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AROMATIC JOHA RICE OF ASSAM- A REVIEW

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ABSTRACT

Rice is a widely grown staple food crop for half of the world's population. Assam being one of the centres of origin has got wide range of variation of rice cultivars. Among all the common cultivars, aromatic rice of this region enjoys a top position in terms of popularity. The Joha rice cultivars are known for its unique aroma, superfine kernel, good cooking qualities and excellent palatability. Except elongation ratio, Joha cultivars of Assam have compatible aroma and quality as that of other scented rice of India. However, the class of aromatic rice has not been studied by researchers and workers due to various constraints. Only some preliminary breeding works and tissue cultures are done till date in local research stations and universities. Unfortunately, many of them have now become extinct. In this review, the scattered information and data on Joha rice cultivars of Assam are being tried to put together which could be useful for further studies on this valuable and endemic rice variety. This could eventually be helpful in drawing the attention of the researchers and scientists to work on it.

Key words: Rice cultivars, Aromatic rice, Joha, 2 acetyl - 1- pyrroline

INTRODUCTION

Rice is the major cereal crop playing significant role in diet, culture and economy of millions of people across the world. It is the leading food source in terms of calories being consumed for mankind and feeds about 60 % of the world's population (FAO 2007). It is the primary staple food crop throughout Asia and other part of the world. Today the demand for increase in productivity and quality of rice in available marginal land is very high. Japonica and Indica are two major subspecies grown in different regions of the world of which Indica is the most widely cultivated variety and popular in terms of consumption. The Indica variety grows in wide area ranging from temperate to tropical regions occupying about 85-90 % of the total cultivable rice in the world (FAO 2007).

Among the rice growing countries, India enjoys the top position in context to area sown with 44.6 million hectare of land, having production and productivity of about 90 million tones and 2086 kg/ha respectively. It is estimated that in India alone the demand for rice in 2010 will be 100 million tones and by 2025, it will be around 140 million tones (Murali 2005). Thus, there is a challenging need to improve rice yield to meet the growing demand. During last two decades, significant progress has been made in increasing the yield and other qualities.

Indian agriculture is the best example of largest private cum public sector and rice is the most preferred cultivated crop grown on 70 % of total arable agricultural land extending from south to northeast region. The northeastern region of India lies between 21-29° North latitude and 89-97° East longitude covering a geographical area of 2.55×10^5 km^2. About 7000 plant species which form 43-45 % of total floral constituents of the country are found in this region. It is the richest reservoir for genetic variability in agri horticultural crops (Hore 2005). Rice is principal food crop of the region and is extensively cultivated in upland, lowland and deepwater conditions. Among these, Assam is particularly rich in rice germplasm. The state has an average rainfall of 1654-5080 mm (Source: Directorate of Economics and Statistics, Govt of Assam, Guwahati 2009, unpublished data). Assam is considered as one of the origins for rice and has got wide collection of rice cultivars. Total rice

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coverage in Assam is about 25.3 million hectare while production and productivity are about 3.8 million ton and 1540 kg/ha respectively (Source: Directorate of Agriculture, Govt of Assam, and Guwahati 2009, unpublished data).

Rice Cultivars of Assam

There are four broad divisions of rice cultivars grown in Assam - Sali, Ahu, Boro and Bao rice, having various traits like stickiness, high starch content, waxy, non waxy, aroma flavor etc. About 70 % of total agricultural land of Assam is used for rice cultivation (Source: Directorate of Agriculture, Govt of Assam, Guwahati 2009, unpublished data). The four chief categories of rice are classified on the basis of the amount of rainfall and zonal distribution of the state.

Sali rice (winter rice); Ahu rice (autumn rice); Boro rice (summer rice); Bao rice (deepwater rice)

Aromatic Rice of Assam

Among different categories of rice, scented rice enjoys a special demand and is highly valued. The aromatic rice of Assam is a unique class under Sali rice traditionally known as 'Joha'. This class of rice has high demand in domestic market and is used mainly for preparation of special dishes like table rice, *Kheer Pulao* and frumenty.

The Joha rice cultivars are known for its unique aroma, superfine kernel, good cooking qualities and excellent palatability. It is very popular due to its inherent scent and is much in demand for export (Raina et al. 1987). The area under Joha rice is however nominal owing to its poor yielding ability. The low productivity and yield of this class of rice make it less favorable among the producers. Moreover, due to its aroma, pest attack is frequent, prone to lodging and takes relatively longer time to mature (120-160 days).

Assam maintains a diverse gene pool of aromatic rices that differs in aroma intensity, durability, grain shape and size, production potentialities etc. Joha rice is grown in marginal lands, uplands or on Sali seed beds after uprooting the seedlings, late in the season. No authentic data about area, production and productivity are available. About 5% of Sali rice area is occupied by Joha with an average yield of 1-1.5 t/ha.

Phenotypic and Genotypic Variation of Joha Rice

Joha rice is an intermediate of typical Indica and Japonica class. It belongs to medium slender or medium broad category with an L: B (length: breadth ratio) less than 3. It elongates about 1.4 times but tears on cooking. Joha differs from Basmati rice (scented rice of India other than Joha) in many aspects (Fig 1). Basmati has superfine grains (>6.5 mm length), extra elongation (1.8times), strong aroma and soft texture on cooking. In contrast, Joha grains are shorter (<4.7 mm), have limited elongation (1.1 times). Though they don't posses strong aroma and soft texture after cooking but don't loose aroma either (Ahmed 1993).

Although Joha rice grown in Assam is well known for its flavor, aroma and taste, it is still not a preferred variety for cultivation due to its low

Table 1: Collected germplasm maintained at Assam Agricultural University

S. No.	Name of the Joha spp	S. No.	Name of the Joha spp	S. No.	Name of the Joha spp
1	Ahu Joha	17	Chuban Joha	33	Kon bogi Joha
2	Arab Joha	18	Chufap Joha	34	Kon Joha I
3	Baberi Joha	19	Goalporiya Joha I	35	Kon Joha II
4	Badshabhog	20	Goalporiya Joha II	36	Kon Joha III
5	Bokul Joha	21	Govind bhog Joha	37	Kolari bhog
6	Bangali Joha	22	Joha	38	Krishna Joha
7	Bhaboli Joha	23	Joha bora	39	Kunkuni Joha
8	Bhugi Joha	24	Kamini Joha	40	Maniki madhuri
9	Boga Joha	25	Kalgira	41	Manipuri Joha
10	Boga tulasi	26	Kapow Sali	42	Nepali Joha
11	Bogi Joha	27	KD ML 105	43	Rampal Joha
12	Bhugri Joha	28	Keteki Joha	44	Ronga Joha I
13	Boga maniki madhuri	29	Khorika Joha	45	Ronga Joha II
14	Bor Joha	30	Kola Joha I	46	Tulasi bhog
15	Borsali Joha	31	Kola Joha II	47	Tulasi Joha
16	Cheniguti Joha	32	Koli Joha		

Figur 1: (a) Basmati. (b) Joha

productivity and yield. For the same reason it has drawn least interest of the researchers too. Very little has been studied on Joha cultivars of Assam compared to the other scented rice of India. However, Assam Agriculture University has initiated activities in collecting, maintaining and characterizing Joha cultivars for subsequent improvement and production of this class of rice. The collected Joha germplasm till date maintained by AAU (Assam Agricultural University) is given in Table 1.

Variability and correlation among physical quality characters of Joha rice was studied by Pathak and Sarma (1997) as shown in the Table 2. However, there is no report on quality traits of Joha rice and information on this rice is vague.

Physical Quality Traits

Sarma and Pathak (1990) and Sarma (1989) studied the agro-morphological characteristics of this class of rice. They studied 37 indigenous Joha

Table 2: Variability and correlation among physical quality characters of Joha rice

Characters	Joha cultivars	Basmati
Type	Short-medium grained	Long slender grained
Length-breadth ratio	Less than 3	More than 3
Elongation after cooking	1.4 times, but breaks	1.8 times without breaking
Aroma	Strong	Strong
Yield potential	Low	High

cultivars along with 'Pusa Basmati' & 'Kernel local' as checks. The traits considered in the study were as follows:

1. Hulling Recovery, 2. Milling Recovery, 3. Head rice Recovery, 4. Kernel Dimensions (length-breadth), 5. Elongation Percentage, 6. L/B ratio, 7. Alkali Value.

It was reported that there was low variability for hulling and milling percentage, but high variation for head rice recovery, kernel length, breadth and L/B ratio, and elongation and alkali value. The mean hulling and milling recovery of Joha cultivars are above 75 % and 60 % respectively. Head rice recovery was more than 60 %, more than that of Pusa Basmati and Kernel local.

None of the Joha cultivars possesses kernel length > 5.5 mm. breadth readings don't match very much. However, L/B ratio of all is always <3. It determines the shape of the rice (bold/ slender) thus confirming that Joha rice belongs to the medium category. Elongation percentage was found highest (110 %) in *Koli* Joha, followed by '*Manipuri* Joha' (107 %) and *Ronga* Joha among the indigenous cultivars (Sarma 1989).

Alkali value is a prime determinant of cooking quality and alkali value of 4.4-5.5 is likely to cook easily without disintegration of kernels. In Joha cultivars it ranges from 3-7. There was also a high range of variation for head rice recovery, kernel length, and L/B ratio and elongation percentage. Joha cultivars have a range of 38-67.5 % head rice recovery, which is a commercially promising trait. Significant positive correlation was found between i) hulling and L/B ratio; ii) kernel length and L/B ratio; iii) kernel length and elongation percentage and iv) kernel length and alkali value. Whereas negative correlation was found between i) hulling percentage and kernel breadth; ii) milling recovery and kernel length breadth; iii) kernel breadth and L/B ratio (Hussain et al. 1987; Chauhan and Nanda 1982). Chauhan and Chauhan (1994) also reported negative correlation between head rice recovery and kernel breadth.

Little work has been done in phenotypic and genotypic variations of the Joha rice cultivar of Assam. Bharali (1990) studied on genetic variation in 18 Joha cultivars of Assam. He studied the genetic variations of yield and yield attributing characters and also nature and extent of association among these traits.

Observation recorded was for six characters;

(1) Yield per plant, (2) 100 grain weight, (3) No. of tillers per plant, (4) No. of spike lets per panicle, (5) Plant height, (6) Panicle length.

All the characters exhibited high level of genetic variability except tiller number per plant and panicle length. High value of GCV (Genotype coefficient variation) for 100 grain weight and number of spike lets per panicle indicated high degree of genetic variability for these traits. These two traits also had high heritability. Yield per plant was found to be significantly and positively correlated with 100 grain weight at genetic level, whereas it was negatively correlated with plant height and panicle length.

Bharali (1990) in his study used 18 scented rice genotypes collected from RARS Regional Agricultural Research Station, Titabor for genetic variability. Comparative study of the mean performances of the genotypes with reference to. yield per plant revealed that two genotypes - Joha *bora* and *Nepali* Joha had highest performances. Joha *bora* also showed high performances for 100 grain weight and tiller number. *Nepali* Joha also showed high performance for 100 grain weight, plant height and panicle length. Among rest of the genotypes, *Maniki madhuri* Joha, *Krishna bhog*, *Rampal* Joha, *Kali* Joha, *kola* Joha and *kapan Sali* Joha were promising.

Maniki madhuri Joha had high mean performance for number of tillers per plant and highest number of spike lets per panicle, along with its high yielding capacity. Krishna bhog was moderate for all the traits studied. *Badshabhog* was the shortest of all the studied genotypes, but exhibited highest tiller number per plant. Number of spike lets per panicle was also quite high. Among all the genotypes Joha *bora* and *Nepali* Joha were found to be high yielders on the basis of yield per plant and 100 grain weight.

Stability Analysis in Scented Rice

To have a clear and balanced knowledge about genetic variance, knowledge of GE (genotype environment) interaction is very important; keeping this fact in view Bhuyan (2000) carried out stability analysis of some aromatic rice of India. Phenotypic stability is the ability of a population to perform uniformly well over a wide range of environment and is a desirable character.

Bhuyan studied GE interaction in some basmati and Joha rice varieties, to identify stable high yielding basmati and Joha rice varieties over different growing environments. Considerable magnitude of GE interaction was observed that was scored across the population, however, characters differed with regard to linear and non linear responses to GE interactions. Genotypes *Govindabhog, Badshabhog, Kon* Joha*, Keteki* Joha and *Pusa Basmati 1* exhibited high mean performance for yield per plant with linear stability. Other Joha genotypes showed average stability for some other characters, like-

Govindabhog - for grains per panicle

Badshabhog -for days to 50 % flowering (late)

*Kon*Joha - for grains per panicle and days to 50% flowering (late flowering) etc.

None of the genotypes exhibited below or above stability for yield per plant. *Govindabhog* exhibited highest mean value for head rice recovery, where as *keteki* Joha was found with lowest mean value for kernel breadth.

Chemical Composition of Joha Rice Cultivars

Ahmed et al (1995, 1998) analyzed chemically seven local Joha varieties taking 2 improved varieties (Basmati and Kasturi) as checks. Based on this evaluation chemical composition of Joha rice can be summarized as shown in Table 3.

Crude protein content of Joha grains has a good range (9.17-11.67 %) in comparison to that of basmati and kasturi. Again the observed variations in protein, amylase, amylopectin and mineral contents of the grains were attributed to genetic make up and environmental influences. The local Joha rice varieties are nutritionally comparable to Basmati and Kasturi in higher content of albumin, globulin and amylase. High levels of albumin and globulin in scented rice may play an important role in protein digestibility and also increase biological value. On an average, the different Joha rice cultivars of North East India have albumin: globulin: prolamin: glutelin ratio as 11:1:6:70.

Among all, *Kola* Joha*, Badshabhog* and *Keteki* Joha have very strong aroma. The characteristic odor of scented rice was identified as

Table 3: Comparative chemical composition between Joha, Basmati and Kasturi varieties.

Chemical composition	Joha	Basmati	Kasturi
Grain crude protein (%)	10.42	9.69	11.77
Soluble protein (%)	5.72	5.04	6.21
Protein fractions (Albumin) (%)	13.48	14.37	12.12
Protein fractions (Globulin) (%)	15.86	15.75	13.04
Protein fractions (Prolamine) (%)	5.77	5.12	5.54
Protein fractions (Glutelin)	64.65	64.75	69.00
TSS (%)	0.644	0.725	0.425
Reducing sugar (%)	0.14	0.104	0.144
Non reducing sugar (%)	0.506	0.585	0.281
Starch (%)	72.67	72.0	77.0
Amylose (%)	21.39	20.53	18.9
Amylopectin (%)	78.61	79.47	81.1
P (%)	0.2825	0.279	0.27
Ca (%)	0.215	0.019	0.019
Fe (mg/100g)	3.25	3.2	2.3

an aromatic compound 2 acetyl-1 pyrroline**.** It has higher potency than other volatile component of rice (Buttery *et* al. 1982). Ahmed (1993) and Ahmed *et* al. (1995) categorized Joha cultivars according to their intensity of aroma and concentration of 2-acetyl-1-pyrroline (Fig 2).

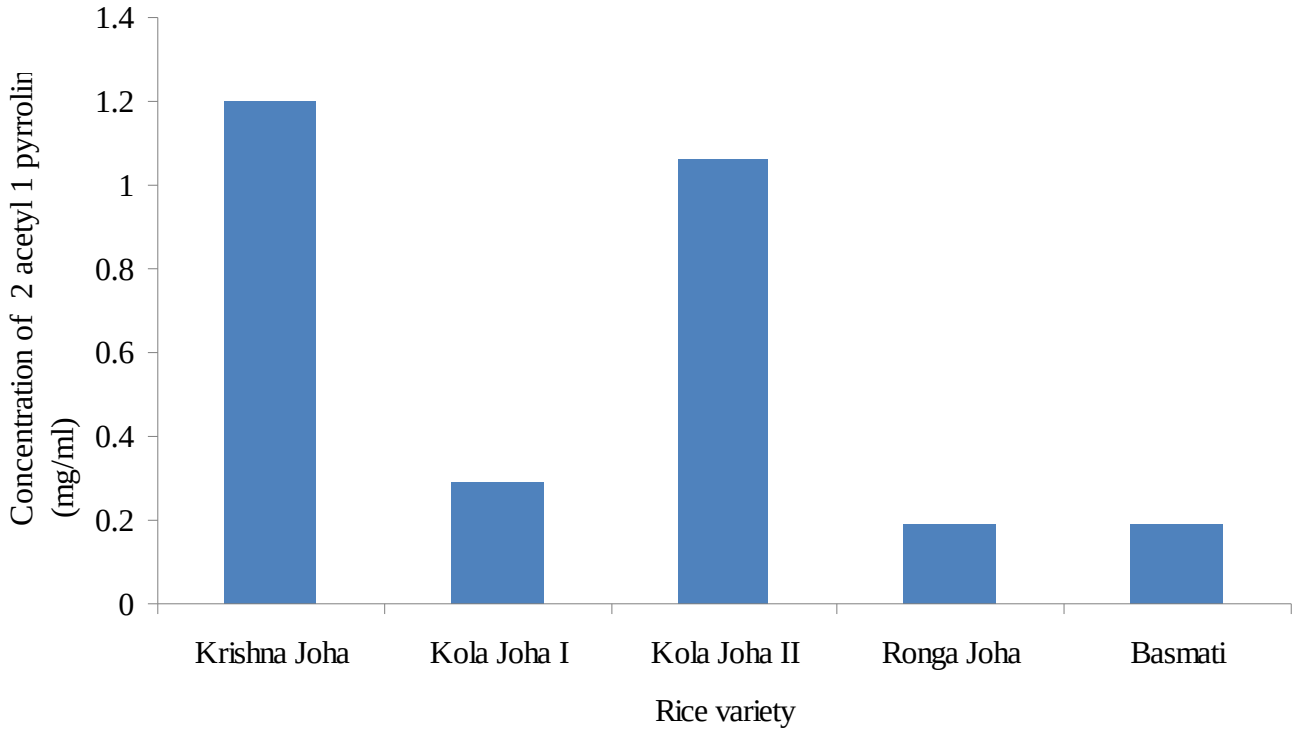
Inheritance of Scent in Joha Cultivars

The characteristic odor in scented rice was identified as a compound named 2-acetyl-1-pyrroline**.** It is said to be 'popcorn like aromatic compound' having higher potency than any other volatile components of rice (Buttery *et* al. 1982). Ahmed *et* al. (1995) categorized Joha cultivars according to their intensity of aroma and concentration of 2- acetyl-1-pyrroline.

The inheritance patterns of different morphological traits were studied under AAU. According to the Anonymous (1939), aroma is governed by duplicate factors. Talukdar (1992) reported monogenic recessive in three F_2 populations, monogenic dominance in one F_2 populations and complementary dominance in another F_2 population derived from five crosses involving five Joha and three unscented high yielding varieties (Rasi, Ratna and Joya) (Table 4). Studies on F_3 populations were also done by Das (1993) and confirmed the same trend of aroma.

Breeding and Tissue Culture Works on Joha Rice

Since the inception of the Rice Research Station (RRS),in Karimganj in 1913 , followed by RRS at Titabor, Jorhat in 1923 research has been going on by the groups of scientists. Various schools of workers are working on the improvement of scented rice. Earlier researchers were emphasizing



(Source: modified from Ahmed *et* al. (1995)

Figure 2: Aroma intensity of Joha cultivars

Table 4: Breeding studies on Scented rice by Das (1993)

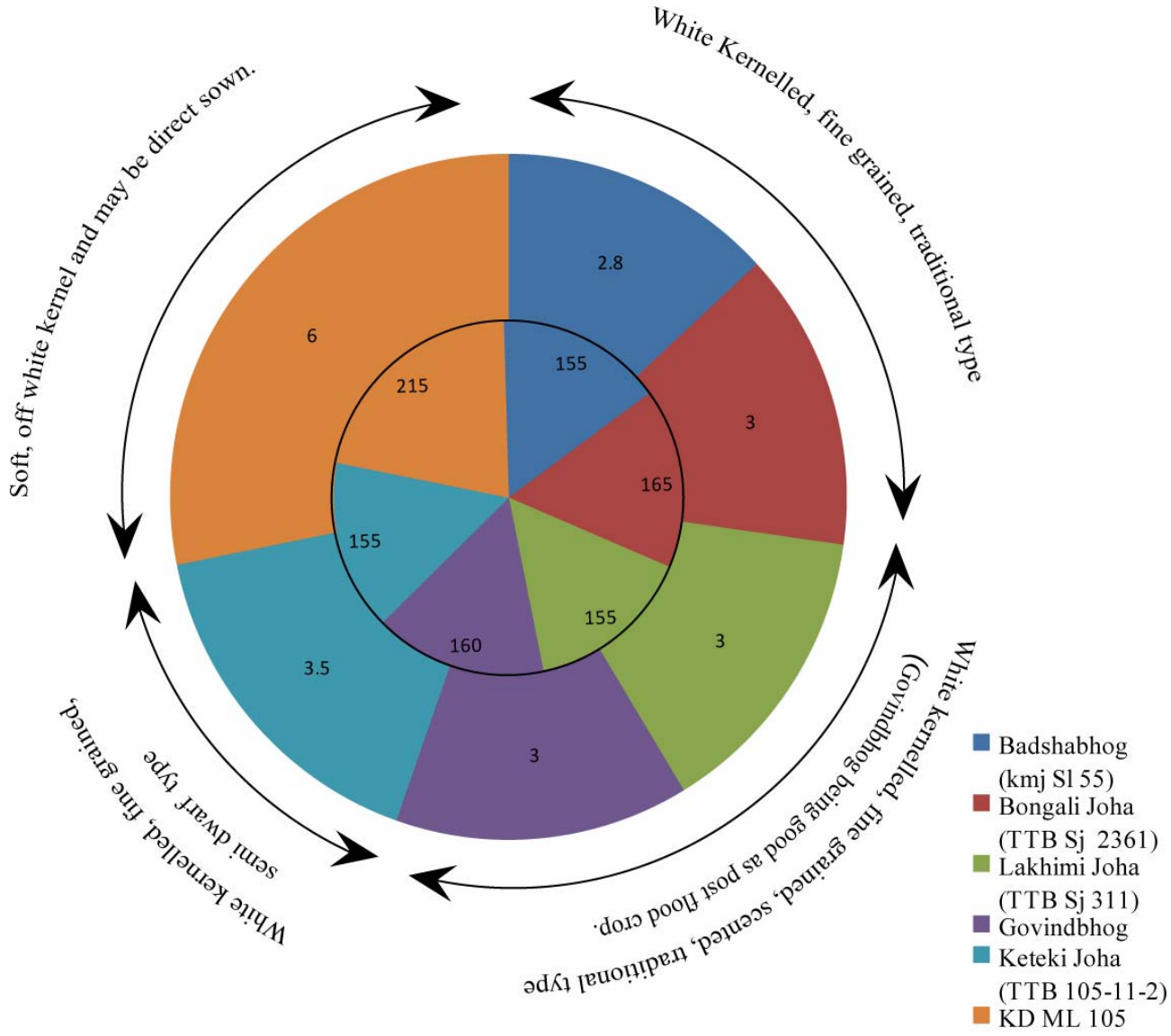
Crosses	No. of F2 plants		Ratio
	Scented	Non scented	
Ronga Joha X Rasi	61	44	9:7
Bor Joha X Ratna	30	105	1:3
Chufon Joha X Ratna	26	94	1:3
Ronga Joha X Ratna	27	93	1:3
Arab Joha X Joya	80	25	3:1

more on high yielding rice varieties; hence improvement of local scented rice faced negligence.

Around 50-80 aromatic rice cultivars were under cultivation in Assam during pre independence times. Unfortunately, several traditional varieties including aromatic ones have been lost due to extinction. Assam Agricultural University had taken keen steps in collecting, maintaining and evaluating the landraces of Assam (Barua and Das 1995). For these reasons, there was a long gap in the release of Joha varieties through conventional breeding.

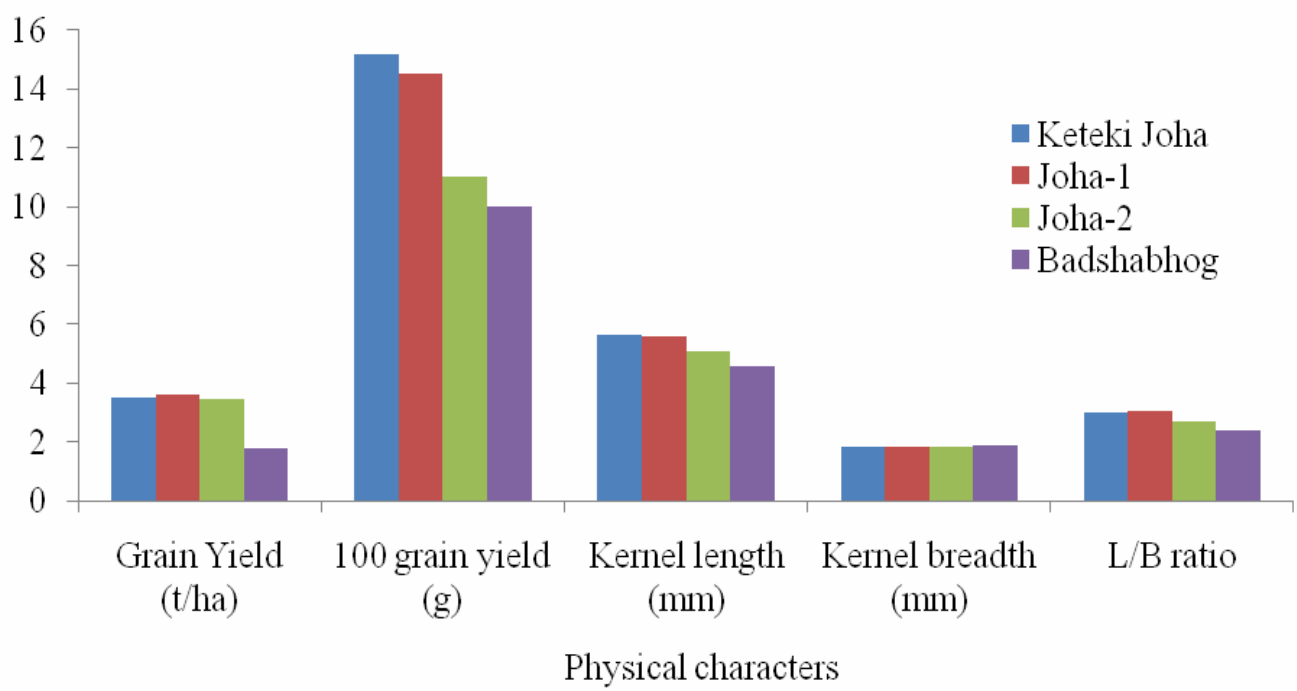
During 1985, a Pure Line selection Govindabhog (aromatic) was recommended for cultivation in Assam particularly as a post flood crop (Fig 3). Later, Regional Agricultural Research Station , Titabor has carried out a series of crosses to increase the productivity of Joha cultivars, by incorporating high yielding genes. Among these only the cross between *Savitri* and *Badshabhog* produced three promising line (Fig 4).

Savitri X *Badshabhog* → 1) TTB 105-11-2
2) TTB 105-11-1
3) TTB 105-6-1



Source: Modified from RARS Titabor, 2007

Figure 3: Maturation time and yield of hybrid scented rice varieties (Inner circle: time of maturation; Outer circle: yield in ton per hectare)



(Source: Modified from Bhuyan 2000)

Figure 4: Physical quality characters of some promising Joha cultivars

TTB 105-11-2 was later released as *Keteki* Joha. It has an average yield of 3½ times more than that of most popular scented cultivars *Kola* Joha, *Ronga* Joha and *Bhaboli* Joha etc (Bhuyan, 2000).

Sarma et al. (1999) introduced *KDML 105* a famous scented, semi deepwater rice variety from Thailand, into the semi deepwater ecosystems of Assam (Received through International germplasm exchange program by International Rice Research Institute (IRRI), Philippines. This variety has 33 % more yield than the local semi deepwater variety *Panikekua* and 51 % more than best Joha variety *Kola* Joha, and is fast spreading.

Scented varieties of rice of Assam (Joha) are a totally neglected group from tissue culture point of view and were far away from the improvement carried out by using tissue culture techniques. However few tissue culture works has been found to be performed in a few Joha cultivars till date (Sarma, 1993) as in *Govindbhog, Maniki Madhuri, Bogi* Joha, *Ronga* Joha etc.

Sarma (1993) investigated four local Joha varieties to determine the

a) Suitable germinative stages and morphogenetic potentiality of immature rice embryo.

b) To identify the best nutrient medium for germination of embryos.

c) To study the induction of calli from mature seeds and various plant parts like roots, leaf bases, nodes and internodes.

d) To study the possibility of regeneration of plants from mature seed derived callus and also from roots node and internode derived callus in regeneration medium.

In case of embryo culture, it was found that with the increase in age from 6-10 days after anthesis, the size of the embryos increased. Germination percentage was also found to be higher in 10 and 20 days old embryos than in the 6 and 8 days old ones (response *in vitro* is affected by embryo size and age) (Sarma 1993). In case of mature seeds, it was observed that germination and callus induction percentage was higher in a modified MS medium (Sarma 1993). Percentage of callus induction increased with increasing concentration of 2, 4-D (0.5-2 mg/L) but, concentration more than 2mg/ml is inhibitory to callus growth. It was indicative from the study that the callus induction was highest on MS medium supplemented with 1.5 mg/L 2,4D and 1 mg/L Kinetin. The higher concentration of 2,

4-D (above 1.5 mg/L) is detrimental for callus induction from mature seeds for all the four varieties used. Govindbhog produced highest (43.03 mg) amount of callus followed by *Bogi* Joha (27.77 mg) *Maniki Madhuri* (26.07 mg), and *Ronga* Joha (24.23 mg) (Sarma 1993).

MS medium with 4 mg/L 2,4D was found to be effective for callus induction in all the four varieties used for somatic culture (from root, leaf, leaf base, node and internodes) (Murali 2005, Sarma 1993) while MS with 2 mg/L 2,4D was ineffective. Somatic explants took relatively longer time for callus induction than the mature seeds. Root segments responded best for callus induction in all the varieties followed by nodes and internodes. Leaf and leaf bases showed no response. All calli when transferred to regeneration medium (MS with 2 mg/L KN + 0.2 mg/L IAA), all callus masses developed roots except internode calli of Ronga Joha. But further differentiation was not observed. Sarma (1993) viewed that MS medium was superior over the other media of germination of embryo and embryo cultures. The maximum percentage of germination was observed after 20 days of anthesis (for aromatic rice).

Diseases of Joha Rice

Being strongly aromatic, Joha rice varieties get easily attacked by insect pests. Among them, Neck blast pest is very common. It also suffers from Stem borer. When lately cultivated, the crop suffers from Gall mist disease. To get rid of the pests, farmers use smoke in the field by lighting leaves and all, especially during flowering and booting time. Rainfall during harvest decreases the quality of the Joha cultivars. Very little is known about other diseases of this group of rice. Joha cultivars are tall, photoperiod sensitive and most of them are weak strawed. Flowering needs cool weather. Some of the most serious pests are:

i) Yellow stem borer- caused by *Scirpophaga incertulus*, (Lepidoptera). It attacks the plant from seedling to maturity stage. It attacks the stem and makes a hole there and so is the name. When attacks at vegetative stage, the symptoms are called 'Dead heart' as the innermost part of the stem dies and appears black. When attacks at the reproductive stage, the panicle becomes white with immature and white grains. This is called as 'White ear head'.

ii) Leaf borer- Caused by *Cnaphalocrosis medinalis*, (Lepidptera). It attacks the leaves. The symptom is folding of the leaves at first and later white stripes appear on them.

iii) Rice hespa- Caused by *Dicladispa armigera* (Insecta). It attacks the leaves and the stem, which dry up and become straw like.

iv) Case worm- Caused by *Nymphula depuntalis*. This is a very rare disease seen when waterlogged condition occurs soon after sowing or transplantation. The worm cuts the terminal portion of the leaves and forms a 'case'. The cut part floats on water, reaches other plants and thus the disease spreads.

For controlling all such diseases, farmers are known to use various insecticides and pesticides. Studies on the ARC (Assam Rice Collection) made under PL 480 grant of United States Department of Agriculture (USDA) by IRRI, has revealed the existence of valuable genes for resistance to pest and diseases, drought, flood and cold, high protein amylose, aroma and dwarfism etc. Unfortunately, many of them have now become extinct. Except elongation ratio, Joha cultivars of Assam have compatible aroma and quality as that of other scented rice of India.

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