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A Comparative Analysis of Some Popular Rice Cultivars in Dhubri District of Assam

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Abstract: ***Rice, a vital staple for half the worlds population, plays a pivotal role in food security and nutrition. With the increasing global population, the demand for high-yield rice production is on the rise. However, challenges in meeting this demand persist, especially in countries like India. This study focuses on characterizing popular rice cultivars in Dhubri district, Assam, using morphological, physiological, and biochemical parameters. It reveals a rich diversity of rice varieties in the region, with distinct characteristics related to grain size, shape, and aroma. Traditional rice landraces remain crucial, not only for their agronomical attributes but also for their cultural and commercial significance. Additionally, the study underscores the importance of assessing rice quality for its nutritional contribution to human health, particularly in areas like Dhubri district, where rice is a primary source of sustenance. These findings hold significant implications for addressing food security and nutritional challenges in flood-prone, socio-economically disadvantaged regions, emphasizing the need for comprehensive rice quality evaluations to combat hidden hunger and enhance both rural economies and human well-being.***

Keywords: rice cultivars, Dhubri district, Assam, morphological properties, physiological and biochemical parameters, grain quality, nutrition, human health

1. Introduction

Among other cereals, rice is the key for food security for half of the world population (Girma, 2018) and provides nutrients for two-thirds of the population (Nguyen et al., 2006). It provides instant energy; regulate digestion and metabolism in addition to provide nutrition (Kolahdouzan et al., 2013). Since the time of green revolution its productivity has been increasing by developing new cultivars, irrigation facility, infrastructure development, new management techniques fertilizer and pesticides. With increasing the population the demand for a high yield is also rapidly increasing. . It is estimated that the world will need to produce 60% more rice by 2030 than it did in 1995 (Virmani et al., 1998). As a result, increasing rice production is crucial for providing food security. Breeder paying more attention on the development of high yielding rice varieties to meet the demand. Indian breeder has also challenges the enhancement of grain yield production under new high yielding variety and hybrid rice variety from the present level of 5% to more. But India could not meet the required demand of production with newly developed technology, as well as by development of new varieties or hybrid varieties. This may occur due to higher seed production cost, poor grain quality, complicated seed production system in India and could not cover much area under rice cultivation (Singh et al., 2011). It is the major challenges for the rice breeder to mitigate the production particularly for second largest populated developing country India.

Quality improvement is also a major challenge for rice breeders as it is staple food for most of the world population. Grain quality is a generally covers many characteristics ranging from physical to biochemical and physiological properties. It may vary with different factor such as the choice of producers and consumers of different regions (Chen et al., 2012). For instant people in the East prefer sticky and soft rice, while in Indian people generally prefer non sticky rice. Developed country mainly prefers good cooking and eating quality where as for developing countries nutritional quality is most crucial as rice is the most consumed staple food. Four types of rice quality is generally considered. These are milling quality, appearance, nutrition and eating quality. The quality of appearance of grain is depending on grain shape, size, and starch granule. Eating quality depends on multiple factors which are related to the amylase content, amylopectin content, gel consistency, gelatinization temperature and protein content. Low amylase content increases the high taste quality of cooked rice. Rice grain quality is influenced by the various physiochemical characteristics which determine the cooking behavior as well as the cooked rice texture (Bocevska et al., 2009). Additionally, amylose content as well as gelatinization temperature and gel consistency can highly influence cooking and eating qualities of rice, which can vary based on the varieties (Juliano, 1972).

Of the four quality traits nutritional quality is the most important for developing country particularly in India as it is the staple food. The protein present in seed also determines nutritional quality. Protein content is also involved cooking quality by impeding starch gelatinization (Chen et al., 2012; Ma et al., 2017). Starch and protein are the two main key to determine rice quality. The quality of rice mainly depends on the content and composition of starch and protein present in grains. Rice starch is easily digestible as compared to other starchy foods such as wheat, noodles etc. This leads to the increase of the blood glucose level (= high glycemic index) after the ingestion of rice. Blood glucose level is also increase in white bread or pure glucose (Frei et al., 2004). Rapid starch digestion is not favourable, as fast digestion can cause a sensation of hunger only shortly after the ingestion and the energy is also released quickly.

India is home to wide varieties of rice cultivars, landraces and many lesser known types that have been under cultivation since ages by indigenous farmers as well as local entrepreneurs (Vinita et al., 2013). It has more than 75,000 local cultivars/landraces of rice (Roy et al., 1985; Paroda and Malik, 1990; Khush, 1997). As the population of India is increasing in alarming rate the demand of rice production is also thus increasing. Rice breeders paying attention to increasing the production rate in one hand and on the other hand paying less attention on nutritional quality. Study of Nutritional quality is very much crucial as rice is a staple food for the people of India. On the contrary, the high rate of arrival of hybrid varieties and other new high yielding rice varieties, local farmers throw away their previously cherished indigenous varieties without critical comparison.

Environmental factor in addition to the effect on grain yield also effect grain quality Environmental condition or seasonal variation which affects the grain quality are water availability, temperature, types of fertilizers application, drought stress and salinity stress. Chen et al. (2012) reported that molecular and environmental factors determine the quality of rice. The water status present in soil not only effect yield but also effect grain quality (Dingkuhn and Le Gal, 1996). Cheng et al. (2003b) also reported the water status has strongest effect on protein content of rice grain. Growing rice in an upland non-flooded environment also affects grain quality. Guo et al. (2007) studied the cooking and nutrient quality by growing different environment and found that amylase content, gel consistency, gelatinization temperature and protein content will be significantly higher under upland environment than the lowland environment. Seasonal variations also affect the grain yield and qualitative traits due to difference in temperature and solar radiation. Seasonal variation and temperature affect the structure and composition rice grain. Changing temperature during grain filling affect the chain length distribution of amylopectin (Umemoto et al., 1999; Yamakawa et al., 2007). High temperature effect the formation of amylopectin thus change the glycemic index (Zakaria et al., 2002).Therefore it is great necessary to analyze rice quality in more systematic and comprehensive manner to understand the relation between environment and cultivars effect in terms of yield and quality.

Objectives of the present study

Very limited study has so far been made to characterize the popular rice cultivars of Dhubri district of Assam inspite of the fact that this region is one of the areas in the state having a rich diversity of rice. In light of the above, the present study has been proposed to undertake with the aim to characterize the popular rice cultivars of Dhubri district of Assam using morphological, physiological and biochemical parameters with the following objectives.

1) To document the different popular rice cultivars of Dhubri district of Assam
2) To assess morphological properties of the collected rice grains
3) To find out the physiological, biochemical and nutritional properties to evaluate the quality of the rice grains

2. Review of Literature

The review of literature on the various aspects which are related to the present investigation is presented under the following.

For the people of NE India, rice is the only staple food with estimated 10,000 indigenous cultivars of rice landraces grown in this region. In Assam rice is cultivated throughout the year in three different seasons viz Ahu rice (Autumn rice), Sali rice (Winter rice) and Boro rice (Summer rice). It is the traditional home to wide varieties of rice cultivars, land races and many lesser known types that have been under cultivation since ages by indigenous farmers. Altogether, 13 categories of rice are known to exist in the state (Sarma et al., 2015). A total of 1003 upland adapted rice germplasm are known to exist and are being conserved in the state of Assam (Das and Ahmed, 1995). These traditionally rich land races are reported to have biotic stress against various pests and diseases (Shastry et al., 1971; Chatterjee et al., 1977; Devadath and Rao, 1976; Jain et al., 2004). Traditional land races also have different types of nutritive quality. Presence of different types of nutritive quality in land races mainly presence of genetic diversity (Pomeranz et al., 1992) as well as surrounding environmental factors where they are grown (Singh et al., 2005). However, in view of their low yield potential local farmers through away their previously cherish diverse indigenous rice variety for all time. Scientist has also paying less attention for the improvement of these varieties growing in this region. On the contrary, arrival of high yielding new variety like hybrid variety, synthetic variety or other newly introduced variety farmers become more attracted towards them and start to cultivate by throwing their indigenous varieties without considering other quality. Every year by comparing among the new variety as need farmers reject as well as choose some for further cultivation. Thus every year farmers get option to choose the better variety according to their need. In spite of farmers of lower Assam in particular have been cultivating few adopted rice varieties many years ago. These varieties namely, Aijong, Ranjit and Bahadur. These adopted varieties are very common to all people and most popular among the farmers for the cultivation of lower Assam. These genotypes are characterised by early maturity, photo insensitive, tolerance to water stress, erratic climate and are well adapted to surrounding environment prevailing in this region. Due to their wide range of adoptability farmers has been growing these varieties for all the three seasons viz, Sali seasons, Ahu seasons and Boro seasons i.e., throughout the year. Due to this reasons these varieties could not be replaced by any other high yielding new variety till today as new varieties are not adopted in all the seasons and they may be susceptible to biotic stress, drought stress, salinity stress as well as erratic climate stress.

Research works on indigenous rice variety growing in Assam will be done in different field for their documentation, characterization and conservation as well as their trait improvement found in literature survey. Sarma et al. (1995) Genetic variability and diversity in rice under irrigated transplanted condition. Sarma et al. (2004) studied the genetic variability and divergence studies in Ahu rices of Assam. He (Sarma et al., 2014) also studied genetic variability and diversity in indigenous rice germplasm of Assam under aerobic condition. Bhattacharyya et al. (2015) studied the productivity of direct seeded rainfed rice variety of Assam.

Though number studies has been found on traditional rice varieties of Assam as mentioned above the overall yield performance and qualitative assessment of these popular varieties viz Aijong, Ranjit and Bahadur has not been done yet. Seasonal performance on yield and nutritive quality has also not been studied. Since Assam has distinct climatic seasons viz. Autumn, Summer and winter seasons and prevailing erratic climate (flood and drought), the study of performance of these rice varieties in terms of yield and quality is most important to mitigate with hunger and hidden hunger.

Burton (1952) made comparisons among characters on genetic variability by estimating genotypic and phenotypic coefficient of variation. GCV together with heritability estimates can give the best picture of expected genetic gain out of selection.

Panse (1957) advocated that genetic advance under selection depends on the amount of genetic variability, the magnitude of masking effects of environment and the intensity of selection practice. High heritability with genetic advance indicates the concern character is governed by additive gene action. But, if the heritability is due to non additive gene effects, the genetic gain will be low.

Johnson et al. (1955) reported that for reliable selection, high together with high genetic advance is important. Gandhi et al. (1964) suggested that such association of high heritability with high genetic advance provides suitable conditions for making successful selection.

Singh et al. (1980) reported that phenotypic coefficient of variability will be high for number of sterile grains per panicle, followed by grain yield per plant, ear bearing tillers and plant height, while genotypic coefficient of variation will be recorded to be high for the number of sterile grains per panicle, plant height, ear bearing tillers and grain yield per plant.

Kaul and Kumar (1982) observed significant variation for all the traits studied and it will be found to be highest for plant height followed by tiller number, grain weight and grain fineness. High heritability estimates will be found for plant height, panicle length, grain length, grain breadth and L/B ratio but low for grain yield and tiller number. Genetic advance will be high for plant height but moderate for tiller number and grain fineness.

Singh et al. (1986) studied 11 traits in 98 rice cultivars and observed a wide range of phenotypic coefficient of variation except sheath length. De and Rao (1988) studied genetic variability of nine characters in a collection of 30 rice strains grown under semi-deep lowland situation. The results also showed that sterility percentage, ear bearing tillers per hill and grain yield/m2 had high coefficient of variation.

Morphological variations and extent of variability of some panicle and grain characters will be studied by Chauhan et al. (1989), in 109 land race of rice from pateau region of Bihar (India). Padhi et al. (1991) reported significant genotypic variation for 11 growth parameters, yield and yield attributes among 15 tall and dwarf genotypes grown at Pantnagar. Varities IR20, RP633 and UPR174-14 gave the heighest grain yield (6.69. 6.41 and 5.86 tones/hectare respectively).

Singh et al. (1990) collected 24 of 28 Gora rice from Hazaribage and Giridih districts on the basis of 9 agronomic traits and grouped into 2 clusters. Grains per panicle, grain length: breadth ratio and 1000 grain weight will be the least variable characters between the two clusters.

Rema Bai et al. (1992) studied on genetic variability and correlation in 58 medium duration rice cultivars. Estimates of genetic variance, phenotypic coefficient of variation for grain yield and other contributing characters will be computed. In all these cases, phenotypic coefficient of variation will be higher than genotypic coefficient of variation indicating the influence of environment on the characters.

Remina et al. (1992) conducted an experiment with twelve rice genotypes comprising of four indigenous boro and eight improved cultivars to evaluate these performance under normal and late boro season. Significant variation will be observed among genotypes examined under both the environments. High estimates of genotypic and phenotypic coefficient of variation and heritability in broad sense and genetic advance will be noticed for grain yield per plant, no of grains per panicle, sterility percentage and flag leaf area under both the testing environments indicating the possibility of improvement of these traits through selection.

Roy and Kar (1992) evaluated twenty early elite breeding lines with five check varieties under direct seeded and transplanted conditions to assess the comparative yield, range of variability and characters association among 11 metric characters. Character express will be manifested best under transplanted condition but the variety yielding high (OR495-18) under direct seeded upland condition did not rank among the ten high yielders under transplanting. However, check varieties like Ananda and Pathara will be among top yielders in both conditions. High heritability estimates of characters maintained correspondence under either conditions but these characters expressed low genetic grain.

Ramlingam et al. (1994) studied genetic variability, heritability and genetic advance for panicle characters in 20 rice genotypes. They observed high phenotypic variance for total filled grains, chaffy grains and number of secondary branches. The difference between GCV and PCV will be relatively low in magnitude indicating less environmental influences on these characters. Heritability estimates will be high for all the characters and ranged from 82.1 – 99.4 percent (grain yield). Selection based on number of primary and secondary branches, total filled grains and grain yield will be effective since these traits showed high heritability as well as high genetic advance.

Sawant and Patil (1995) in their study using 75 genotypes of rice found that these genotypes showed wide range of variation for all the characters. High coefficient of variation will be observed for grains per panicle, plant height and grain yield per plant. High values of heritability coupled with high genetic advance will be observed for the characters grains per panicle, plant height, grain yield per plant and 1000 grain weight.

Sivakami Rajeswari (2018) Studied on association and path analysis for ten grain quality characters of 30 pre-released cultures and high yielding varieties of rice revealed that alkali spreading value and elongation ratio also showed high positive direct effect on kernel length after cooking.

Sandeep Singh et al. (2019) studied the response of three rice cultivars in different planting dates and found that the variety PR124 showed the maximum growth parameters, yield attributes and grain yield on earlier transplantation.

Grain quality of rice plays an important role in consumer acceptability since rice is mainly consumed as whole grain especially in Asia (Srivastava et al., 2013). According to Juliano (1985) over 2 billion people in Asia alone derive 80% of their energy needs from rice, which contains 80% carbohydrates, 7-8% protein, 3% fat, and 3% fibre.

Grain quality of rice is determined by the factors: The term rice quality encompasses Hulling, head rice recovery, cooking and eating quality of the grains, gel consistency, grain elongation, and Alkali spreading value. Development of high yielding variety with superior nutritive and cooking qualities is now one of the most important objectives in all rice improvement programmes.

According to Bocevska et al. (2009), rice grain quality is reported to be influenced by the various physiochemical characteristics that determine the cooking behavior as well as the cooked rice texture.

Dolson et al. (2009) reported that brown rice has showed slow starch digestibility and have some starch which is never turned into sugar at all and reaches the large intestine intact. Qi et al. (2010) showed that the replacement of white rice by brown rice or whole grains will be associated with a lower risk of diabetes. Qureshi et al. (2002) found that stabilized rice bran significantly reduced hyperglycemia and hyperlipidemia in both Type I and Type II diabetics.

Oko et al. (2012) studied the rice cooking quality and physic chemical characteristics of local and newly introduced rice variety of Nigeria and found that in terms of cooking quality some local variety showed better performance then newly introduced variety.

Thankachan et al. (2012) determined the efficacy of extruded rice grains fortified with multiple micronutrients on the prevalence of anemia, micronutrient status, and physical and cognitive performance in 6-12 year old, low-income school children in Bangalore, India. The fortified rice will be efficacious in improving vitamin B-12 status and physical performance in Indian school children.

Subed et al. (2016) studied quality assessment of some popular variety of Nepal and found that there will be positive correlation between amylose content and minimum cooking time. They also found that rice varieties with higher amylose content had short cooking time.

According to Xi et al. (2016) and Shi et al. (2017), the chalky endosperm, compound starch granules are irregularly arranged with numerous airspaces, which could have resulted in poor grain weight and quality. While in the translucent endosperm, starch granules (polyhedral shape) will be regularly filled.

Noori et al. (2018) conduct an experiment to clarify the physicochemical and morphological traits on different local rice varieties and check varieties in Afghanistan. The result shown that grains (long slender) associated with high amylase and protein content decline taste point. The short and medium grain type containing lowest amylase and protein amplifying grain taste type.

Noori et al. (2018) micrograph observations revealed that the endosperm of chalky grains in local rice varieties will be differed compared to check varieties (Super Basmati and Koshihikari), irregularly developed starch granules together with single spherical shape and dent-portion on their surfaces with numerous air-gaps will be observed due to high temperature. Such irregular arrangement leads in lower grain weight and quality.

He (2021) studied the relationships between chemical composition, structure and physicochemical properties of 12 temperate rice cultivars in China. Correlation studies indicated that amylose, damaged starch, protein, fat and ash played a more important role in determining the rice properties of pasting, thermal, crystallinity and texture. According to them Japonica rice with high amylose and protein content showed strong significant positive correlation with hardness, gumminess, cohesiveness and appeared to be rough and low sticky after cooking.

For the majority of the population of the world the nutritional quality of rice bears an important position as staple food. Rice is an important source of protein also. It has a high proportion of lysine and high protein digestibility. Rice protein, which comprises up to eight per cent of the grain, has a special benefit as it has eight of the essential amino acids in a delicately balanced proportion.

The cooking and eating quality preferences vary with the country (Azeez and Shafi, 1966). Thus improvement of protein in rice with respect to quantity and quality may be a vital task for overcoming the malnutrition problem in developing countries. Morrison (1948) found that the average protein content of brown rice will be 9.1 percent. In some Amerícan brown rice the average protein content recorded by Morris (1949) will be 8.9 percent.

Several workers have reported that protein content of dehusked, polished and paraboiled rice varied from 7.5, 5.6-6.7 and 5.6 -7.1 percentages respectively (Sadavisan and Sreenivasan, 1938; Rao et al. 1961). Juliano et al. (1964) found a variation in the protein content of dehusked rice of a few Asian countries, ranging from 6.54-11.85 percent. From a series of experiment on long, medium and short grained rice cultivars, Simpson et al. (1965) reported that protein content of rice varied between 5.80 and 8.51 percent; 6.60 and 10.18 percent and 5,80 and 8.80 percent respectively.

Cagapang et al. (1966) reported that two samples of waxy rice had protein content similar to those of non–waxy variety BPI-76. According to them, the gross protein content is not related to the amylase amylopactin ration of the starch granules of the grain.

A wide degree of variation of protein content of twenty popular rice varieties collected from various parts of Northewrn India will be recorded by Raghavaiah and Kaul (1970) and the variation will be from 6.9-12.1 percent. But the variation of protein content in a few high yielding varieties of rice will be 8.0-10.8 percent as reported by Gaghavaiah and Kaul (1971) though Sharma et al. (1972) reported a variety wide degree of variation ranging from 6.0 to 14.0 percent in some collections of Assam rice of which twenty samples contained more than 10 percent protein.

Borkakoty (1975) studied on the nutritive quality of ten Bora and ten Chokuwa varieties of Assam and reported the variation of protein content as 7.16-9.07 and 6.73-9.90 on percentage basis respectively. Dutta (1975) made an investigation on the quality aspects of some varieties of Assam including two Chokuwa varieties and found the variation of protein content as 7.66 to 10.56 percent.

Wardsworth and Spadaro (1981) made an investigation on two lots of Starbonnet variety (long grained) for rice and reported the variation of protein content as 8.9-12.9 percent and 8.0-12.7 percent respectively. Jati et al. (1985) reported the variation of protein content as 6.96-11.59 percent in six high yielding varieties on dry weight basis. Siddiq (1985) suggested that it is desirable to assess the yield before the quality evaluation and recommendation for general cultivation.

Li (1990) investigated different aspects of an elite glutinous rice variety, 'Liaonu' and reported the protein content as 7.26 percent. The variation of protein content of fifteen rice varieties of Ivory Cost will be reported as 6.10 to 8.57 percent (Firmin, 1991). Borah and Goswami (1995) induce varieties of higher yield with higher protein content although several earlier studies shows negative correlation between protein content and grain yield. Dutta (2000) mutation breeding will be carried out for higher protein content and for better balance in amino acid composition in rice.

Dutta (2000) mutation breeding will be carried out for higher protein content and for better balance in amino acid composition in rice. It should be possible to induce varieties with higher protein content although several earlier studies shows negative correlation between protein content and grain yield (Borah and Goswami, 1995). Siddiq (1985) suggested that it is desirable to assess the yield before the quality evaluation and recommendation for general cultivation.

The major carbohydrate of rice is starch, which is about 72-75%. Rice starch has a bland taste, white color, smooth texture and is hypoallergenic to many people. Furthermore rice starch possesses superior attributes such as greater acid resistance, spreadability, and relatively good freeze-thaw stability.

Starch consists of two components: Amylose and amylopectin. Amylose is a long, unbranched chain with 200-1000 D-glucose units held by alpha (1-4) glyosidic linkages. Amylose content of rice is considered to be one of the most important compositional indices of rice cooking and processing behaviour (Williams et al., 1958). Khush et al., (1979) classified rice varieties on the basis of amylose content into waxy, low, intermediate and high. Amylopectin is a branched chain with alpha (1-6) glyosidic bonds at the branching points. Amylopectin molecule containing thousand glucose units looks like a branched tree (20-30 glucose units per branch). The rate of hydrolysis of starch containing high amount of amylopectin will be found to be rapid (Frei et al., 2003).

Amylose and Amylopectin ratio can predict the glycemic index of rice. Lower amylose content will have higher glycemic index. Starches with higher amylose content will be less susceptible to gelatinization. The starch with higher amylose content does not easily hydrolyse to glucose. This could be due to the formation of complexes between amylose and lipids upon heating, thus making them less accessible to enzymatic digestion which results in a slower rate of digestion (Frei et al., 2003).This is the reason for low glycemic index of starches with higher amylose content.

The glycemic index (GI) is a method used to classify dietary carbohydrates based on their impact to the blood glucose response usually 2-hours after meals (Wolever, 2006). A lower diet GI may results in a slower rate of digestion and absorption, hence reducing the rapid elevation of postprandial hyperglycemia as well as insulin concentration which will then influence the management of diabetes (Yusof et al., 2009)

Thus, identifying the value of amylose in rice is an alternative inexpensive and less-time consuming strategy for screening and predicting the glycemic response and GI value of the rice. Strocchi and Levitt (1991) found that, in comparison with other sources (wheat, potato, and maize), rice starch is nearly completely absorbed by the human body Positive qualities of high digestibility of starch, high biological value of amino acids, high content of essential fatty acids and selenium, and anti-hypertension effect have been confirmed scientifically. Rice can therefore be described now as a functional food. Dipnaik et al. (2017) studied the gyycemic Index (GI) of long, medium and short type of rice grain and found that Long grain will be found to have high amylose and low amylopectin content due to which it is a low glycemic food. The long grain rice can be consumed by diabetics because of its comparative low GI.

In addition Starch also determines the physico-chemical and cooking properties of rice. Pasting and gelatinization characteristics of starch depend on the amylose: amylopectin ratio. The amylase content is different due to rice variety, which is one of the most important determinants of rice starch quality (Liu, 2013). Viturawong (2008) stated that Starch is the major component of rice grain that mainly determines the physico-chemical and cooking properties.

In South Indian polished rice, the amylase content ranged from 4.5-17.5 percent except one variety which contained traces of this constituent as reported by Rao et al. (1952). Juliano et al. (1964) reported that amylase content varied from 13.7-32.8 percent in few rice varieties grown in some Asian countries. They also found as 2.8-5.7 percent of amylase in three varieties of Assam grown in Thiland.

Swaminathan et al. (1971) found that amylase content of rice grown in North East India varied from 6-35 percent. Raghavaiah and Kaul (1971) reported that the amylase content of some Indian rice varieties varied from 16.5 to 35 percent. Chakravarthy et al. (1972) reported that the amylase content ranged from 19.4-29.4 percent where as a variation of amylase content from 22.4-27.9 percent will be reported in contain long grain rice by Wardsworth and Spadaro (1980).

Investigation on various properties of paraboiled rice will be made by Unnikrishnan and Bhattacharya (1987) and revealed that the amylase content ranged from 19.4-29.3 percent. Chaubey et al. (1988) reported that the amylase content of nine scented and eleven non-scented rice varieties varied from 17.38-20.93 percent and 14.53-21.64 percent respectively. Hussain (1987) studied on quality status on indigenous rice cultivar and found that red kernel types had relatively higher protein content as compared to the white kernel types.

Li (2016) and Dutta (2015) stated that pasting and gelatinization characteristics of starch depend on the amylose: amylopectin ratio, chain length, the degree of branching of amylopectin, and the granular structure of statch affect quality of rice flour. Subramaniam et al. (2016) studied the relationship between amylose content and glycemic index of commonly consumed white rice and showed that white rice categorized as low amylose may have high GI value.

Batuagahge and Rohitha (2018) studied the glycemic index of four traditional red pigmented rice in Srilanka and found that unpolished traditional rice cultivars have low-medium GI values are suggested as a better alternative for the regular diet of type 2 diabetes patients. Cahyuning et al. (2019) studied the effect of preparation method on chemical property of different thai rice variety and found that parboiling treatment may not change the GI values among rice varieties. They concluded that natural composition of each rice variety is different and it affects human health. However, preparation process can alter the chemical property of rice as well as influence health benefit of rice. Kabir et al. (2021) studied the glycemic index of rice varieties commonly available in the market of Bangladesh and found that Sworna, BRRI Dhan 29 and Kalijira as low GI rice varieties that could be beneficial for consumption by diabetics as well as healthy individuals.

Fukai (1999) found that pheotoperiod and temperature are two main environmental factors determining the flowering time in rice. Singh et al., (2005) have been opined that the variations in composition and cooking quality of rice to mainly depend on the genetic as well as the surrounding environmental factors where they are grown. Brar et al. (2011) studied the behaviour of two rice cultivars transplanted on different dates and found that delayed transplanted leads to the increase of sterility percentage. Singh (2019) found different yield performance growing three rice varieties with different planting dates.

Nagaraju (2020) investigated 22 hybrid rice varieties for evaluation of quality traits and reported that different hybrids possess different quality performance. Aside from differences in nutritional values of different rice varieties, processing also affects the nutrient quality of rice. White (milled) rice predominates in the market and Asian diets. Babu et al. (2009) reported that rice processing like milling and polishing destroy 67% of Vitamin B3, 80% of Vitamin B1, 90% of Vitamin B6, 50% of manganese, 50% of phosphorus, 60% of iron, and all the dietary fibre and essential fatty acids. In contrast, brown unpolished rice has four times more dietary fibre which increases beneficial bacteria in the large intestine, aiding digestion and protecting against heart disease and high blood pressure.

Cheng et al. (2003) studied on the effect of water management on rice quality and found that water treatments significantly affected all quality traits in the study. They also reported that of all variables, water treatment has the strongest effect on protein content. Different water management treatments, namely PM, water-saving irrigation, and conventional irrigation, significantly affected brown rice rate, head rice rate, chalky grain rate, amylose content, and protein content in a cultivar and grain position dependent manner. Chen et al. (2012) studied on Molecular and environmental factors determining grain quality in rice and reported that grain quality has been shown to be affected significantly by growing and environmental conditions, such as water availability, temperature, fertilizer application, drought, and salinity stresses. Kalita et al. (2021) studied on the effect of different processing methods on nutritional value of rice and found that right processing methods may help to obtain maximum yield of nutrition.

Flood also affects the quality of rice. Singh et al. (1990) reported that the kernels in flood-affected samples became soft and developed fissures which contributed to low head rice recoveries, and the milled rice had lower kernel weight and protein content, but showed higher amylose and ash content. Guo et al. (2007) found that rice grown in an upland nonflooded environment also affects grain quality. Their study involved several cooking and nutrient quality traits, including amylose content, gel consistency, gelatinization temperature, and protein content, in the same populations grown under upland and lowland conditions. They found that phenotypic values of all four traits will be significantly higher under upland environment than lowland environment. Grain quality is not only by the genetic constitution but also by environmental conditions. Bao et al. (2004a), Cameron et al. (2008) and Sharifi et al. (2009) found significant genotype × environment effects for several quality traits in rice cultivars grown at different locations and also during different seasons.

3. Materials and Methods

Collection and documentation of popular rice cultivar from Dhubri district of Assam

Methodology

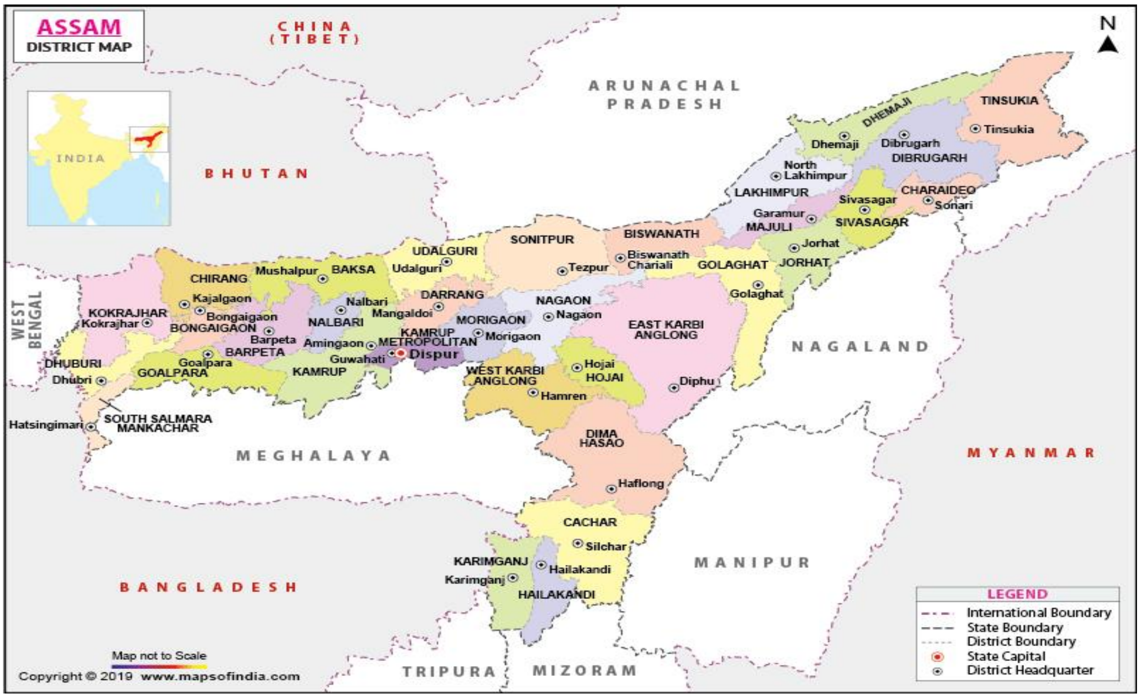
Study area

Assam is the central part of Northeastern India. It lies between 24°08/ N and 27°09/ N latitude and 89°42/ E to 96°10 E longitude, covering an area of 78 438 sq. km. Assam is surrounded by a number of Indian state and few foreign countries. Foreign country Bhutan is situated in the North –West side. North eastern side is surrounded by Arunachal Pradesh.Nagaland and Manipur is situated in the east side. Mizoram is situated in the south side. Tripura, Meghalaya and foreign country Bangladesh on the south west side. The state Assam has two natural divisions' viz plain division and hill division. The plain division includes Brahamaputra valley and the Barak Velly. The mighty river Brahamaputra runs from north east to west a distance of 450 kms splitting the valley into two parts The Brahamaputra valley constitutes about 72% of total geographical areas and about 85% of the population of the state.

The Assam is a part of the Himalayan biodiversity hotspot, while the southern region is a part of the Indo-Burma hotspot, and thus Assam is a home to an extensive exhibit of vegetation, running from tropical and sub-tropical to temperate or near temperate. This is because of the various geology, shifted and rich precipitation and differential climatic and edaphic conditions in the state. Based on pattern of rainfall, terrain, soil type and climatic condition Assam has been divided into six agro-climatic zones. These are North Bank plain zone (NBPZ), Upper Brahamaputra Valley Zone (UBVZ), Central Brahamaputra Valley Zone (CBVZ), Lower Brahamaputra Valley Zone (LBVZ), Barak Valley Zone (BVZ) and Hills Zone (HZ).

In Assam paddy is grown in three seasonal types on the basis of harvesting period Viz autumn paddy, winter paddy and summer paddy. Autumn paddy is locally known as Ahu paddy is grown in February- March and harvested in July-August. Winter paddy is called Sali paddy is grown in July – August and harvested in November – December. Summer paddy is called Boro paddy is grown in November-December and harvested in March-April. In Assam winter or Sali paddy has been dominating the two types as it occupies at around 64% net area.

According to population census report (2011) the population of the district Dhubri is 9148632 and population density is 1171 per square km. The district occupies an area of 2,17600 hactares out of which only an area 4086 hectares has slope of more than 20%. The net sown area of this district is 135112.5 hactares. (**Source: District Agriculture contingency plan**) The gross cropped area is 230511.8 hactares. The cropping intensity is nearly 93246.51 hactares. The rainfed or unirrigated area of this district is 90509 hactares and net irrigated area is 44689.69 hactares.



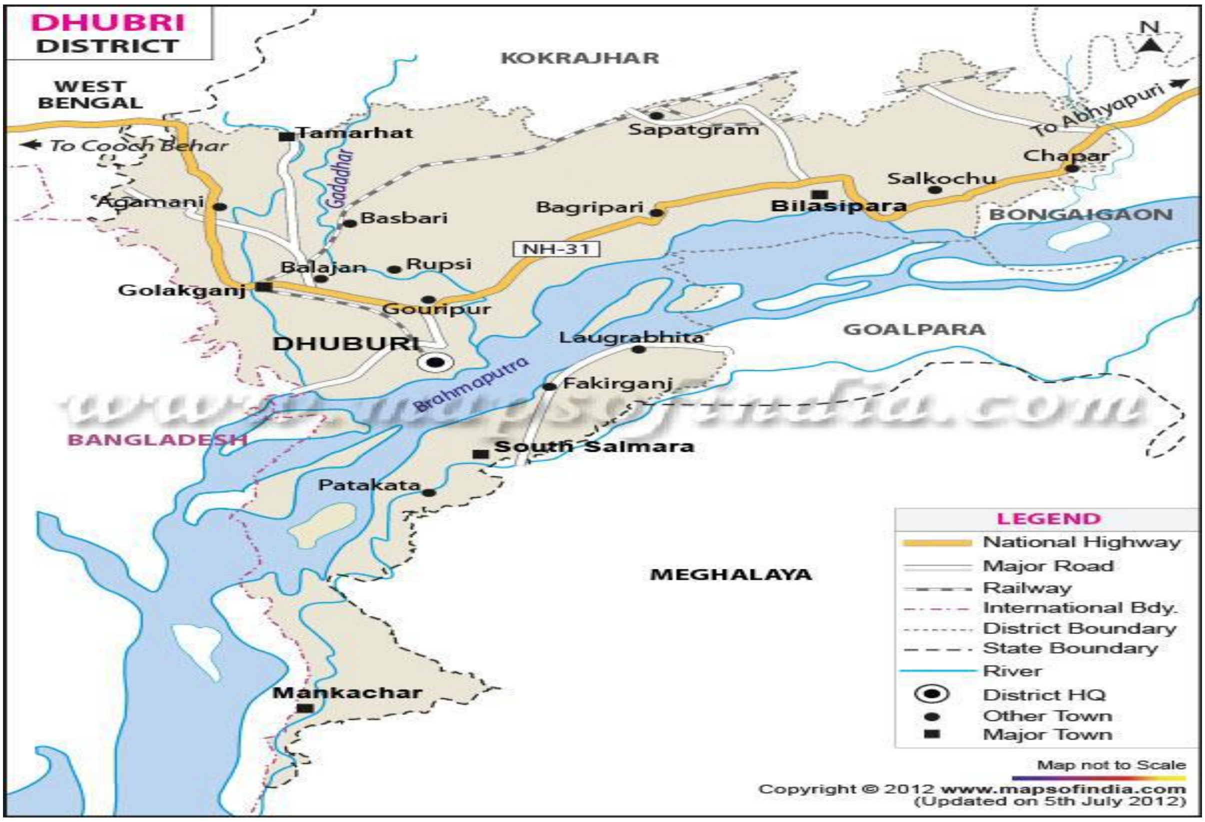
Temperature and Rainfall pattern and distribution

The average minimum temperature is observed in December and January and the maximum average temperature is observed in May. The average annual rainfall in the district is 2877.9 mm. The rainfall pattern observed that is that during November to March average rainfall is low and considered as dry period while from April to October received high average annual rainfall is considered as rainy period. Unevenly distribution of rainfall suffers the district from heavy flood during rainy season as well as moisture stress during dry period. The relative humidity was highest during Jun and July and the lowest during February and March.

It falls in the Brahmaputra valley and has a plain topography with patches of small hillocks, wetlands, floodplains, grasslands etc. The mighty river Brahmaputra bisects the district, on Northern side with Dhubri and Bilasipara Sub-Division and Southern side with South Salmara-Mankachar Sub-Division. The district constitutes the vast alluvial plains of Brahmaputra River system. Soil exhibits heterogenous characteristics. Major part of the district particularly reverine part soils are predominantly loamy to sandy loamy. In some parts clay to heavy clay soil are found. Major part of this area is suitable for crop cultivation. Soil is highly acidic to slightly alkaline in nature. Soils are characterized by presence of low organic carbon and low soluble salts. The productivity of crops damaged every year due to regular flood problem. The southern part of district South Salamra-Mankachar division is adversely affected by floods. Major parts under Mankachar revenue circle has already been washed away by erosion.

Desirable soil and climatic condition favors the district to grow a wide range of crops. People of this district mainly depend on agriculture and forest products. As paddy is the main source of income people grown all the three types viz Autumn paddy, winter paddy and summer paddy to meet their requirement. Surplus production is their source of income. In addition Mustard, Jute, Potato, lentil, Black gram and different vegetables like Brinjal, Cabbage,Cauliflower, ladisfinger, Radish, Tomato, cucumber are also grown as source of income.

Survey and data collection:
At first a pilot survey was done in the entire Dhubri district and on the basis of potentiality of agriculture different blocks of both the Northern part and southern parts of this district was selected as study site. The field survey was started in the year 2022. The agricultural fields were visited in all the seasons of cropping, viz. summer, winter and autumn seasons. A periodic visit was carried out for collection of information on the rice varieties and during harvesting time daily visits were made for collection of rice germplasms. Survey was conducted with approximately 70 villagers whose primary occupation was agriculture. Details of each collection regarding their uses and specific features were collected and documented along with seeds from the respective farmers. Some secondary data were also collected from District Agricultural Office (KVK) for the study.The passport information of every collection was prepared. The collected germplasm were sent to NBPGR, New Delhi for obtaining indigenous collection number (IC.No). Rice germplasms were deposited in the Department of Botany, Goalpara College, Goalpara, Assam.



Survey and data analysis:

The field survey was conducted with a questionnaire of selected 70 farmers. The questionnaires were divided into three sections. In the first section, we compiled the information about knowledge of hybrid/improved rice varieties and also preferable variety in terms of productivity, economical and cost effective. In addition, here are also included information on nutrition quality, cooking quality and other important specific information of improved variety/hybrid and traditional variety. Any specific reasons of cultivation of traditional varieties.

In the second part asked about area of crop land used for rice cultivation. What type of rice is mostly cultivated? In which season maximum land is used for rice cultivation. Name the type of variety where maximum land is used for cultivation. In which season of cultivation is economical and cost effective in terms of productivity. Which type of rice is preferable in terms of cooking and eating?

In the third part asked about the source of seeds. In addition here are also asked to include name of popular rice varieties including if some rice varieties were cultivated in most of the seasons.

Figure: Rice germplasm collected Dhubri District

The crop lands and households were visited in all the seasons at harvesting time of rice crops. The farmers were asked to accompany and tell the vernacular name of the germplasm. The details information and special information of each accession were collected and documented along with seeds from the respective farmers. The passport information of every collection were prepared. The required amount of collected germplasms was sent to NBPGR New Delhi for obtaining Indigenous Collection Number (IC. No). The remaining amount were stored in the laboratory of Department of Botany Goalpara College, Goalpara,Assam,India for qualitative analysis.

4. Results and Discussion

Rice cultivation in the study area was carried out in three well defined seasons namely Sali (winter rice), Ahu (autumn rice) and Bora (summer rice). A total of 44 rice varieties comprising of 20 traditional varieties and 22 improved varieties cultivated in the three cropping seasons were collected from the study area. Assam, the Northeastern region of India is considered as one of the hotspots of rice diversity with 948 accessions of rice including their wild relatives, till 2002 reported from the NBPGR Regional Station, Shillong. The collected varieties in the present study exhibited distinct variations in their specific characteristics including the shape and size. The 15 rice germplasms were found to cover more than 50% of the total area under the cultivation in the study area. Genetic diversity of traditional rice varieties is still maintained by the farmers because of their some specific agronomical characteristics and traditional knowledge base. The farmer’s main criteria for selection of traditional rice varieties are yield, grain quality, pest and disease resistance as well as their adaption to biotic and abiotic stress with their prevailing local climatic conditions. Large numbers of traditional rice varieties were still cultivated because of their good taste and aroma content. Among the traditional landraces Sarnamasuri and different varieties of Jaha were found to be cultivated by maximum number of farmers and larger area was covered by the two varieties. The kernel of these land races are short slender and are highly prefer by consumer because of their high taste and aroma. Other important landraces include Kolamota and Solpona which has short bold kernel are slowly digestible as reported by farmers. Diabetics patient generally prefer type of kernel as it slowly and instantly energy giving food. Glutinous rice variety Paneer bora is used in the preparation of rice cakes, rice flakes, pancakes and pithas during festival and special occasions such as *Makar Sankranthi* (Harvest Festival). Landraces like Salibora, Kaberi and Cranti are also preferred for their scented aromatic character and are often used on special occasion and also preparation of sweet dishes.It may also be mentioned that land race Phul pakhri have short slender kernel and has high commercial and medicinal value besides being religious importance. Certain traditional varieties Sarnamasuri and Kola bhug are still retained by the farmers because of their high commercial value.

Among the collected varieties Ranjit, Ranjit sub-1, Bahadur, Bahadur Sub-1, and Natun Aijong were found to be cultivated by maximum number of farmers. They can be grown in all three seasons. In addition to higher yielder they are well adopted to local environment and they are partially adpted to environmental stress. Partial erratic climate does not impact on their production. These germplasm occupy use maximum area of land in winter season and winter and summer season than other traditional or improved varieties. These varieties were considered as most popular adopted rice varieties as reported by farmer's feedback.

The yield from traditional varieties are low but farmers still continue to cultivate them, even as they adopt newer varieties, because compared to modern varieties the yield from traditional varieties are reliable and prevents the risk of yield failure. Certain varieties were found to be on the verge of extinction due to the displacement and replacement of varieties by farmers. However, it is important to mention that it does not mean such varieties have completely disappeared from the District.

The present studies highlighted the different rice landraces available to the farmers in the study area and documented the traditional knowledge base associated with cultivation of rice landraces. This can serve as reference for researchers and farmers interested in reviving the rice landraces in the region. The rice landraces in the study recorded many interesting qualitative characteristics which could be used in rice breeding strategy and biotechnological research for further yield and quality characters improvement which would be useful in mitigating hidden hunger.

5. Conclusion

In the present study, the characterization of rice germplasms recorded from the farmers feedback showed vast diversity for specific quality traits viz. aroma, good cooking quality, eating quality grain type and shape, kernel colour, biotic and abiotic tolerance etc. Traditionally, farmers growing many rice varieties and prone to accepting new varieties with seemingly better grain yield without considering other qualities. In the race to increase production, farmers neglected the good qualities of rice germplasm in terms of their cooking, nutrition, and mineral content. Rice is consumed as staple food in this area therefore; the quality of grain is a matter of primary concern for maintaining human health (Kumar, 1989; Hossain et al., 2009). As rice meets most of the requirements of health there is an urgent need to assess the quality of rice germplasm cultivating in this area to know the amount of contribution of nutrition towards development of human health and in mitigating the hidden hunger.

The Dhubri district occupies the westernmost part of Assam. The severe adversely flood affected larger part of this district occupies by char village (480 Char village). The majority of the people living in rural area are not only socio-economically poor but also they have nutrient deficiency. Since rice production is the primary source of livelihood for the overwhelming majority of the farming community (Nath *et al.*, 2021), there is need to study the quality of rice for not only upliftment of rural economy but also the improvement of human health.

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