Multiplicative method (AMMI) (McLaren & Chaudhary, 1994), the Genotype plus Genotype-by-Environment Method (GGE) (Yan et al., 2000, 2007; Acuña et al., 2008; Nassir & Ariyo, 2011; Acuña & Wade, 2012). The ultimate aim is to generate conclusions that would guide breeding direction to develop genotypes with good adaptation to fairly wide environments within seasons and across regions and cultivation conditions.

A lot of GE studies have placed emphasis on identification of megaenvironments. Rice production in the upland ecology however suffers from variation in cultivation conditions within and across seasons, thereby making evaluation of stability necessary, with some emphasis on within location environment factors. In most cases, genotypes that show most stable yield appear in the centre of the AMMI Biplot and thereby combine stability with average yield (Kempton, 1984; McLaren & Chaudhary, 1994; Yan et al., 2000; Gauch, 2006; Acuña et al., 2008). This average yield is often a compromise of many plant and environment factors and may not always meet the aspiration of farmers, hence the renewed emphasis on combining stability with high grain yield. The combination of recent techniques for analysing genotype-by-environment interaction with the Yield-

Stability index has been canvassed by Nassir and Ariyo (2011). This study consequently focused on the evaluation of stability of grain yield components of upland rice using the Yield-Stability method of Kang and Pham (1991), along with the AMMI model.

MATERIALS AND METHODS

Study Location

This study was conducted at the College of Agricultural Sciences, Olabisi Onabanjo University. The first four plantings were done at Ago-Iwoye, Nigeria (3.92^{o}N, 6.95^{o}E) tropical rainforest ecology from 2001 to 2004, either with the early or the late rains. Two plantings were done at Ayetoro, Nigeria (6.5^{o}N, 5^{o}E); a location with derived savanna ecology in 2009 and 2010. The 2009 planting suffered from severe drought and was unable to produce panicles and hence not used in the analysis.

Varieties

Fifteen varieties of upland rice were obtained from the African Rice Centre (formerly West African Rice Development Association, WARDA) the substation of the International Institute of Tropical Agriculture (IITA) Ibadan and were used for the study. The varieties were: ITA 150 and OS 6 (which are frequently cultivated and established in the study region), ITA 257, ITA II7, ITA 315 and ITA 321 (which are improved release varieties), IGUAPE CATETO, LAC 23, IDSA 10 (which are cultivated in other upland ecologies in the west African sub-region), WAB 35-2-FX (hereinafter identified as WAB 35), WAB 56-60, WAB 33-25, WAB 96-1-1, WAB 99-1-1and WAB 375-B-5-H2-1 (WAB 375), which are breeding lines being developed for improved yield and especially tolerance to drought.

Plant Establishment

The upland rice varieties were sown in a nursery and later transplanted onto ploughed upland paddy as soon as rainfall became steady. There were fifteen plants per single row plot, arranged in a randomised complete block design with three replicates. The plants were separated by 30cm between and within rows. Similar planting procedure and agronomic practices were carried out for all the plantings. Only the five internal plants for each plot were used for data collection.

Data Collection

Data were collected on each plant included both panicle and reproductive characters, as described by Anon (1988) following the standard evaluation system for rice (SESR). In particular, the data were collected on panicle number, panicle length, primary branches on panicles, secondary branching, spikelets number per panicle, grain weight per panicle, grain weight per plant, 100-grain weight, grain length and width, and spikelets fertility.

Data Analysis

Results were analysed using the means recorded on the characters for each variety. Computer analysis of variance (ANOVA) was done using the SAS (2000) package. The analysis was based on the five-season (year) environment data. Meanwhile, the Additive Main Effect and Multiplicative Interaction (AMMI) analysis was done to obtain Interaction Principal Components (IPC) using the GENSTAT package Version 12. The AMMI PC 1 particularly presents the non-crossover attribute of the data and quantifies the response of genotypes to the trial environments (Yan et al., 2000; Gauch, 2006; Yan et al., 2007). Broad sense heritability estimates H_B for characters were determined from the ANOVA results using the methods enumerated by Breese (1969).

Stability variance for grain weight per plant was calculated following the procedure established by Shukla (1972). In addition, the yield stability index (YSi) was calculated to determine the genotypes, which have a combination of high yield and stability using the procedure of Kang and Pham (1991).

RESULTS AND DISCUSSION

Analysis of Variance and Broad Sense Heritability

The mean squares (MS) and broad sense heritability (H_B) for the panicle characters of the rice genotypes over the five environments are presented in Table 1. All the characters showed significant genotype, environment and genotype by environment interaction. Heritability estimates were quite low with the least value of 1.9 for panicle number and the highest estimate of 18.0 for secondary branching.

Table 2 shows the mean squares and broad sense heritability (H_B) for grain characters. All the characters also recorded significant genotype, environment and genotype by environment interaction. Grain weight per panicle and grain weight per plant had low H_B of 11.6 and 5.6, respectively. The highest H_B estimates of 62.4, 58.9 and 40.0 were recorded by 100-grain weight (62.4), grain length (58.9) and spikelet fertility (40).

The significant mean squares for the genotype effect indicate genetic differences among the varieties for all the characters. Similarly, the significant environmental effect implies that the study seasons presented discriminatory conditions for a genotype by environment (G X E) study. Following other reports on rice (Nassir & Ariyo, 2005; Acuña et al., 2008; Shrestha et al., 2012), significant differences in environmental influence are to be expected when cultivating upland rice over seasons. The significant G X E interaction for all the characters clearly implies differential genotypic response to different environments such that character expression and hence genotypic performance cannot be expected to be stable over cultivation seasons. Hence, upland rice breeding effort must be conscious of this complex scope of interaction of environment with panicle and grain characters in plant improvement.

Low heritability estimate for a number of panicle and grain characters in upland rice has been similarly reported by Nassir and Ariyo (2006). Characters that show low heritability would require many cycles of hybridisation and selection in a fair range of environments for meaningful progress. However, gains from selection for hundred (100) grain weight and grain length is likely to be faster, given the moderately high heritability estimate, and this may impact positively on larger grain weight per plant.

GE and Yield-Stability analysis for panicle and grain characters

The mean, stability variance (σ^2) and AMMI PC 1 and yield-stability statistic (YSi) for panicle characters of each genotype over the five environments are presented in Table 3. ITA 321 had the highest mean panicle number of 6.71 but was considered as unstable by the stability variance. However, it recorded a near zero, but negative AMMI PC 1 and was the only one selected by the YSi statistic among the genotypes considered as unstable by the stability variance. Similarly, ITA 117 and ITA 315 had high mean panicle number, and returned stable by the stability variance. The two also had positive interaction with the environment and were consequently selected by YSi. ITA 257 recorded above average panicle number but was the most unstable according to σ^2 and had the largest negative interaction with the environment with the largest AMMI PC 1 score of -0.964.

The longest panicles were recorded by WAB 375 (27.22cm) and OS 6 (27.19cm). The two genotypes selected by the YSi were adjudged as unstable by the stability variance and had relatively large negative

Table 1
Mean squares and broad sense heritability (H_B) for the panicle character of upland rice varieties over five environments

Source of variation	Panicle number	Panicle length (cm)	Primary branches (No)	Secondary branching (s)	Spikelets per panicle (No)
Genotype (G)	4.59*	51.49**	28.32**	1.21**	5948**
Environment (E)	305.81**	580.75**	501.90**	9.24**	121737**
GE	6.56**	21.62**	6.79**	0.55**	2980**
Pooled Error	2.33	5.51	4.17	0.22	1064
H_B (%)	1.9	13.5	11.5	18	6.9

* Significant at P< 0.05, ** Significant at P< 0.01

Table 2
Mean squares and broad sense heritability (H_B) for the grain characters of upland rice varieties over five environments

Source of Variation	Grain weight per panicle (g)	Grain weight per plant (g)	Hundred grain weight (g)	Grain length (mm)	Grain width (mm)	Spikelet fertility (s)
Genotype (G)	4.28**	146.44*	2.40**	1.09**	0.75**	5.94**
Environment (E)	39.38**	2914.58**	3.78**	0.88**	4.81**	14.27**
GE	2.60**	89.64**	0.36**	0.72**	0.16**	2.89**
Pooled Error	1.01	49.38	0.09	0.11	0.61	0.55
H_B	11.6	5.6	62.4	58.9	26.7	40.0

* Significant at P< 0.05, ** Significant at P< 0.01

AMMI PC 1. Indeed, most of the genotypes were deemed unstable by σ^2 and also had large AMMI PC 1 scores. WAB 33-25 had the highest YSi value on account of having above average panicle length, stable σ^2 and relatively lower PC 1 score.

WAB 99-1-1and WAB 375 had the highest mean primary and secondary branching scores and were returned unstable by the stability variance. WAB 375 however had positive interaction with improving environment in contrast to WAB 99-1-1. OS 6 had the highest YSi for primary branches. The genotype recorded above average mean primary branching and was considered stable by both the σ^2 and AMMI PC1. More varieties were considered as stable by σ^2 for the primary branching than secondary branching.

Table 4 presents the mean, stability variance, AMMI PC 1and the YSi values for grain and spikelets characters. The results indicated that only two genotypes (IDSA 10 and OS 6) were stable with respect to grain length. The two had positive interaction with improving environment. However, only OS 6 had above average mean grain length and was consequently selected by YSi. ITA 150, which recorded the mean longest grains and had a significant σ^2, showed positive interaction with the high environment with an AMMI PC 1 score of 0.42 and was also selected by YSi. For grain width, three of the genotypes (ITA 321, OS 6, and WAB-96-1-1) were declared as stable by σ^2 and also had small AMMI PC 1 scores. However, only the latter two, along with WAB 35-2-FX, IGUAPE CATETO and WAB 33-25, had mean grain width of up to 3mm, large YSi and were consequently selected.

WAB 99-1-1 had the highest mean spikelets number of 175.03 per panicle. It had the largest negative AMMI PC 1 score and was also highly unstable by the stability variance. WAB 375 also produced a high mean spikelets number of 168.2 per panicle, and was deemed as stable by σ^2. It also had the least AMMI PC 1 score and the best YSi. ITA 315, which had a non-significant σ^2 and WAB 35, which had positive interaction with improving environment, also had high YSi values and were therefore selected. In term of spikelets fertility, most of the genotypes were highly unstable by σ^2 verdict and also had relatively large AMMI PC 1 scores. ITA 315 had the lowest mean spikelets fertility scores, a non-significant σ^2, as well as a high and positive AMMI PC scores. It also had the best YSi and was consequently selected as a choice genotype for the character.

The stability variance, AMMI PC 1 and the YSi values for grain yield characters are shown in Table 5. Nine of the genotypes had mean 100-grain weight above 3.0g. Of these, however, only three (IDSA 10, ITA 150 and OS 6) had non-significant σ^2 and large YSi. WAB 33-25 recorded the largest mean panicle grain weight of 4.76g and the least non-significant σ^2, which consequently earned it the highest YSi. ITA 315 and WAB 99 also had high YSi but with lower mean panicle grain weight. WAB 35 and WAB 375 also had high mean panicle weight of 4.71g and 4.70g, respectively, and also with significant σ^2. Nine of the fifteen genotypes

Table 3
Means, stability variance (σ^2) and AMMI PC 1 and yield-stability statistic (YSi) for the panicle characters of upland rice genotypes

Genotype	Panicle number				Panicle length (cm)				Primary branches				Secondary branching (s)			
	Mean	σ^2	PC 1	YSi (s)	Mean	σ^2	PC 1	YSi (s)	Mean	σ^2	PC 1	YSi (s)	Mean	σ^2	PC 1	YSi (s)
IDSA	5.53	3.01**	-0.84	-1	21.18	7.86**	-0.29	-7	9.69	1.87	-0.08	1	1.83	0.23**	-0.29	0
1TA 150	5.38	2.85**	-1.02	0	23.37	4.03*	0.68	4	9.33	1.34	-0.75	0	1.46	0.04	0.19	3
ITA 257	5.19	5.66**	-0.96	-5	24.27	4.15*	1.01	9^{+}	10.33	2.70	-0.82	3	2.05	0.29**	0.68	6
WAB 35-2-FX	4.99	0.17	0.05	2	21.83	1.68	0.56	3	10.75	2.63	-1.03	0	1.85	0.13	-0.25	10^{+}
WAB 56-60	5.37	0.62	-0.06	6^{+}	23.09	8.84**	1.50	-2	11.51	3.85*	-1.28	9^{+}	2.11	0.07	-0.26	15^{+}
IGUAPE CATETO	5.53	3.93**	1.29	3	21.73	3.98*	0.74	-2	12.09	0.66	0.38	12^{+}	1.33	0.01	0.07	0
LAC 23	5.87	4.28**	-0.80	5	24.13	8.48**	-0.57	4	11.24	1.92	0.86	5	1.40	0.02	0.07	1
0S 6	5.20	2.92**	1.07	-4	27.19	9.70**	-1.26	7^{+}	12.73	0.91	0.05	14^{+}	1.40	0.20*	0.35	-3
ITA 117	6.44	1.45	0.55	15^{+}	23.33	4.63*	-0.85	5^{+}	12.25	1.28	0.66	13^{+}	1.53	0.12	0.33	4
ITA 315	6.05	0.37	0.11	14^{+}	20.98	0.96	0.20	0	11.53	1.20	-0.56	10^{+}	1.65	0.14	0.16	5
ITA 321	6.71	2.29**	-0.09	8^{+}	22.55	2.24	-0.26	4	11.48	0.58	0.54	6	1.84	0.17*	-0.31	5
WAB 33-25	4.65	0.20	0.22	0	24.27	1.66	-0.15	14^{+}	11.69	5.38**	1.30	3	1.97	0.27**	0.37	5
WAB 96-1-1	5.57	1.29	-0.63	12^{+}	22.95	11.52**	-0.75	-3	10.17	0.80	0.32	2	1.95	0.21*	-0.27	8^{+}
WAB 99-1-1	5.37	3.72**	0.88	-2	23.29	18.11**	1.32	-1	13.49	4.52**	-0.17	7	2.21	0.65**	-0.96	8^{+}
WAB 375-B-5-H2-1	4.96	0.01	0.24	1	27.22	20.25**	-1.88	8^{+}	14.37	4.34**	0.56	9^{+}	1.93	0.22*	0.11	7^{+}
Grand Mean(LSD) (P<0.05)	5.52 (2.05)				23.43 (3.14)				11.51 (2.74)				1.81 (0.64)			

*,** significant at p<0.05 and 0.01, respectively;
$^{+}$, selected based on one-third selection from total genotypes.

Table 4
Stability variance (σ^2), AMMI PC 1 and yield-stability statistic (YSi) for the grain and spikelets characters of upland rice genotypes

Genotypes	Grain length (mm)				Grain width (mm)				Spikelets per panicle				Spikelets fertility (s)			
	Mean	σ^2	PC 1	YSi	Mean	σ^2	PC 1	Ysi	Mean	σ^2	PC 1	Ysi	Mean	σ^2	PC 1	Ysi
IDSA	8.86	0.00	0.10	5	2.85	0.27**	-0.83	5	113.25	254.40	1.68	1	3.25	0.37	-0.43	8^{+}
1TA 150	9.32	0.27**	0.43	9^{+}	2.71	0.08**	-0.39	-4	107.6	404.19	-3.15	0	3.21	0.87**	0.30	1
ITA 257	9.00	0.10*	-0.62	7+	2.76	0.03**	0.20	0	150.23	3073.92**	-5.87	3	3.55	0.62**	-0.60	-2
WAB 35-2-FX	9.00	0.14*	-0.25	6	3.15	0.01*	-0.08	13^{+}	153.94	801.53*	3.30	10^{+}	3.99	0.90**	-0.63	-5
WAB 56-60	9.25	0.63**	-0.55	7^{+}	2.40	0.05**	0.10	-8	150.20	1331.65**	-3.17	2	2.83	0.35	0.22	10^{+}
IGUAPE CATETO	8.84	0.15**	0.32	1	3.09	0.04**	-0.03	12^{+}	125.47	771.14*	1.52	0	2.49	0.27	0.02	12^{+}
LAC 23	8.91	0.15**	-0.24	3	2.50	0.19**	0.50	-3	119.58	1129.74**	4.07	-6	4.21	0.43*	0.04	-1
0S 6	9.11	0.05	0.23	13^{+}	2.79	0.00	0.08	9^{+}	125.14	944.45*	3.60	-1	3.26	1.21**	-0.37	0
ITA 117	9.31	0.17**	0.01	8^{+}	2.62	0.05**	0.12	-5	128.91	235.97	1.88	5	3.43	1.42**	-0.90	-1
ITA 315	8.57	0.17**	0.01	-8	2.82	0.03**	0.24	3	151.48	216.79	-0.77	12^{+}	1.93	0.44	0.47	13^{+}
ITA 321	8.90	0.17**	0.23	-2	2.71	0.00	-0.09	5	136.89	782.09*	2.52	2	2.81	2.83**	1.35	3
WAB 33-25	9.14	0.33**	0.64	6	3.00	0.01*	0.17	11^{+}	146.89	499.30	2.17	9^{+}	2.37	1.14**	0.65	5^{+}
WAB 96-1-1	8.66	1.00**	-0.98	-7	2.84	0.00	-0.01	12^{+}	153.03	943.46**	-1.60	5	3.69	0.51**	0.24	-3
WAB 99-1-1	8.39	0.16**	0.38	-9	2.40	0.04**	-0.03	-9	175.03	2829.36**	-6.02	8^{+}	3.77	1.01**	-0.78	-4
WAB 375-B-5-H2-1	8.80	0.07*	-0.26	2	2.80	0.01*	0.06	6	168.20	683.62	-0.16	15^{+}	2.92	2.06**	0.42	1
Grand Mean(LSD) (P<0.05)	8.94 (0.12)				2.76 (0.16)				140.43 (43.8)				3.17(1.0)			

*,** significant at p<0.05 and 0.01, respectively.
[+], selected based on one-third selection from total genotypes.

recorded above mean grain weight per plant with the highest grain weight per plant of 24.58g by WAB 96-1-1, followed by ITA 315 with 20.36g. The two genotypes were however deemed unstable by σ^2 although the latter was eventually selected by YSi. WAB 99-1-1, WAB 33 and ITA 117 had the next best grain weight of 19.24g, 18.59g and 17.26g respectively in that order per plant and were selected by YSi.

The significant stability variance of many of the genotypes for the panicle and grain characters underscores the necessity to shift focus away from yield alone in genotype – environment and stability analysis. It would appear that there is a necessity to attain a converging compromise involving the panicle characters in the development of high quality phenotypic expression, eventually in terms of yield and yield stability. This partly explains why the YSi, which attempts to adopt a compromise between higher and stable trait expression, selected different genotypes for many characters (Kang & Pham, 1991). The instability of ITA 257 for grain weight per plant, for instance, appeared to be the cumulative effect of the instability of most of the characters with the exception of primary branches and grain width. Similarly, WAB 96-1-1, which was the most unstable in terms of grain weight per plant, was also unstable for the characters except panicle number, primary branches and grain width. Conversely, ITA 357, which was unstable for grain weight per plant, was stable for most of the characters. It would seem that the instability of grain length, width and 100-grain weight were absorbed by the stable and above average performance of most of the other characters. Noteworthy, however is the advantage posed by high panicle number by ITA 321, the longest and most branched panicle by WAB 375 and the longest grains and largest 100-grain weight by ITA 150. These genotypes and others identified by superior character expression can for a pool of genotypes for the evolution of synthetic genotypes for overall increase grain yield.

Generally, the stability variance and the AMMI PC 1 appeared to be consistent to a reasonable extent in the value returned as a measure of stability of genotypes for different characters. However, AMMI PC 1 is only a fraction of the of the GE component of the AMMI 1 values and would not be expected to capture the entire interaction as much as the stability variance. While σ^2 does not give the direction and manner of instability, the non-crossover attribute AMMI PC 1 (Yan & Hunt, 2001; Samonte, 2005) helps to complement the decision on stability by specifying the manner of genotype reaction to improving (or declining) environment. The selection of different genotypes by the YSi for the characters attests to the need to concentrate traits for higher expression. For instance, WAB 33-25 can be improved for the panicle number without sacrificing its stability in respect of grain production. Similarly, ITA 315 would possibly have higher grain weight per plant through a carefully planned improvement in primary and secondary branching and spikelets number per panicle.

Table 5
Stability variance (σ^2), AMMI PC 1and yield-stability statistic (YSi) for the grain yield characters of upland rice genotypes

Genotypes	100-grain weight (g)				Panicle grain weight (g)				Grain weight per plant (g)			
	Mean	σ^2	IPC 1	YSi	Mean	σ^2	IPC 1	YSi	Mean	σ^2	IPC 1	YSi
IDSA	3.61	0.05	0.16	14+	4.12	0.49	0.29	8+	16.74	10.29	-0.26	4
1TA 150	3.68	0.03	0.10	16+	3.22	0.57	-0.64	1	11.31	10.03	0.22	0
ITA 257	3.26	0.08*	0.03	6+	4.23	0.86**	-0.71	1	15.86	65.24**	0.17	-5
WAB 35-2-FX	3.26	0.08*	0.08	11+	4.71	1.24**	-0.68	7+	17.40	-1.30	-0.17	10+
WAB 56-60	3.04	0.07*	-0.10	1	3.96	1.30**	-0.91	-4	16.96	6.98	0.42	5
IGUAPE CATETO	3.60	0.27**	-0.55	5	4.25	1.75**	0.12	2	17.32	24.82	-0.12	9
LAC 23	2.57	0.07	0.02	1	2.88	0.92**	0.72	-8	12.78	14.71	-0.52	1
0S 6	3.34	0.07	-0.23	11+	4.01	0.26	0.08	5	14.28	9.48	0.07	2
ITA 117	2.59	0.05	-0.29	2	3.69	1.25**	0.65	-6	17.56	5.59	0.40	11+
ITA 315	2.59	0.17**	0.15	-2	4.39	0.51	-0.45	13+	20.36	32.18*	-0.05	11+
ITA 321	2.80	0.06	-0.19	3	3.74	0.78*	0.46	-1	17.24	9.27	-0.02	7
WAB 33-25	3.36	0.43**	0.80	4	4.76	0.04	-0.12	16+	18.59	8.08	0.02	13+
WAB 96-1-1	3.11	0.21**	-0.59	-1	4.32	1.27**	0.82	3	24.58	200.45**	-0.11	8
WAB 99-1-1	2.56	0.10**	-0.10	-8	4.36	0.53	-0.07	12+	19.24	12.38	0.16	14+
WAB 375-B-5-H2-1	2.99	0.18**	0.49	-4	4.70	1.24**	0.43	6	18.28	39.99*	-0.19	8
Grand Mean(LSD) (P<0.05)	3.15 (1.31)				4.09 (1.35)				17.2 (9.44)			

*,** significant at $p<0.05$ and 0.01, respectively.
+, selected based on one-third selection from total genotypes.

CONCLUSION

Stability analysis in rice would continue to attract attention as different agro ecological zones present variable environmental conditions. The need to accumulate desirable genes into genotypes so as to have appreciable plastic response that would assure adequate character expression from intra- and inter-ecological variations is quite germane. The use of simultaneous selection for higher phenotypic expression and stability resulted in the selection of genotypes with significant stability variance. From the practical point of view, the YSi statistics is useful in identifying genotypes with high and stable expression for different characters. The complimentary role of AMMI PC 1 further shapes the decision on the genotypes that are compatible to season- or location-based improving or declining environmental conditions, particularly in upland rice cultivation.

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