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Genetic variability Studies on some Indigenous Cultivars of Assam under Organic and Conventional Cultivation Method

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ABSTRACT: A field experiment was carried out with 11 genotypes of indigenous Assam rice cultivars collected from Kakopothar, Tinsukia District where rice cultivation is practiced organically for more than 10 years. The experiment was conducted under organic and conventional condition at Instruction cum Research Farm of Department of Plant Breeding and Genetics, Assam Agricultural University, Jorhat, Assam, India to study the variability and genetic parameters for yield and its components and grain quality traits. Variance analysis displayed extensive traits-wise variations across accessions, indicating variability and the opportunity for genetic selection for desirable traits. The studies on genetic variation and its understanding in indigenous cultivars of Assam rice (*Oryza sativa* L.) can help to select varieties for organic cultivation. The investigation revealed that the estimates of pooled GCV for all the characters studied were slightly less than pooled PCV estimates indicating the influence of the environment on the genotype performance. The traits ear-bearing tiller, thousand-grain weight, grains per panicle, grain length, grain length by breadth ratio, kernel length, kernel breadth, harvest index, and grain yield per hectare all showed moderate to high variability, high heritability coupled with high genetic advance as percent of mean indicating the role of additive gene effect and simple selection procedures may be effective for improving these traits. Low PCV and GCV were recorded for the traits *viz.*, days to 50% flowering, hulling percentage, and milling percentage. High heritability coupled with low genetic advance as percent of mean was observed for days to 50% flowering, hulling percentage and milling percentage indicating the role of both additive and non-additive gene effects in the inheritance of these traits.

Keywords: Analysis of variance, genetic advance, heritability, additive gene effect, non-additive gene effect.

INTRODUCTION

Rice is a self-pollinated cereal crop with chromosomal number 2n=24 that belongs to the family Gramineae (synonym-Poaceae) in the order Cyperales and class Monocotyledon. There are 25 identified species in the genus Oryza, of which 23 are wild species and two, *Oryza sativa* and *Oryza glaberrima*, are domesticated. For one-third of the world's population, rice (*Oryza sativa* L.) is the most versatile staple food, and Asia produces about 90% of the world's rice. Numerous rice landraces can be found on the Indian subcontinent; however, the Green Revolution promoted the cultivation of better types at the expense of the native landraces (Nelson *et al.*, 2019). While heterogeneous indigenous landraces contain a variety of stress-resistant genes and are genetically diverse, improved varieties are high-yielding but susceptible to biotic and abiotic stresses and lack local adaptability.

Organic farming has attracted the attention of present-day agriculture due to its resilience in the farm ecosystem against environmental and health hazards. It has been realized that organic farming is a solution to conserve the agro-biodiversity above and below the soil (Beuren *et al.*, 2002). Although efforts of conventional breeding for the development of varieties have proved to be beneficial in organic farming conditions, modern varieties are not the best in all cases. The organic system approach requires varieties that match different crop ideotypes which is more important to adapt in an organic environment.

Recent studies indicated that such varieties lack important traits required under organic and low input production conditions which is primarily because of the selection in conventional breeding program that is carried out in the background of high inorganic fertilizer and crop protection inputs (Hoad *et al*., 2008). It is essential that the traits expressed under low input conditions should be identified. It is assumed that there can be some traits of interest in organic systems. It is believed that varieties bred in the organic situation will be better adapted in chemical-free agriculture without sacrificing the grain yield and quality (Surekha *et al.*, 2010). Further, most of the new varieties are derived from a limited number of parental lines and are thus genetically related to each other. Broadening the genetic basis becomes important when we want to search for adaptation to organic farming. The ability to suppress weeds, good productivity, high yield level, high yield stability, and ability to produce healthy seed under organic conditions are highly desirable (Bueren *et al*., 2002).

In Northeast (NE.) India, rice is the main crop for food and nutritional security and occupies an area of 4.8 mha with about 10,000 landraces of rice (Kumar *et al.*, 2017). Assam ranks ninth among the top ten rice producers in India. Since a very long time, farmers have been cultivating and preserving a vast variety of rice landraces in Assam. All districts of Assam, regularly farm several landraces, including Joha, Bora, Baodhan, and Chokuwa. Traditional rice landraces can be used as a source of valuable genes which contribute to various yield-attributing characteristics such as resistance to biotic and abiotic stresses, rich in valuable micronutrients, herbicide resistance, etc. which can be used in rice improvement programmes (Whankaew *et al.,* 2020). In this decade, both globally and in India, research on organic methods has received more attention. However, there are very few reports on rice breeding that is organic. Indian studies primarily concentrate on farming techniques. Breeding-related reports related to organic farming are quite rare.

The basic prerequisite for carrying out any crop enhancement effort is sufficient genetic variation. It is important to select the genotypes based on heritability and genetic advancement since phenotypic selection based on their performance may occasionally be ineffective because these genotypes may perform poorly in later segregating generations. The genotypic coefficient of variation, which indicates the heritable component of genetic variability, quantifies the extent of genetic variability. The amount of genetic gain anticipated through selection would be provided by estimates of genetic variability and heritability (Burton, 1952). To develop selection criteria for effective yield augmentation through breeding, it is crucial to examine the diversity of grain yield and its characteristics, quality, and nutritional parameters in rice genotypes. The present study aims to estimate the genetic variability and relation between yield and its related traits of 11 indigenous rice varieties collected from Kakopathar, Assam, an area where organic cultivation is followed by farmers through generations.

MATERIALS AND METHOD

The current study was carried out at the Assam Agricultural University's Instructional-cum-Research (ICR) Farm in Jorhat, Assam, which is physically located at an elevation of 87 m above mean sea level, 26°45'N latitude, and 94°12'E longitude. The experiment was carried out in Sali 2018, that is, on June 12, 2018, for sowing, and July 12, 2018, for transplanting. The experimental material included a standard check variety called Ranjit and ten indigenous cultivars. In Table 1, the genotypes' pedigree, origin, and sources are described in detail. The study used a Randomised block design (RBD) with three replications and two environments, namely organic and conventional. In a row of 5 meters in length with a space of 20 centimeters between rows and 15 centimeters between plants within each row, two seedlings of each genotype per hill were transplanted. Plots measuring 2 m × 5 m were used to transplant each genotype. Fertilizer was applied in accordance with the recommendations of 20 kg N, 10 kg P_2O_5, and 10 kg K_2O per hectare in the form of urea, single super phosphate and Muriate of potash in the conventional plot and FYM in accordance with the recommendations of 5 tons per hectare in the organic plot. For plots of each genotype, phenological information on days to 50% flowering was recorded. Five plants were randomly chosen from each accession at maturity to record data on grain yield per plant, yield component traits, including plant height, productive tillers per plant, panicle length, grains per panicle, and test weight, as well as quality characters, including hulling percentage, milling percentage, head rice recovery percentage, kernel length, kernel breadth, and length/breadth (L/B) ratio. A random grain sample was taken from each plot and replicated using standard techniques to acquire observations for the test weight investigated. Using the formula provided by Burton (1952), the mean performance of the genotypes was computed, and the genotypic (GCV) and phenotypic (PCV) coefficients of variation were estimated. Sivasubramanian and Madhavamenon (1973) categorized the estimations of PCV and GCV as low (0–10%), moderate (10–20%), and high (>20%). Heritability in the broad sense (H) was calculated using the formula proposed by Hanson *et al*. (1956); Johnson *et al*. (1955). Following the formula provided by Johnson *et al*. (1955), an estimation of genetic advance was made.

RESULTS AND DISCUSSION

The pooled analysis of variance (ANOVA) indicated significant variations between the genotypes for all characteristics, showing that the genotypes under study exhibit substantial levels of variability and inherent genetic variation (Table 2a and 2b). The mean squares with respect to environment were found to have significant variation for all the characters studied like days to 50 % flowering, plant height, ear bearing tiller, grain per panicle, flag leaf area, panicle length, grain length, grain breadth, grain length/breadth ratio, kernel length, kernel breadth, kernel length/breadth ratio, thousand-grain weight, harvest index, hulling percentage, milling percentage, head rice recovery and grain yield per hectare. The mean squares with respect to genotype × environment interaction were found to have significant variations for all the characters studied except flag leaf area, grain length, grain breadth, grain length/breadth ratio, kernel length, kernel breadth, kernel length/breadth ratio, and harvest index. The results indicated the existence of significant differences in the traits under both organic and conventional situations. Similar results were reported by Kumar *et al*. (2006); Salgotra *et al*. (2009); Dhanwani *et al*. (2013); Dhurai *et al*. (2014). The significance of mean squares indicates that the environment has a significant influence on the characters. This clearly indicates that a separate breeding program for the improvement of varieties in organic situations would be useful. Vanaja *et al*. (2013) emphasized on separate breeding program for organic cultivation.

Mean performance of Quantitative trait: The mean performance of the quantitative traits under organic situations indicated that *Jahinga Sali* was early flowering type among the varieties under study while the same variety was also found to flower earlier than any other variety under conventional situations. *Jahinga Sali*, *Nekera Lahi*, *Solpona*, and *Mugi Joha* were at par for days to 50 % flowering for both organic and conventional situations while the varieties *Beji Lahi, Kola Joha, Kola Sali, Malbhog Lahi, Lothow Bora and Ronga Sali* were observed to be late in flowering under organic situation as par by and large of the varieties flowered late under organic condition than the conventional condition which might be due to availability of the nutrients in conventional condition (Table 4a and 5a).

In the case of the plant height, none of the varieties were found to be of shorter stature than *Ranjit* under both organic and conventional situations (Table 4a and 5a). This indicates that traditional varieties under study were of tall stature. Plant height of the varieties under conventional situations was taller than those grown under organic growing conditions which is attributed to high nutrition under conventional conditions.

The ear-bearing tiller of the genotype was higher in the conventional situation as compared to organic growing conditions (Table. 4a and 5a) which would be due to the availability of nutrients in the root zones of the varieties. This warrants that the ear-bearing tillers of varieties could be increased by supplying nutrients in optimum quantity in the organic form.

Flag leaf area of this variety *viz., Kola Joha, Kola Sali, Nekera Lahi* and *Malbhog Lahi* were at par under both organic and conventional situations (Table 4a and 5a) indicates that this character to be improved in the varieties through breeding program taken in either situation. But the overall mean of the flag leaf area of the genotypes was at par in both situations which also indicates that the character improvement could be taken either in organic or conventional situations.

Panicle length is an important yield-attributing trait in *indica* rice among the genotypes under study. Panicle length of the varieties *Beji Lahi, Nekera Lahi, Malbhog Lali,* and *Ronga Sali* were at par with both organic and conventional situations (Table 4a and 5a). In these characters, the mean was higher in conventional than organic situations which reveals that the character is more dependent on the nutrient availability of soil.

An important yield attributing character is grains panicle^{-1}. *Solpona* exhibited higher grains panicle^{-1} in organic conditions (Table 4a and 5a) than conventional, indicating that the variety would be taken as parents for hybridization in organic situations. However, *Beji Lahi, Mugi Joha, Kola Joha,* and *Nekera Sali* were also promising genotypes under both organic and conventional conditions.

As expected, grain yield hectare^{-1} was higher in the conventional plot (Table 4b and 5b) than in the organic plot which is due to the availability of N, P, and K in sufficient quantity and on time availability. Organic farmers prefer yield stability to higher yield (Vanaja *et al*., 2013; Bueuren *et al.*, 2002), this warrants proper management practices of the crop under organic conditions to harness the genetic potential of the varieties. Earlier reports indicated that continuous use of chemical fertilizers over a long period of time causes nutrient imbalances which are not conducive for stable high yield (Samy, 1997).

Genetic parameters of quantitative characters: Studies on the coefficient of variation suggested that the estimates of GCV for every character under study were marginally less than the estimates of PCV, indicating a minimal impact of the environment on genotype performance. Sudeepthi *et al.* (2020) previously reported a similar finding. Genetic parameters for the quantitative characters indicated that PCV and GCV were high in the case of ear-bearing tiller, flag leaf area, and thousand-grain weight which is supported by the respective estimate of heritability (Table 3). High estimates of PCV and GCV were reported earlier by several workers (Ravindra Babu *et al*., 2012; Shibani and Reddy 2000; Sao, 2002; Dhurai *et al*., 2014; Dhanawani *et al*., 2013). For most of the characters where PCV and GCV are of higher magnitude, improvement in varieties can be achieved through direct selection (Chandra *et al*. 2009; Bhadru *et al*., 2012). This indicates that these characters will respond to selection in both growing conditions.

Burton and Devane (1953) suggested that the GCV along with heritability estimates could provide a better picture of the amount of advance to be expected by direct phenotypic selection. Heritability estimates with genetic advances will be more reliable in predicting the response to selection (Johnson, 1955). In this study, high heritability was estimated for most of the characters under organic situations, indicating the greater role of additive gene action in the inheritance of these traits. According to Panse (1957), if the character is governed by non-additive gene action, it shows high heritability but low GA whereas it is under additive gene action, high heritability with high GA provides good scope for further improvement.

Pooled analysis of genetic variability parameters indicates high genetic advance in flag leaf area, grain yield per plant, and ear-bearing tiller while it was moderate in plant height and harvest index (Table 3). Moreover, pool analysis indicates that the ear-bearing tiller with high GA and high heritability (Table 3) is the indication for the preponderance of additive gene action for the character which may be confirmed with proper plant breeding models. High heritability with moderate to high GCV and high GA for grain yield hectare^{-1} and ear bearing tiller respectively may be taken as a parameter for selection under both situations. Grains panicle^{-1} and 1000-grain weight can also be used for selection for the improvement in organic and conventional situations. Similar findings were reported by Ravindra Babu *et al*. (2012); Shibani and Reddy (2000); Sao (2002); Dhurai *et al*. (2014); Dhanawani *et al*. (2013); Gannamani (2001); Chaubey and Richharia (1993).

Mean performance of grain characters: Organically produced products are viewed by consumers for their luster, texture, size, shape, aroma, etc. in the market. Attractive grain fetches high market value. Hence, while breeding varieties the grain characteristics should get due weightage in selection. In general, long to medium grains with high-head rice recovery are the most desirable characteristics for organically produced rice. The kernel length of *Beji Lahi* (8.47 conventional and 8.7 organics) was longer in comparison to other varieties under study (Table 4 b and 5 b) while kernel breadth was bold in the case of *Malbhog Lahi* and *Lothow bora* and slender in the case of *Kola Joha* in organic condition. By and large kernel L/B ratio of *Beji Lahi* (3.68), *Nekera Lahi* (3.69), and *Solpona* (3.45) falls under the slender category grown in both organic and conventional conditions (Table 5b). This reveals that executing breeding program for improvement of grain quality *Beji Lahi* could be an ideal variety. The head rice recovery of Beji Lahi (83.96) was found to be acceptable to get unbroken grains (Table 5b). *Beji Lahi* might break in the mills of Assam due to the usage of steel haulers which will reduce the market value of this promising variety.

The study indicated that *Kola Joha* and *Kola Sali* were found to have head rice recovery to the tune of 98 percent in organic situations (Table 5b). Such varieties may be used as donors for head rice recovery in breeding programs under organic situations. *Solpona* (77.78) is a rice variety which is having higher hulling percentage (Table 5b) in organic conditions while all other varieties under study produced higher hulling in conventional situations. This indicates that *Solpona* can be a parent in hybridization for the improvement of grain characters in organic situations. The milling percentage of *Beji Lahi*, *Mugi Joha* and *Ranjit* were found to be high in both organic and conventional growing conditions (Table 4b and 5b). The study indicated a higher milling percentage of the varieties grown under conventional conditions. *Beji Lahi* and *Ronga Sali* exhibited high-head rice recovery under both growing conditions, however, *Mugi Joha* (95.99) produced high-head rice recovery under conventional conditions only (Table 4b). This indicates that grain type could be improved for head rice recovery under both the situation through *Beji Lahi* and *Ronga Sali.*

Genetic parameter of grain character: It is essential to estimate the grain characteristics to take up a breeding program. Pooled estimates reveal that moderate GCV and PCV for grain length, grain L/B, and kernel breadth (Table 3). The heritability estimates were high for these characters indicating the scope of genetic improvement of the grain characters through selection. Genetic advance is a useful indicator of progress that can be expected due to selection. In the present study genetic advances were high with respect to GL, GL/B, KL, KB and KL/B. Dhurai *et al.* (2014) reported high estimates of heritability associated with moderate GA for kernel breadth and kernel L/B. Similar findings were also reported by Sarawgi *et al*. (2000). Moderate PCV, GCV, high heritability, and high genetic advance for these characters would help to improve the said characters through simple selection. High genetic advance is likely to accumulate more additive genes leading to further improvement of the performance. PCV and GCV were low in the case of hulling percent, milling percent and HRR while heritability estimates were found to be high. Therefore, these characters are least influenced by the environment. So, the breeder can perform a selection based on the phenotypic expression of the characters. Genetic advance was also low for the above characters indicating that the progress of phenotypic selection would be less. Sarkar *et al.* (2007); Raju (2004) reported high heritability coupled with low genetic advance for kernel length. Ravindra Babu *et al.* (2012), also presented low and moderate heritability and low GA for milling (%), hulling (%) and Head Rice Recovery (%) in their experimental materials. Additionally, the high heritability and low genetic advance of the hulling % indicate non-additive gene activity in the inheritance of this characteristic. Thus, to improve this character, simple selection may not be effective (Nirmaladevi *et al.*, 2015).

Table 1: Details of the rice genotype used during the experiment.

Genotype number	Genotype name	Pedigree	Source	Origin
V1	*Begi 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	*Solpuna*	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 2a: Pooled analysis of variance for quantitative and grain character of 11 Assam rice cultivars evaluated under organic vs conventional method.

Source of Variations	Degrees of freedom [df]	Days to 50 % Flowering [DFF]	Plant Height [PH] (cm)	Ear bearing tiller [EBT]	Gains per panicle [GPP]	Flag leaf Area [FLA] (cm^2)	Panicle length [PL] (cm)	Grain Length [GL] (mm)	Grain Breadth [GB] (mm)	Grain length/breath ratio [GLBR]
Replication within environment	4	0.97	1.72	0.11	26.30	17.15	2.43	0.06	0.99	0.04
Environment (E)	1	28.24**	613.36**	25.74**	149.30**	154.67**	103.12**	1.49**	0.92**	0.07**
Genotype (G)	10	112.53**	686.17**	11.94**	2177.70**	572.88**	15.52**	12.60**	0.71**	1.17**
Genotype × Environment (G×E) interaction	10	5.98**	49.35**	0.78**	73**	0.70	8.21**	0.01	0.01	0.01
Pooled Error	40	0.89	3.60	0.09	16	5.87	1.94	0.04	0.03	0.01
CV (%)		0.75	1.48	6.90	3.37	5.52	5.54	2.40	4.37	4.87

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

Table 2b: Pooled analysis of variance for quantitative and grain character of 11 Assam rice cultivars evaluated under organic vs conventional method.

Source of Variations	Degrees of freedom [df]	Kernal length [KL] (mm)	Kernal Breadth [KB] (mm)	Kernal length by breadth ration [KLBR]	Thousand grain weight [TGW] (g)	Harvest Index [HI] (%)	Hulling Percentage [HP] (%)	Milling Percentage [MP] (%)	Head Rice Recovery [HRR] (%)	Grain yield per hectare [GYH]
Replication within environment	4	0.06	0.10	0.13	0.42	2.17	0.43	0.16	0.07	0.05
Environment (E)	1	1.49**	0.92**	0.28**	23045.0**	47.64**	115.24**	45.07**	150.06**	11.61**
Genotype (G)	10	12.60**	0.71**	2.88**	247.84**	63.62**	14.26**	22.04**	84.85**	2.23**
Genotype × Environment (G×E) interaction	10	0.01	0.01	0.02	9.14**	2.30	4.16**	7.92**	17.32**	0.36**
Pooled Error	40	0.04	0.03	0.04	0.87	1.95	0.21	0.28	0.11	0.04
CV (%)		3.13	6.49	7.78	3.55	4.07	0.59	0.71	0.36	6.11

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

Table 3: Pooled estimates of genetic variability parameter for quantitative and grain character of 11 Assam rice cultivar evaluated under both organic vs conventional cultivation method.

	GCV	PCV	H	GA % of mean	GM	Sem
PH	8.29	8.42	96.93	16.81	128.69	0.77
EBT	32.83	33.54	95.76	66.17	4.28	0.12
GPP	16.01	16.36	95.75	32.27	118.57	1.63
FLA	22.15	22.83	94.15	44.28	43.88	0.99
PL	5.99	8.16	53.85	9.05	25.12	0.57
GL	16.91	17.08	98.02	34.50	8.55	0.08
GB	9.21	10.19	81.60	17.14	3.67	0.07
GLBR	18.68	19.30	93.62	37.23	2.35	0.05
KL	22.08	22.30	98.02	45.03	6.55	0.08
KB	13.68	15.14	81.60	25.45	2.47	0.07
KLBR	25.50	26.66	91.49	50.25	2.70	0.09
TGW	24.28	24.54	97.93	49.49	26.42	0.38
DFF	3.41	3.49	95.45	6.87	126.33	0.38
HI	9.34	10.19	84.05	17.65	34.31	0.57
HP	1.99	2.08	91.92	3.94	76.72	0.19
MP	2.57	2.66	92.93	5.10	74.18	0.21
HRR	4.05	4.06	99.23	8.31	92.84	0.14
GYH	19.40	20.34	90.98	38.12	3.11	0.08

Table 4 a: Mean performance for quantitative and grain character for 11 Assam rice cultivars under conventional cultivation method (Superscript letter are Tukey's range-based ranking).

Genotype	D50F	PH	EBT	GPP	FLA	PL	GL	GB	GLBR
Begi Lahi	125^{bc}	135.67^{ab}	3.29^{ef}	140.03^{ab}	38.97^{ef}	25.13^{bcd}	10.47^{a}	3.47^{bcd}	3.02^{a}
Jahinga Sali	117^{d}	135.07^{ab}	5.45^{b}	72.4^{g}	47.54^{cd}	23.03^{d}	7.77^{d}	4^{a}	1.94^{ef}
Kola Joha	124.67^{bc}	135.13^{ab}	4.97^{bc}	134.17^{abc}	54.78^{ab}	26.37^{abcd}	5.7^{e}	3.03^{d}	1.88^{f}
Kola Sali	130.67^{a}	138^{a}	4.08^{de}	117.9^{e}	58.92^{a}	25.73^{abcd}	7.3^{d}	3.63^{abc}	2.02^{def}
Nekera Lahi	123^{c}	135.53^{ab}	4.31^{cd}	134.13^{abc}	53.09^{abc}	25.23^{bcd}	9.67^{bc}	3.13^{d}	3.09^{a}
Malbhog Lahi	123^{c}	128.47^{cd}	3.21^{f}	104.87^{f}	51.03^{bc}	24.3^{cd}	9.87^{b}	4^{a}	2.47^{b}
Solpuna	125^{bc}	131.27^{bc}	5.52^{b}	97.5^{f}	25.69^{g}	27.7^{abc}	9.63^{bc}	3.33^{cd}	2.91^{a}
Lothow Bora	127^{b}	137.13^{a}	4.06^{de}	120.73^{de}	39.9^{ef}	29.17^{a}	9.27^{c}	3.83^{ab}	2.42^{bc}
Ronga Sali	130^{a}	137.33^{a}	4.46^{cd}	123.37^{cde}	52.98^{abc}	28.67^{ab}	7.43^{d}	3.8^{abc}	1.96^{ef}
Mugi Joha	127^{b}	125.93^{d}	5.01^{bc}	144.8^{a}	33.92^{f}	28.63^{ab}	7.73^{d}	3.4^{bcd}	2.27^{bcd}
Ranjit	127^{b}	109.6^{e}	9.6^{a}	130.97^{bcd}	42.67^{de}	26.13^{abcd}	7.6^{d}	3.47^{bcd}	2.19^{cde}

Table 4 b: Mean performance for quantitative and grain character for 11 Assam rice cultivars under conventional cultivation method (Superscript letter are Tukey's range-based ranking).

Genotype	KL	KB	KLBR	TGW	HI	HP	MP	HRR	GYH
Begi Lahi	8.47^{a}	2.27^{bcd}	3.74^{a}	28.6^{bc}	33.53^{b}	79.03^{bc}	74.13^{cd}	83.94^{g}	3.29^{bc}
Jahinga Sali	5.77^{d}	2.8^{a}	2.06^{cd}	28.73^{bc}	34.39^{b}	81.34^{a}	79.82^{a}	88.03^{e}	2.83^{c}
Kola Joha	3.7^{e}	1.83^{d}	2.02^{d}	17.73^{f}	33.74^{b}	77.96^{cd}	76.79^{b}	92.21^{d}	2.96^{c}
Kola Sali	5.3^{d}	2.43^{abc}	2.19^{cd}	28.1^{bc}	34.45^{b}	76.15^{f}	74.22^{cd}	92.29^{d}	3.38^{bc}
Nekera Lahi	7.67^{bc}	1.93^{d}	3.98^{a}	23.1^{e}	33.6^{b}	78.32^{bcd}	75.26^{c}	87.06^{f}	3.33^{bc}
Malbhog Lahi	7.87^{b}	2.8^{a}	2.81^{b}	40.03^{a}	34.37^{b}	79.59^{b}	79.06^{a}	86.57^{f}	3.37^{bc}
Solpuna	7.63^{bc}	2.13^{cd}	3.64^{a}	24.8^{de}	33.6^{b}	76.22^{ef}	73.3^{de}	92.41^{d}	3.34^{bc}
Lothow Bora	7.27^{c}	2.63^{ab}	2.77^{b}	29.47^{b}	34.02^{b}	77.21^{def}	75.6^{bc}	94.16^{c}	3.61^{b}
Ronga Sali	5.43^{d}	2.6^{abc}	2.1^{cd}	26.63^{cd}	34.38^{b}	78.05^{cd}	70.98^{f}	96.55^{a}	3.66^{b}
Mugi Joha	5.73^{d}	2.2^{bcd}	2.61^{bc}	17.9^{f}	34.02^{b}	77.05^{def}	73.27^{de}	95.99^{ab}	3.25^{bc}
Ranjit	5.6^{d}	2.27^{bcd}	2.47^{bcd}	19.07^{f}	46.68^{a}	77.49^{de}	72.62^{e}	95.45^{b}	5.85^{a}

Table 5 a: Mean performance for quantitative and grain character for 11 Assam rice cultivars under organic cultivation method (Superscript letter are Tukey's range-based ranking).

Genotype	D50F	PH	EBT	GPP	FLA	PL	GL	GB	GLBR
Begi Lahi	127.67^{b}	135.97^{a}	2.69^{e}	134.1^{ab}	36.34^{de}	24.8^{abcd}	10.7^{a}	3.57^{bc}	3^{a}
Jahinga Sali	117^{d}	133.13^{ab}	4.19^{b}	76.73^{g}	44.34^{bc}	20.2^{e}	8^{d}	4.2^{a}	1.91^{d}
Kola Joha	126^{b}	130.23^{bc}	4.01^{bc}	137.47^{a}	51.08^{ab}	23.13^{bcde}	6.07^{e}	3.23^{c}	1.88^{d}
Kola Sali	134.67^{a}	134.9^{ab}	3.45^{bcde}	109.4^{ef}	54.94^{a}	26.67^{ab}	7.63^{d}	3.93^{ab}	1.94^{cd}
Nekera Lahi	122^{c}	127.27^{cd}	3.11^{de}	124.67^{bc}	49.51^{ab}	25.9^{abc}	10.07^{b}	3.4^{c}	2.97^{a}
Malbhog Lahi	126.33^{b}	123.33^{d}	2.66^{e}	111.27^{ef}	47.59^{b}	22.37^{cde}	10.1^{b}	4.23^{a}	2.39^{b}
Solpuna	126^{b}	127.53^{cd}	3.98^{bc}	104.9^{f}	23.96^{f}	23.37^{bcde}	10.07^{b}	3.57^{bc}	2.84^{a}
Lothow Bora	132.33^{a}	136.7^{a}	2.71^{e}	113.43^{def}	37.21^{de}	24.27^{abcd}	9.43^{c}	4.23^{a}	2.23^{b}
Ronga Sali	133.33^{a}	130.43^{bc}	3.65^{bcd}	119.33^{cde}	49.41^{ab}	27.63^{a}	7.7^{d}	4.13^{a}	1.87^{d}
Mugi Joha	128^{b}	110^{e}	3.21^{cde}	133.2^{ab}	31.64^{e}	22.73^{cde}	7.97^{d}	3.63^{bc}	2.19^{bc}
Ranjit	126.67	92.57^{f}	6.55^{a}	123.23^{bcd}	39.79^{cd}	21.53^{de}	8^{d}	3.57^{bc}	2.25^{b}

Table 5b: Mean performance for quantitative and grain character for 11 Assam rice cultivars under organic cultivation method (Superscript letter are Tukey's range-based ranking).

Genotype	KL	KB	KLBR	TGW	HI	HP	MP	HRR	GYH
Begi Lahi	8.7^{a}	2.37^{bc}	3.68^{a}	29.47^{c}	32.74^{b}	77.31^{b}	74.15^{bc}	83.96^{f}	2.64^{b}
Jahinga Sali	6^{d}	3^{a}	2^{cd}	29.4^{c}	32.6^{b}	79.49^{a}	77.4^{a}	93.45^{d}	2.37^{bc}
Kola Joha	4.07^{e}	2.03^{c}	2^{cd}	17.5^{g}	32.7^{b}	74.24^{cd}	73.12^{cde}	98.33^{a}	2.42^{b}
Kola Sali	5.63^{d}	2.73^{ab}	2.07^{cd}	28.73^{cd}	32.97^{b}	74.09^{cd}	71.94^{ef}	98.02^{a}	2.71^{b}
Nekera Lahi	8.07^{b}	2.2^{c}	3.69^{a}	29.43^{c}	32.6^{b}	74.77^{c}	72.6^{def}	96^{b}	2.85^{b}
Malbhog Lahi	8.1^{b}	3.03^{a}	2.68^{b}	38.47^{a}	32.82^{b}	75.23^{c}	73.81^{bcd}	91.55^{e}	2.84^{b}
Solpuna	8.07^{b}	2.37^{bc}	3.45^{a}	26.7^{de}	32.75^{b}	77.78^{b}	74.67^{b}	94.54^{c}	2.78^{b}
Lothow Bora	7.43^{c}	3.03^{a}	2.46^{bcd}	34.4^{b}	32.94^{b}	73.02^{d}	71.47^{f}	95.51^{b}	2.65^{b}
Ronga Sali	5.7^{d}	2.93^{a}	1.95^{d}	25.3^{e}	32.76^{b}	74.56^{c}	73.01^{cde}	96.14^{b}	2.75^{b}
Mugi Joha	5.97^{d}	2.43^{bc}	2.45^{bcd}	17.3^{g}	31.72^{b}	73.99^{cd}	72.7^{cdef}	94^{cd}	1.85^{c}
Ranjit	6^{d}	2.37^{bc}	2.54^{bc}	20.47^{f}	41.52^{a}	74.85^{c}	71.99^{ef}	96.34^{b}	3.79^{a}

CONCLUSIONS

The study concluded that significant yield-attributing traits such as the ear-bearing tiller, thousand-grain weight, grains per panicle, grain length, grain length by breadth ratio, kernel length, kernel breadth, harvest index, and grain yield per hectare all exhibited moderate to high variability, high heritability, along with high genetic advance as a percentage of mean, indicating the predominant role of additive gene action. For most of the characters where PCV and GCV are of higher magnitude, improvement in varieties can be achieved through direct selection. This indicates that these characters will respond to selection in both the growing conditions. PCV and GCV were low in case of hulling per cent, milling per cent and HRR while heritability estimate was found to be high. Therefore, these characters are least influenced by environment. So, the breeder can perform selection based on the phenotypic expression of the characters. *Jahinga Sali* was found to be early flowering type as compared to other traditional varieties under study. Plant height was found to be higher in conventional situation than organic due to high fertilizer intake. From the study, ear bearing tiller and panicle length can be increased in organic situation by application of organic fertilizers which is a direct component towards achieving higher yield. Flag leaf area of varieties like *Kola Joha*, *Kola Sali*, *Nekera Lahi*, and *Malbhog Lahi* were found to be highest and is at par under both the growing condition. Thus, character improvement could be taken either in organic and conventional situations. *Solpona* exhibited higher grains per panicle in organic conditions than conventional, indicating that the variety could be taken as parents for hybridization in organic situations. Given the high demand for organic food in domestic and international markets, grain characteristics play an important role. Thus, from the study, *Beji Lahi* was found to be a promising genotype for its long and slender grain quality and good head rice recovery. This reveals that for executing a breeding program for improvement of grain quality *Beji Lahi* could be an ideal variety. The study indicated that *Kola Joha* and *Kola Sali* were found to have head rice recovery to the tune of 98 percent in organic situations. Such varieties may be used as donors for head rice recovery in breeding programs under organic situations. *Solpona* is a rice variety which is having higher hulling percentage in organic conditions. This indicates that *Solpona* can be a parent in hybridization for the improvement of grain characters in organic situations.

FUTURE SCOPE

The present study gives an indication of the scope of improvement of rice varieties under organic growing condition. Extent of variation and G×E interactions are useful information generated from the study. In view of the increasing demand of rice with increased rice consumers, the study is likely to help in undertaking breeding programs for yield improvement under organic condition. It is clear from the study that there is ample scope to exploit traditional varieties to harness the optimum yield potential of rice to cater the grain demand of domestic and international markets of organic rice.

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Conflict of Interest. None.

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