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Physiological investigation of Rice land races in a low Temperature area of Bangladesh

Faruk Hossain M.[1], Chandra Sarker B.[2], Kamaruzzaman M.[1], Abdul Halim M.[1], Najim Uddin M.[2] and Siddique M.N.A.[1*]
[1]Soil Resource Development Institute, Ministry of Agriculture, Dhaka, BANGLADESH
[2]Department of Agricultural Chemistry, Hajee Mohammad Danesh Science and Technology University, Dinajpur-5200, BANGLADESH

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Abstract

An experiment was conducted to assess physiological characteristics for screen out yield potentiality and grain quality of nine rice land races produced in different low temperature area in Bangladesh. The races were Bashful, Posursail, Gochi, Taipi, Pariza, Lafaya, Jirashail, BRRIdhan28 and Banglamoti. Leaves of nine cultivars were used to estimate proline content.Moisture and some minerals such as Fe, Zn, and Ca contents were determined from the grains. Grain characters i.e. grain shape, size; length, breath and length/breath were also measured for screening out the popular rice cultivar(s). Low level of temperature tolerance was observed for most cultivarsat growth stages; exceptions being some varieties of Posursail from Hobigonj, Pariza and Jirashail, which were tolerant or moderately tolerant, to low temperature due to accumulation of higher amounts of proline. Lafaya and BRRI dhan 28 performed very poorly at low temperature. Cultivars from Hobigonj (Posursail) and Joypurhat (Pariza) found to be tolerant of low temperature consistently during entire growth and development. These varieties could be important gene donors for breeding and genetic studies. However, Posursail, Taipi and Lafayaa was found having lowest starch; Bashful, Pariza, Lafayaa and Posursail found higher quantity of protein which is important for selecting cultivar for quality. No single cultivar was found containing all characters of yield potential and assured grains quality. But Posursail is considered a potential rice land race for growing in low temperature areas of Bangladesh.

Keywords: Rice cultivars, low temperature, mineral and proline content and grain quality.

Introduction

Several Asian countriesconsider rice as staple food. Thus, around 90% of rice is produced, marketed and consumed in Asian countries. Bangladesh has a long tradition of rice cultivation; this crop has greater impact on the socio-economic condition of the country. Rice is an ancient food grain, it is cultivated for over 10000 years and a great number of people depend on rice for food. Rice is grown above hundred countries in the world.Rice is main food itemabove half of population in earth.Area under rice cultivation and in terms of subsequent production compared to other leading rice growing counties, Bangladesh is holding fourth position[1]. During 1970's rice production was less in amounts, i. e., it wasbelow10 million tons.Later, production of rice increased sharply due to introduction of HYV; and production exceeded 30 million tons in 2011[2-3]. About 18% of the country's GDP comes from rice;and average calorie intake is about 70% compared to total calorie intake in Bangladesh[4]. Total rice area is 10 million ha in Bangladesh which is 75% of total cropping area and 93% of total area where cereals are cultivated[5-6]. Many local and high yielding varieties are available in the country; and rice is grown in three season, namely pre-monsoon, winter and rainy season. Many rice varieties are suitablefor different agro ecological regions and physiographic units of Bangladesh. Population in Bangladesh is ever increasing, thus decline in average farm size is evident and farm size declined from 1.43 ha to 0.87 ha between the years 1961 to 2008[7]. Rice average yield remains low compare to potential yield in Bangladesh. This is caused by drought conditions, colder climate in North-eastern and North-western parts of the country. Excessive flooding during rainy season in many areas of the country is another reason which cause yield damage. Expansion of areas under irrigation, introduction of high yielding variety, efficient pest-disease management and application of chemical fertilizer along with improved crop management practices have increased total production and yield of rice after 1990's.

Quality of rice grain is another important factor for popularization to consumer. Because of its low sodium content, a rice diet is also commonly prescribed to patients suffering from hypertension and or high blood pressure[8]. Rice research on the basis of soil, water and environmental aspects was limited but its primary objective was to increase yields. Land productivity and preservation of scarce land resources of Bangladesh was not great concern before. Presently, land productivity and environmental sustainability along with higher yield and quality grain of rice is a great concern for the scientist. Thus, it is urgently need to screen out the better performer local land races on the basis of their physiological and biochemical characteristics and give a fruitful suggestion to the rice researchers, academicians, planners and others to meet up the additional quantity of food in the country.

Dutta *et al.* characterized a lot of local rice cultivar both on morphology and their physico-chemical quality and pointed out some physiological and biochemical limitations which should be considered for the improvement of those cultivars[9-10]. Local scented rice could be characterized on the basis of physiological and other characteristics as such partitioning. They emphasized improvement of partitioning efficiency of scented rice and there remains wider scope of improvement. While Dutta *et al.* identified physiological limitations of modern rice[11]. Moreover, other author suggested improvement apart from IRRI works and proposed a new model of rice improvement program[12]. These finding could be significant for rice breeders to decide on useful future breeding policy.

There are very little attempts have been made to characterize the local cultivars as to their genetic, physiological and biochemical expressions and limitations. This experiment was undertaken to assess the physiological characteristics and adaptability in the area where low temperature prevails during rice cultivation by using nine rice land races. The main objectives of this investigation were to assess the rice land races in regarding of their physiological characteristics to screen out the yielding potentiality and grain quality of the selected rice land races produced in low temperature area.

Material and Methods

Experiment was done in Dept. of Agricultural Chemistry experimental plots of the Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh. Duration of the study was from months October 2011 to July 2012. Experimental fields are located between 25.13ºN latitude and 88.23ºE longitude. Elevation of the area was 37.5 m. Study site belongs to the Old Himalayan Piedmont Plain. The site belongs to Agro-Ecological Region (AEZ) One[13]. Experiment field was medium high land and texture was sandy loam. Soil pH was 5.6. The experimental area possesses sub-tropical climate. Usually there is no or less rainfall during winter season. The air temperature ranges were low to moderate and low during the winter season and increases as the season proceeds towards Kharif season (monsoon crops during July-October) with occasional gusty winds. Seeds of nine selected rice land races and or cultivars and or variety were used for this study. Seven cultivars were local and rest two of them was HYV varieties. The cultivars were Bashful (V1), Pasursail (V2), Gochi (V3), Taipi (V4), Pariza (V5), Lafayaa (V6), Jirashail (V7), BRRI dhan 28 (V8) and Banglamoti (V9). Design of experiment was randomized complete block design. Seedlings that were of fourty days usedfor transplanting in experimental plots. Fertilization, intercultural operations such as weeding by hand picking and applications of pesticides by hand sprayer at the vegetative growth stages were done as and when necessary. Data collections of the following parameters from the experiment on different growth stages were done.

Leaves from nine cultivars were collected for determination of proline content. Grains were used for determination of minerals Ca, Fe and Zn and determination of physical properties, i.e., length/breadth ratio, shape and size, moisture content etc. Plants leaves samples were collected at 35 DAG (days after germination), 25 DAT and 50 DAT (days after transplanting) from the seed bed and from main field. Grains were collected after crop harvest.

Determination of L/B ratio of selected rice grains: Slide caliper was used to measure length and breadth (L / B). L/B proportion was obtained by dividing length with breadth. Long (>6mm) size and slender shape, Medium (5-6) size and bold shape; and Short (<5) size and round shape categories were of rice was found. While, L / B proportions were >3, 2-3 and <2 for size category long, medium and short respectively.

Procedure for proline determination from plant leaves sample: Sample holder was marked by labeling, small test tube considered as micro fuse tube1.5 ml-2.0 ml. Micro fuse tube (sample holder) was weighed. The micro fuse tube + leaf sample → (leaf → about 60-80 mg) → (freshly in prepared) was weighed, dipped in a liquid N_2 solution for 3 minutes, 500 µl (micro liter) 3% sulfosalicylic acid with micro-pipette was added. Then, samples were ground with a stick/plastic rod to mix well. Test tube was placed with a vortex mixer for about 30 sec ~1 min. On another micro test tube, the mixer was placed for 1 ~ 15 min in a thermomixure. 500 µl more suftosalicylic acid 3% was added to micro fuse tube. It was centrifuged for 20 ~ 30 min at 25^0C and with 15000 rpm. Ten ml test tube with a glass tube pipette was used to collect supernatant. One ml sulfosalicylic acid was further added to the small test tube + sample. Place again in the test tube mixer for 10 min. Again, mixer was placed in the centrifuge machine for 20 min at 25^0C and with 15000 rpm. Supernatant was collected again and mixed with previously collected supernatant. Ninhydrin solution was prepared. Standard proline solution 0, 1, 2, 5, 20, 50, 100, 150, 200 and 300 µg/2ml, 3% sulfosalicylic acid was taken in a test tube for standard curve. 2 ml acetic acid was added into each sample + proline standard solution. 2 ml Ninehydrin acid was added into each sample + proline standard solution → mix well by end to end. Test tube was heated for exact 15 minutes in thermo aluminum bath/water bath 96-100^0C. It was cooled in an ice box. The optical density was measured at 520 nm wave length with a spectrophotometer for standard curve and for sample solutions.

Moisture content: Working stepsthat were involved for moisture content determination; i. 5g ground samples (rice grain) were taken in a petridis, ii. oven dry samples prepared at 60^0C for 72 hrs, iii. dried samples were taken in desiccators, iv. oven dried sample were weighed, and v. Moisture % was calculated.

Estimation of minerals (Ca, Fe and Zn) content in rice grain: Digestion was done with 0.5 g sample. 25 ml acid mixture (H_2SO_4, $HClO_4$ and HNO_3–proportion of 0.5:1.0:0.5) by volume was used. Approx. 200^0C temperatures was used during digestion and high neck volumetric flask was used which was thermal proof. Digestion was continued to get clear and or greenish solution. Solution was taken into test tube after cooling. Concentration of Fe^{2+}, Ca^{2+} and Zn^{2+} were determined after dilution and Chemito atomic absorption spectrophotometer was used for this purpose. Wavelength used for Fe^{2+}, Ca^{2+} and Zn^{2+} were 248.3, 422.7 and 213.9 nm respectively. A calibration curve was used for all analyzed samples. Glassware contamination was avoided with caution. Reagents and deionized water were used during mineral analysis[14].

Data were statistically analyzed using MSTAT-C program. Then, analysis followed by least significance difference test and duncan's multiple range test[15].

Results and Discussion

Effect of low temperature on leaf proline content: Proline plays various roles in stress tolerance of plants. Plants accumulate free proline during environmental stresses such as drought, more salinity and lower temperature condition. Key factors of metabolism include amino acids and proline content; and also play significant role for development of higher plants[16-17]. Proline content in leaves of some selected rice varieties are given in the table-1.

Highest proline content was observed in V9 cultivar and followed by V2, V4, V1, V8, V3, V7, V6 and V5 respectively at 35 DAG. The lowest proline content was obtained from the leaves of V5 cultivar. While at 25 DAT, the highest proline was obtained in V2 cultivar followed by V4, V3, V9, V1, V7 and V8, respectively. Lowest amount was observed in V6 cultivar. At 50 DAT, the highest proline was also synthesized in V2 cultivar and lowest in V1 cultivar. Rice leaves tended to accumulate proline, which was found up to 3.07 mg g^{-1} in V2 rice land races at 50 DAT in this study. Kamata and Uemuran oticed the accumulation of proline and total amino acids in leaves of wheat plants during cold acclimation[18]. Proline content (table-1) in leaves of amongst in different cultivars at 35 DAG had statistically significant differences ($P \leq 0.01$). Lowest amount of proline content was observed in V5 cultivars at 35 DAG. At 25 DAT, proline content in V2 showed statistically greater ($P \leq 0.01$) than in other cultivars (1.36 mg g^{-1} FW). V6 performed a lowest amount of proline (0.79 mg g^{-1}) than other cultivars. At 50 DAT, V2 rice land race and or cultivars was also performed better praline content statistically ($P \leq 0.01$) than other cultivars (3.16 mg g^{-1}) (figure-1).

Table-1
Content of proline (mg.g^{-1}) in leaves of some selected rice cultivars

Cultivars	35 DA G	25 DAT	50 DAT
V1	1.1D	0.94CDE	1.2H
V2	1.41B	1.32A	3.07A
V3	0.82F	1.01BC	2.63D
V4	1.23C	1.1B	2.77C
V5	0.7G	0.85DEF	1.49FG
V6	0.84F	0.77F	1.43G
V7	0.85F	0.92CDE	2.89B
V8	1.02E	0.81EF	1.57F
V9	1.67A	0.95CD	1.85E
LSD	0.075	0.13	0.106
CV%	3.10	5.36	2.05
SE	0.018	0.031	0.025

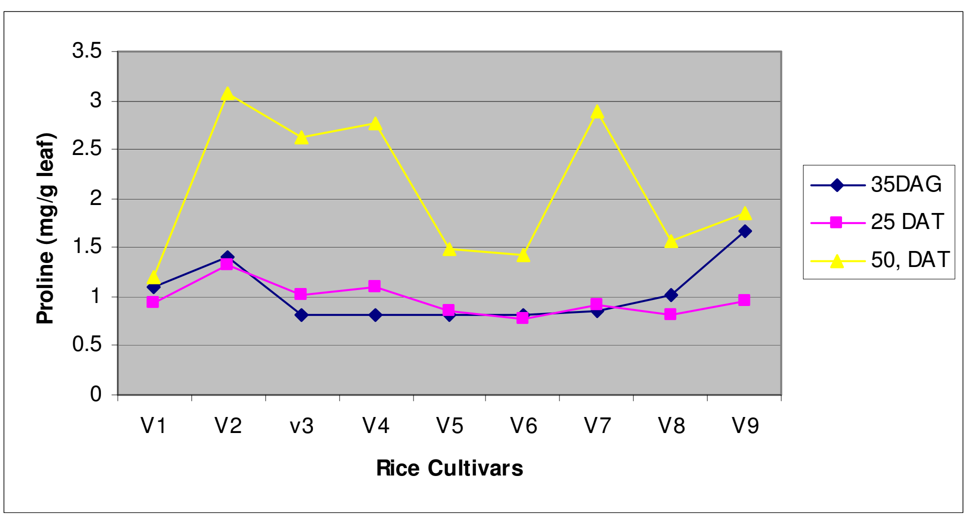

Figure-1
Proline content in leaf of some selected rice cultivars, (DAT=Days after transplanting)

Low temperature within 01 to 35 days resulted in a remarkable change in the proline content amongst the cultivars. The content of proline decreased considerably while 25 DAT than 35 DAG in V6, V8 and V9 (figure-1) due to increase in air temperature. However, the proline content was again sharply increased in V2, V3, V4 and V7 at 50 DAT. Considering the proline content in leaves of plants from the local rice land races accession, the V1, V5 and V6 plants contained a lesser amount of proline while V2, V3, V4 and V7 contained higher amount respectively at 50 DAT. During 35 DAG temperature was at below 10^{o}C. When the seedlings were transplanted in main field, the temperature was 11^{o}C, at 25 DAT the temperature was prevailing under 15^{o}C, comparison between 35 DAG and 25 DAT resulted more or less similar amount of proline content in most cultivars. Though the seedlings were under hardening periods, V2 produced a remarkable amount of proline in their leaves in 25 DAT due to low temperature (figure-1). Van-Rens burg *et al.* indicated positive correlation among accumulation of proline and plant stress tolerance. At 50 DAT, the minimum recorded temperature was 20^{o}C but the proline content was higher that is may br due to plant age[19] (table-1 and figure-1).

In compare torice land races, the local rice plants specially 'Haor' cultivars V2 (Posursail) and V1 (Bashful) showed higher amount of proline where the cultivars V4 and V6 local land races contained lesser amount of proline. However, upon low temperature, proline in the leaves at low temperature, V2 and V4 cultivars accumulated higher amount in every cases (35 DAG, 25 DAT and 50 DAT) but V9 variety showed higher quantity of proline at 35 DAG. This may be due to their genetic ability. Regarding proline content of leaves, V6, V5 and V8 were considered as low temperature sensitive cultivars compared to V2, V3, V4 and V7 cultivars.

Accumulation of proline in V5 and V6 cultivar indicated more sensitive genotypes (figure-1). Result suggested that the increase in proline content might not only be associated with cold tolerance, but rather with the extent of damage encountered by cold stress, as shown by the greater increase in the content of proline in the susceptible genotypes.

Grain quality characteristics: Grain length of examined nine rice cultivars varied (3.93-6.70 mm). Rice breadth was also varied (1.91-2.42 mm) as shown in table-2. Grain length of nine cultivars was significantly different ($P \leq 0.01$). The breath of nine varieties also significantly varied. The co-efficient of variation was 5.92 and LSD was 7.45. Rice hulls and husks account for about 20% of the grain weight. Grain size, shape and appearance significantly influencerice grain quality; quality grain may include 6.0 to 7.5 mm long and 1.5 to 2.0 mm breadth as reported by IRRI[1]. Consumers prefer long / medium long rice grainthatbears slender shape. Biswas *et al.* reported short to medium grain size of HYV ricewith bold shape[20]. For example, Bashful (V1) is of aromatic flavor. Although, it is of a short size and bold shape rice grain. However, choice of grain differs from people to people based on habits and culture[21]. Long size and slender shape rice is preferred by rich people of Bangladesh, while poor earning and or general people satisfy with bold shape rice in take as food due to its lower price and market availability[22].

Table-2
Quality characteristics featuring grain of selected rice cultivars

Cultivars	Length (mm)	Breadth (mm)	L/B ratio	Size and Shape
V1	5.88	2.42	2.43	MB
V2	5.43	2.10	2.59	MB
V3	6.70	2.05	3.27	LS
V4	6.54	1.82	3.59	LS
V5	3.93	1.99	2.05	SB
V6	6.06	1.91	3.17	LS
V7	5.32	1.91	2.79	S
V8	6.19	1.89	3.28	LS
V9	6.41	1.95	3.29	LS
LSD	4.55	7.45	8.75	
CV%	5.10	5.92	4.49	
SE	0.099	0.04	0.043	

Biswas *et al.* reported milling yield of hybrid rice variety from 69-73%,<67% milling yield is considered economically unacceptable[20]. Cultivars of this study gave >69% of milling yield. 72.3% milling yield was recorded for V7, V8 and V5 cultivars.

Moisture content: Rice quality is affected by moisture content of rice grain in many ways. Harvesting of rice with proper moister content is crucial and requires drying around15% moisture content. Moisture content data shown in figure-2.

Moisture content of different rice grains found low to medium; ranging from 10.75% to 11.77% for local cultivars. But for hybrid rice cultivars, moisture content was found between 11.62 and 12.46% (figure-2). Range of moisture content was found 12.1 to 13.0% for rice varieties in Bangladesh[23]. Cultivar Haor (V2) had the lowest moisture content whilst V8 (BRRI Dhan28) had the highest moisture content. The high moisture content indicated the low storage quality and low moisture content had high storage quality. V6 and V8 cultivars showed significantly higher moisture content than those of other cultivars. Figure 2 also showed that V1, V3, V4, V5, V7 and V9 cultivars moisture content statistically similar, whereas V2 cultivar contained lower amount of moisture which indicated the higher storage quality.

Fe, Ca and Zn content of selected rice cultivars: Rice is not considered as rich source of minerals. But nine cultivars that were investigated for screening out of better performer amongst them in this regard. Results of measurement of three minerals were presented in table-3.

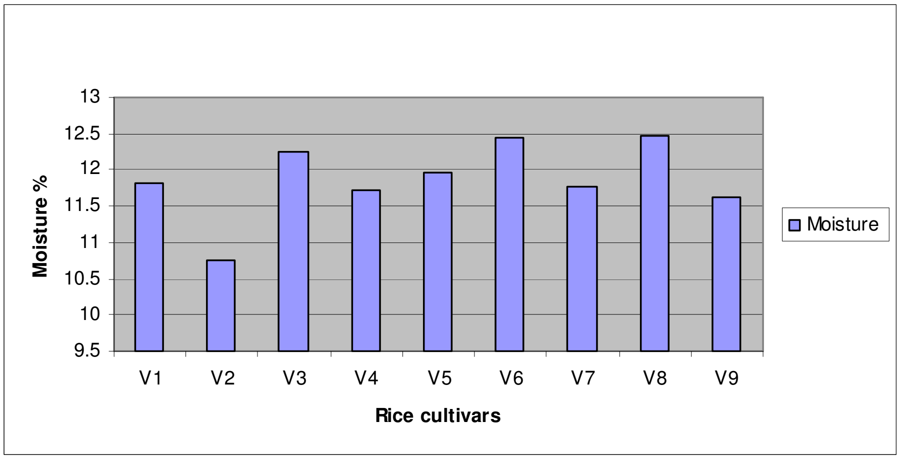

Figure-2
Grain moisture content of selected rice cultivars

Table-3
Content of Fe, Ca and Zn innine rice cultivars

Cultivars	Fe (mg/g)	Zn (mg/g)	Ca (mg/g)
V1	0.0560	0.0267	0.0375
V2	0.0501	0.0387	0.0283
V3	0.0203	0.0553	0.0742
V4	0.0204	0.0147	0.0521
V5	0.0792	0.0654	0.0319
V6	0.0269	0.0421	0.0226
V7	0.0762	0.0218	0.0732
V8	0.0294	0.0705	0.0741
V9	0.0227	0.0740	0.0192
CV%	10.37	7.75	8.72
LSD	0.024	0.025	0.023

Iron content was varied slightly from one cultivar to another except few cultivars. Maximum concentration of iron was found in V5 and V7 cultivar and followed by V1, V2, V6, V8, V9 and V4 cultivars. Lowest iron was obtained from grains of V3 cultivars, while zinc content was varied evidently from one rice cultivar to another (table-3). V8 cultivar showed the highest amount of zinc content amongst nine cultivars tested which was 0.0743 mg g^{-1}. V4 cultivar had the lowest zinc content. Calcium concentration was found maximum in V3 cultivar followed by V7 and V8 V4, V1, V5 and V2rice cultivars of this study. Lesser amount of calcium was obtained from V6 and V9 cultivars. In the HYV Cultivars BRRI dhan28 (0.0741 mg g^{-1}) and Jirasail (V7) represented the maximum calcium. On the basis of calcium content, BRRI dhan28 and Jirasail (V7) can be considered as sustainable variety. For unparboiled grains Ca content were found from 0.0742 to 0.0192 mg g^{-1}.

Conclusion

Examined selected local rice cultivars and HYV varieties are suitable for growing in low temperature areas of Bangladesh with varying extent of adaptability and quality characteristics. Some cultivars bear potentiality of important gene transfer for breeding and genetic purposes, as these varieties synthesized higher quantity of leaf proline during low temperature. Therefore, considering the yield potentiality and grain quality, Posursail local cultivar from Hobigonj was suitable for cultivation in low temperature season (winter season) during Boro rice cultivation at the low temperature areas of Dinajpur district in Bangladesh. Posursail local cultivar might be suitable for other parts of the country with modern agronomic practices but further study is suggested.

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