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Comparative Assessment of Mean Performance, G × E Interaction and Genetic Variability Parameter for Nutritional Traits in Landraces of Assam under Organic and Conventional Cultivation Methods

Lonishree Dutta*, K.K. Sharma and Debojit Sarma
Department of Plant Breeding and Genetics, Assam Agricultural University, Jorhat (Assam), India.

(Corresponding author: Lonishree Dutta)*
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ABSTRACT: Organic has become a buzz word nowadays. It has become a very important area of research for the plant breeders to develop an organic variety as the varieties dominating in the market require high dozes of fertilizer. So, an effort has been undertaken to see the performance of indigenous cultivars towards development of lines. Thus, 10 traditional rice varieties were collected from an area, where it was grown for more than 10 years under organic condition by farmers. These varieties were grown under organic and conventional cultivation in Experimental field of Assam Agricultural University, Jorhat and an initiative was taken to understand the affect on nutritional quality by the two different cultivation methods and to find some varieties having improved nutritional character to be grown under organic growing condition. Most of the characters under investigation showed high G × E interaction indicating necessity for selection of the characters separately for both organic and inorganic situations. Pooled analysis of variance showed high G × E interaction for Fe (Iron) and Zn (Zinc), which indicated that selection, will be effective under organic situation for this two important micro-nutrients. The result of the experiment indicated that variability for biochemical characters in the indigenous varieties for organic situation and separate breeding program has to be taken for organic situation through selection.

Keywords: Analysis of variance; G × E interaction; pooled; organic and variability.

INTRODUCTION

"Organic" word is becoming a recent trend as people are becoming more conscious for health and environment. Thus, organic products serve as a significant avenue in the national and international market. Several folklores and phrases are common in the rural areas of India, which provides the evidence of the type of practices followed in those days, thus the root of organic agriculture lies in India (Sharma, 2016). Food scarcity and famines of early 60's has propelled the agricultural scientist to go for HYV. The wave of Green revolution started in North West India and slowly spread to other states. However, the negative impact on the environment manifests with the increase in grain production. It is the right time for rationalizing the situation before an irreversible change causing food crisis, health hazards and environmental problems. Hence organic cultivation has been rightly emphasized to get rid of all these problems. Thus, there is a growing awareness of health and environmental issues associated with intensive use of chemical inputs has led to the interest in organic agriculture which is a holistic production management system that promotes agroecosystem, health, biodiversity and social, biological activity.

Organic farming systems aim at the resilience and buffering capacity in the farm eco-system, by stimulating internal self-regulation through functional agro-biodiversity in and above the soil, instead of external regulation through chemical protectors (Bueren *et al.*, 2002). Researches on organic practices are getting focus in this decade throughout the globe and in India. However, reports on organic rice breeding are very less. Indian researches mainly focus on cultivation practices. Reports of breeding aspects are very few. Most of the grain quality parameters were moderately improved in nutritional quality in organic production over the inorganic**.** Amylose content was not influenced by the type of practices (Surekha *et al.,* 2010) while Quyen *et al.* (2002) reported that organic sources perform well with regards to chemical and physio-chemical properties and cooking quality of rice. Considerable variation was observed among and between eleven pigmented red rice cultivars and nine non-pigmented rice cultivars of Assam in studies of Dasgupta *et al*., 2018. Moreover, study of Prasad *et al*., 2021 identified superior locally cultivated landraces of Tamil Nadu to be used in future breeding programmes for development of varieties with high protein, fibre and ash content.

As organic farming management and environments are fundamentally different from chemical-based conventional farming. Therefore, organic farmers need specific varieties that are adapted to their lower input farming system and can perform higher yield stability than conventional varieties (Bueren *et al*., 2002). For efficient and sustainable production of food under the organic condition, both varieties and cultivation methods must be optimized since presently available crop varieties mainly originated from conventional breeding program (Bueren *et al.*, 2014). Organic agriculture stands for high genetic diversity at the farm level. It is necessary to grow regionally adapted cultivars to deal with the heterogeneous environment found in organic farming system. These varieties should deliver sufficiently high and stable yield with minimum use of external resources and be of high quality with regards to the morphological and nutritional requirement. Organic farming differs from conventional farming in many aspects, particularly the type and amount of fertilizer and the approach to weed and pest control. Currently, the cultivars used for conventional farming are also used in organic farming. However, there is a doubt that all lines bred for conventional farming will always perform well in organic farming (Herrera *et al*., 2015).

In Assam, rice is grown in an area of 24.95 lakh hectares, production is 51.25 lakh tonnes, and the average yield is 2089 kg/hectare as on 2017-18 (Anonymous, 2017). In Assam, there are many opportunities for farmers concerning organic farming, as most of them apply less fertilizer or no fertilizers at all. The farmers are also conserving the traditional varieties with their effort. Thus, those varieties can be utilized in a breeding programme to present them with an organic variety favourable to be grown under a hostile environment, which brings yield stability and good quality of the produce and is marketable in the international market as organically produced products and can fetch a good return.

MATERIALS AND METHODS

The present study was undertaken at Instructional-cum-Research (ICR) Farm of Assam Agricultural University, Jorhat, Assam which is geographically situated at an altitude of 87 m above mean sea level, 26°45′N latitude and 94°12′E longitude. The experiment was conducted during *Sali*, 2018 i.e. sowing on 12th of June 2018 and transplanting on 12th of July, 2018. The experimental material comprised of ten indigenous cultivars and a standard check variety Ranjit. The details of pedigree, origin and sources of the genotypes are furnished in the Table 1.

The study was conducted under two environments i.e., organic and conventional with Randomised block design (RBD) with three replications. Two seedlings per hill of each genotype were transplanted in a row of 5.0 m length with a spacing of 20 cm between rows and 15 cm between plants within the row. Each genotype was transplanted in 2 m × 5 m plots. Fertilizer was applied as per the recommendation of 20 kg N, 10 kg P_2O_5, 10 kg K_2O per hectare in the form of urea, single super phosphate and Muriate of potash respectively in conventional plot and FYM was applied as per recommendation of 5 tons per hectare in organic plot.

Observations were recorded on five randomly sampled plants without border effect in each genotype in each replication. The biochemical analysis was done to analyse crude protein content, starch content, amylose, zinc, iron, potassium and calcium. Crude protein is estimated by calculating the nitrogen content in the sample and multiplying with factor 6.15 by using Kjeldahl method modified by Scales and Harison (1920). The starch content was estimated by the method as described by Chopra and Konwar (1976).

Amylose was determined by following the simplified colorimetric procedure described by Juliano (1971). The amylopectin content was determined by subtracting the percentage of the amylose from 100 on moisture free basis.

Mineral ash solution was prepared for estimation of potassium, calcium, iron and zinc. Iron was determined colorimetrically using UV-VIS Spectrophotometer at 540 nm by method described by Wong (1928). Calcium was determined using flame-photometer (Systronics; model-MK III). Phosphorous was estimated colorimetrically by the method given by Fiske and Subharow (1925). Zinc was determined by using atomic absorbtion spectrophotometer (AAS Chemito Make, Model AA203D).

The pooled analysis of variances was determined following Panse and Sukhatme, 1978. Genotypic coefficient of variability (GCV) and Phenotypic coefficient of variability (PCV) was calculated by using the formula given by Burton (1952). Heritability in broad sense was calculated following Hanson, Robinson and Comstock (1956). Expected genetic advance as percent of mean was calculated using formula given by Allard (1960).

RESULTS AND DISCUSSION

Analysis of variance for biochemical character of rice genotypes under organic and conventional situation is presented in Table 1. The mean square for starch content, crude protein, amylose content, calcium content, phosphorous, iron and zinc content showed significant variation for all the genotypes under both the growing conditions. The highest coefficient of variation was observed in zinc in both organic and inorganic situation (Table 2). The mean squares with respect to genotype and environment were found to be significant for starch, crude protein, amylose, calcium, phosphorous, iron and zinc content (Table 3). Genotype and environment interaction mean squares of iron and zinc content was found to have significant variation (Table 3). The highest coefficient of variation was observed for zinc content (8.27 %).

Table 1: Details of rice genotypes used in the experiment.

Genotype No.	Genotype name	Pedigree	Source	Origin
V1	*Beji Lahi*	Indigenous	Farmer's field	Kakopothar, Tinsukia
V2	*Jahinga Sali*	Indigenous	Farmer's field	Kakopothar, Tinsukia
V3	*Kola Joha*	Indigenous	Farmer's field	Kakopothar, Tinsukia
V4	*Kola Sali*	Indigenous	Farmer's field	Kakopothar, Tinsukia
V5	*Nekera Lahi*	Indigenous	Farmer's field	Kakopothar, Tinsukia
V6	*Malbhog Lahi*	Indigenous	Farmer's field	Kakopothar, Tinsukia
V7	*Solpona*	Indigenous	Farmer's field	Kakopothar, Tinsukia
V8	*Lothow Bora*	Indigenous	Farmer's field	Kakopothar, Tinsukia
V9	*Ronga Sali*	Indigenous	Farmer's field	Kakopothar, Tinsukia
V10	*Mugi Joha*	Indigenous	Farmer's field	Kakopothar, Tinsukia
V11	*Ranjit*	Improved	Farmer's field	Kakopothar, Tinsukia

Table 2: Analysis of variance for biochemical character of rice genotypes under organic and conventional. situation.

Source of Variations		df	Starch (%) [ST]	Crude Protein (%) [CP]	Amylose Content (%) [AC]	Calcium (%) Ca (x 10^{-4})	Phosphorous (%) PHOS (x 10^{-4})	Iron (mg/100g) [Fe]	Zinc (mg/100g) [Zn]
Replication	Org	2	0.25	0.87**	0.61	0.03	10.00	0.05	0.02
	Inorg		0.03	1.22**	1.51	0.01	1.61	0.03	0.06
Genotype	Org	10	4.38 **	2.69**	105.62**	0.28**	100.00**	0.73**	0.64**
	Inorg		3.48 **	2.81**	109.15**	0.32**	30.00**	0.28**	0.32**
Error	Org	20	0.51	0.04	0.83	0.02	4.47	0.03	0.03
	Inorg		0.61	0.16	0.81	0.00	1.44	0.01	0.03
CV	Org		0.97	2.23	5.2	5.93	7.44	6.09	7.35
	Inorg		1.04	4.13	4.84	2.87	3.76	3.83	9.53

*, ** Significant at 5 % and 1% level, respectively

Table 3: Pooled analysis of variance for nutritional quality traits of the 11 Assam rice cultivars evaluated under organic vs. conventional cultivation method.

Source of variations	DF	Mean squares						
		Starch (%)	Crude Protein (%)	Amylose (%)	Calcium (%)	Phosphorous (%)	Iron (mg/100g)	Zinc (mg/100g)
Replicates/Env	4	0.139	1.045	1.06	0.02	0.782	0.039	0.039
Env	1	20.252**	14.551**	20.653**	0.700**	19.313**	1.518**	7.293**
Gen	10	7.729**	5.359**	213.778**	0.600**	8.141**	0.877**	0.864**
Gen*Env	10	0.13	0.126	0.99	0.01	0.578	0.131**	0.103**
Pooled Error	40	0.557	0.098	0.821	0.011	0.295	0.023	0.03
Total	65	1.872	1.192	33.93	0.11	2	0.195	0.282
CV (%)		1.007	3.416	5.015	4.612	5.691	5.206	8.268

** Significant at 1% level of probability.

Genetic variability parameter: The characters having significant variations in ANOVA were subject to estimates of genetic variation by computing range, mean (± SE_m), genotypic and phenotypic coefficient of variation (GCV and PCV), heritability in broad sense (h^2_{bs}) and expected genetic advance as per cent of mean (GA, % of mean).

Organic condition: The biochemical character under study with respect to genotypic coefficient of variation was found to be higher in amylose (33.75) and moderate for iron(15.90) and zinc (18.70) (Table 4). Phenotypic coefficient of variation was found to be higher in amylose (34.14) and moderate in case of phosphorous (16.40), iron (17.03) and zinc (20.10) (Table 4). The heritability was high for all the biochemical characters. GA % of mean was highest in amylose (68.71) and moderate in case of iron (30.59) and zinc (35.86) (Table 4).

Inorganic condition: The genotypic coefficient of variability was found to be high in amylose (32.25) and moderate in case of zinc (17.91). The other characters exhibit low GCV (Table 5). Similarly, phenotypic coefficient of variation was high in amylose (32.61) and moderate in case of zinc (20.28) (Table 5). Rest of the characters exhibit low phenotypic coefficient of variation. Heritability broad sense was found to be high in all the characters under study except starch (0.61) which was moderate in heritability (Table. 5). GA % of mean was high in amylose (65.70) and moderate in case of zinc (32.57) and rest of the characters exhibit low GA % of mean (Table 5).

Pooled estimates of genetic variability parameters: Moderate GCV was observed in case zinc (17.90) and in case of PCV also zinc (18.52) exhibited moderate percentage (Table 6). Heritability was found to be high in both the content zinc and iron.GA % of mean was moderate in zinc (35.63).

Table 4: Genetic variability parameters for the nutritional traits of the 11 Assam rice cultivars evaluated under organic cultivation method.

Character	Mean ± SEm	GCV (%)	PCV (%)	h^2_{bs}	GA, % of mean
Starch (%)	73.604 ± 0.412	1.54	1.82	71.70	2.69
Crude Protein (%)	8.689 ± 0.112	10.81	11.04	95.90	21.81
Amylose (%)	17.514 ± 0.526	33.75	34.14	97.70	68.71
Calcium (%)	0.022 ± 0.001	13.21	14.48	83.20	24.82
Phosphorous (%)	0.284 ± 0.012	14.62	16.40	79.40	26.84
Iron (mg/100g)	3.034 ± 0.107	15.90	17.03	87.20	30.59
Zinc (mg/100g)	2.416 ± 0.103	18.70	20.10	86.60	35.86

Table 5: Genetic variability parameters for the nutritional traits of the 11 Assam rice cultivars evaluated under conventional cultivation method.

Character	Mean ± SEm	GCV (%)	PCV (%)	h^2_{bs}	GA, % of mean
Starch (%)	74.712 ± 0.450	1.31	1.67	61.20	2.11
Crude Protein (%)	9.628 ± 0.230	9.75	10.59	84.80	18.49
Amylose (%)	18.632 ± 0.521	32.25	32.61	97.80	65.70
Calcium (%)	0.024 ± 0.000	13.34	13.64	95.60	26.86
Phosphorous (%)	0.319 ± 0.007	9.83	10.53	87.20	18.91
Iron (mg/100g)	2.731 ± 0.060	10.88	11.53	89.00	21.13
Zinc (mg/100g)	1.751 ± 0.096	17.91	20.28	77.90	32.57

Table 6: Pooled estimates of genetic variability parameters for the various traits of the 11 Assam rice cultivars evaluated under organic vs conventional cultivation method.

Character	Mean ± SEm	GCV (%)	PCV (%)	h^2_{bs}	GA, % of mean
Nutritional Quality Traits					
Starch (%)	74.158 ± 0.431	1.47	1.58	86.54	2.83
Crude Protein (%)	9.159 ± 0.181	10.22	10.41	96.41	20.68
Amylose (%)	18.073 ± 0.523	32.96	33.09	99.23	67.65
Calcium (%)	0.023 ± 0.001	13.62	13.88	96.32	27.54
Phosphorous (%)	0.302 ± 0.010	11.97	12.42	93.00	23.79
Iron (mg/100g)	2.883 ± 0.087	13.09	13.43	94.99	26.28
Zinc (mg/100g)	2.083 ± 0.099	17.90	18.52	93.36	35.63

Amongst all the biochemical characters amylose (%) have exhibited high GCV, PCV, heritability and GA % under both organic and inorganic condition . This indicates that variety selection under both situations will be useful for the improvement of the character. Amylose percentage will reduce the stickiness of the grains and increase fluffiness which is an important grain characters for the consumers of rice. Moderate GCV, PCV and high heritability along with high GA for iron and zinc in organic situations indicates that these characters can be improved in organic growing condition. High GA for these two characters also indicates that the additive gene action may govern these characters. Babu *et al*. (2012) recorded low PCV, GCV, moderate heritability and moderate GA in a set of hybrid varieties. Hence, simple selection in crop improvement will be useful for increasing the two most important micro-nutrients in rice grain.

Genotypic mean performance: None of the genotype is at par with *Ranjit* in term of starch content (Table 7). The lowest content of crude protein was found in *Lothow Bora* (8.12 %) and highest content was found in *Kola Joha* (11.02 %). The genotype *Mugi Joha* (10.52) was at par with *Kola Joha* in terms of crude protein (Table 7) (Kandali and Borah (1992); Kandali *et al*., 1995; Ahmed *et al*., 1998; Ahmed (2004); Baishya *et al*., 2010). Amylose ranged from lowest content in *Lothow Bora* (1.90) to highest in *Solpona* (22.81) (Dutta and Baruah (1978), Bhagabati (2000) and Ahmed, 2004). None of the variety was found to be at par with *Solpona* in terms of amylose content (Table 7). The highest mean for calcium was recorded in *Lothow Bora* (0.03) and lowest mean was for *Kola Sali* (0.02) (Dutta and Baruah (1978), Kandali *et al*., 1995 and Ahmed *et al*., 1998) (Table 7). None of the variety was at par with *Lothow Bora* in terms of calcium content. The highest mean for phospohorous was recorded in *Ranjit* (0.39) and lowest mean was for *Beji Lahi* (0.24) (Dutta and Baruah (1978)' Kandali *et al*., 1995; Ahmed *et al*., 1998) .None of the variety was at par with *Ranjit* in terms of phosphorous content. Highest Iron content was found in *Solpona* (3.49 mg/100g) and lowest content was found in *Kola Joha* (2.26 mg/100 g) (Dutta and Baruah (1978), Kandali *et al*., 1995; Ahmed *et al*., 1998). None of the genotypes was at par with *Solpona* in terms of Iron content (Table 7). The highest genotype was *Ranjit* in terms of Zinc content having 2.92 mg/100 g and lowest was *Malbhog Lahi* (1.64 mg/100g). No variety was at par with *Ranjit* in terms of zinc content (Table 7) (Sotelo *et al*, 1989; Anjum *et al*., 2007; Thongbam *et al*., 2012).

Environmental mean performance: It is interesting to know that iron and zinc content had significantly higher mean under organic situation. In contrast starch content, crude protein, amylose, calcium and phosphorous per cent had higher mean under conventional condition (Table 8).

G × E interaction: Zinc is an important micronutrient for human health. It is estimated that about 49% of the world's population is at the risk of low zinc intake (Cichy *et al*. 2005). The G x E interaction for all biochemical characters except iron and zinc were non-significant in the study (Table 9). It is interesting to know that *Solpuna* (3.730 mg/100g) has highest iron content and Kola Sali (3.513 mg/100g) is at par with *Solpuna* in terms of iron content. *Solpuna* is the only variety which has given high iron content in organic condition and it is not comparable to any varieties grown under inorganic condition.

Table 7: Genotypic mean performance for nutritional quality traits of the 11 Assam rice cultivars evaluated under organic vs conventional cultivation method.

Genotype	Starch (%)	Crude Protein (%)	Amylose (%)	Calcium (%)	Phosphorous (%)	Iron (mg/100g)	Zinc (mg/100g)
Begi Lahi	72.44 [d]	8.945 d	20.867 bc	0.022 de	0.243 [e]	3.172 [b]	2.470 [b]
Jahinga Sali	73.44 [d]	8.965 d	20.458 bcd	0.023 cd	0.294 [cd]	2.560 [c]	1.727 [fg]
Kola Joha	73.97 [cd]	11.016 a	13.783 f	0.023 cd	0.319 [b]	2.260 [d]	2.118 [cd]
Kola Sali	72.99 [d]	8.331 e	21.118 bc	0.020 f	0.277 [d]	3.202 [b]	1.912 [ef]
Nekera Lahi	73.81 [cd]	9.543 c	20.073 cd	0.021 ef	0.295 [cd]	2.707 [c]	1.960 [de]
Malbhog Lahi	74.30 [cd]	9.191 cd	21.428 b	0.021 ef	0.284 [d]	3.140 [b]	1.642 [g]
Solpuna	75.49 [b]	8.159 e	22.812 a	0.022 de	0.310 [bc]	3.490 [a]	1.657 [g]
Lothow Bora	73.91 [cd]	8.118 e	1.897 g	0.031 a	0.330 [b]	3.247 [b]	2.295 [bc]
Ronga Sali	74.53 [c]	8.446 e	20.838 bc	0.023 cd	0.286 [d]	2.548 [c]	2.078 [de]
Mugi Joha	74.27 [cd]	10.519 b	15.777 e	0.024 c	0.290 [cd]	2.710 [c]	2.140 [cd]
Ranjit	76.59 [a]	9.512 c	19.752 d	0.028 b	0.388 [a]	2.673 [c]	2.915 [a]
CD (5%)	**0.871**	**0.365**	**1.058**	**0.001**	**0.02**	**0.175**	**0.201**

Mean values followed by different lower case letters are significantly different at 5% level of probability

Table 8: Environmental mean performance for nutritional quality traits of the 11 Assam rice cultivars evaluated under organic vs conventional cultivation method.

Cultivation method	Starch (%)	Crude protein (%)	Amylose (%)	Calcium (%)	Phosphorous (%)	Iron (mg/100g)	Zinc (mg/100g)
Organic	73.600b	8.690b	17.500b	0.022b	0.284b	3.030a	2.420a
Conventional	74.700a	9.630a	18.600a	0.025a	0.319a	2.730b	1.750b
Mean ± SEm	74.158 ± 0.431	9.159 ± 0.181	18.073 ± 0.523	0.023 ± 0.001	0.302 ± 0.010	2.883 ± 0.087	2.083 ± 0.099
CD (5%)	**0.371**	**0.156**	**0.451**	**0.001**	**0.009**	**0.075**	**0.086**

Mean values followed by different lower case letters are significantly different at 5% level of probability.

Table 9: Genotypic*Environment mean performance for the nutritional quality traits of the 11 Assam rice cultivars evaluated under organic vs conventional cultivation method.

Genotype	Iron (mg/100g)		Zinc (mg/100g)	
	Organic	Conventional	Organic	Conventional
Begi Lahi	3.437 bc	2.907 e	2.917 b	2.023 fgh
Jahinga Sali	2.643 fgh	2.477 hi	1.953 ghi	1.500 k
Kola Joha	2.297 ij	2.223 j	2.557 c	1.680 ijk
Kola Sali	3.513 a	2.890 ef	2.263 def	1.560 jk
Nekera Lahi	2.873 efg	2.540 hi	2.210 efg	1.710 ijk
Malbhog Lahi	3.447 bc	2.833 efg	1.843 hij	1.440 k
Solpuna	3.730 a	3.250 cd	1.840 hij	1.473 k
Lothow Bora	3.453 bc	3.040 de	2.917 b	1.673 ijk
Ronga Sali	2.640 gh	2.457 hij	2.340 cde	1.817 hij
Mugi Joha	2.870 efg	2.550 h	2.493 cd	1.787 hij
Ranjit	2.473 hi	2.873 efg	3.237 a	2.593 c
CD (5%)	**0.248**		**0.284**	

Mean values followed by different lower case letters are significantly different at 5% level of probability.

In case of zinc highest content is found in *Ranjit* (3.237 mg/100g) grown under organic condition and it is followed by *Begi Lahi* (2.917 mg/100g) and *Lothow Bora* (2.917 mg/100g) which is also grown under organic condition. This indicates improvement of iron content in the rice varieties can be done in organic growing condition which appears to be an important finding of the experiment because iron deficiency affects 3 billion people around the globe (Long *et al.* 2004). Studies of Naik *et al*., 2020 also reported high amount of naturally available zinc and iron sources which is stable over different environments. In case of zinc all the genotypes under organic condition showed higher content than inorganic. Hence, varieties bred under organic situation are likely to improve the important micro nutrient like zinc in the rice grain.

CONCLUSION

The study indicates improvement of iron content in the rice varieties can be done in organic growing condition, which appears to be an important finding of the experiment because iron deficiency affects 3 billion people around the globe. In case of zinc all the genotypes under organic condition showed higher content than inorganic. Hence, varieties bred under organic situation are likely to improve the important micro nutrient like zinc in the rice grain.

Amongst all the biochemical characters amylose percentage have exhibited high GCV, PCV, heritability and GA % under both organic and inorganic condition. This indicates that variety selection under both situations will be useful for the improvement of the character.

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