Population Genetics of Traditionally Cultivated Rice Varieties in the Eastern Himalayan Region of Northeast India

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ABSTRACT

Population Genetics of Traditionally Cultivated Rice Varieties in the Eastern Himalayan Region of Northeast India

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The Eastern Himalayan region of northeast (NE) India covers a geographical area of over 255,000 sq. km. and consists of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura states (Figure 1.1). This region encompasses wide range of eco-geographical conditions, ranging from lowland flood plains of Brhamaputra and Barak River to mountains as high as 4000 m above sea level in the West Kameng and Tawang region of Arunachal Pradesh. Rice (*Oryza sativa*) is the staple food of the local inhabitants in NE India. Traditional farmers of the region cultivate a large number of indigenous rice varieties under diverse topographic and agroclimatic conditions and different growing seasons. However, rice genetic resources in NE India are being rapidly lost due to changes in the land use and agricultural practices that favor agronomically improved varieties. A detailed understanding of the genetic structure and diversity of rice varieties in NE India is crucial for developing conservation and management strategies of rice genetic resources and use of the rice gene pool in the region for breeding and genetic improvement programs.

In this study, genetic structure and diversity of rice varieties representing several ecotypes collected from various regions of NE India were investigated using molecular tools. Chapter 1 covers a study focused on the genetic structure and diversity of 24 indigenous varieties representing *Sali* (12), *Jum* (4), *Boro* (3), and glutinous (5) types and

five agronomically improved varieties. The results revealed that the genetic diversity among indigenous rice varieties was higher than that of the agronomically improved varieties. The *Sali* and *Jum* types showed significantly higher levels of genetic diversity as compared to agronomically improved types. Two major genetically distinct clusters were detected in this study, which corresponded to two subspecies of *O. sativa*, namely *indica* and *japonica*.

In Chapter 2, the results of a study on characterization of rice ecotypes into *japonica* or *indica* subspecies using insertion-deletion (indel) markers are presented. The indel markers were designed based on the genome-wide DNA polymorphism database of typical *indica* cv 93-11 and *japonica* cv Nipponbare. The result showed that the traditional method of *indica* and *japonica* rice classification based on cultivation type, morphological traits, physiological and biochemical characteristics is incongruent with the indel marker based classification. Majority of the upland (*Jum*) and glutinous seeded varieties, which were traditionally classified as *japonica* clustered with *indica* types. Similarly, a few lowland varieties, which were traditionally classified as *indica* clustered with *japonica* types.

Chapter 3 covers the nucleotide polymorphism and patterns of nucleotide diversity at two trait specific genes, *Wx* and *OsC1*. The *Wx* gene is associated with amylose content, which determines the glutinous nature of rice grains while the *OsC1* gene is associated with the apiculus coloration. The polymorphism in the *Wx* gene among glutinous and nonglutinous grain types, and the nucleotide diversity in the *OsC1* gene among colored and colorless apiculus rice varieties were investigated. The results revealed that trait specific nucleotide polymorphisms that were identified in previous studies did not necessarily correspond to the specific phenotypes in the indigenous rice varieties of NE India. The glutinous type varieties showed higher levels of nucleotide diversity as compared to the nonglutinous types at the *Wx* locus. The neutrality analysis did not reveal signature of selection among the glutinous and nonglutinous rice phenotypes at the *Wx* gene. On the other hand, the *OsC1* gene revealed low level of selection among the colorless apiculus varieties as evident by lower nucleotide diversity in colorless types as compared to the colored apiculus varieties.

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General Introduction

Asian cultivated rice (*Oryza sativa* L.) is one of the most important crops in the world and a major food source for over half of the global human population. Rice consumption data between 1961 and 2005 showed that about 20% of the daily calorie needs of the world population are met by rice (World Rice Statistics 2010). Rice is also the basis of food security in many developing countries and closely associated with cultural traditions and customs in local regions (Lu and Snow 2005). It is grown worldwide in diverse agroclimatic, edaphic and topographic conditions.

O. sativa is considered to have been domesticated from its wild ancestor, *O. rufipogon* by the Asian Neolithic farmers approximately 10,000 years ago (Normile 1997). Since its domestication, cultivated rice may have undergone significant genetic differentiation resulting in the evolution of several ecotypes, subgroups and varieties in various rice growing regions. A major differentiation of *O. sativa* resulted in two partially isolated gene pools referred to *indica* and *japonica*. These two major groups of varieties, also often referred to as subspecies, are distinguished on the basis of a number of morphological, physiological, biochemical and molecular traits (Oka 1988; Vaughan *et al*. 2008; Lu *et al*. 2009). A recent genome-wide study revealed that *indica* was domesticated in South and South East Asia while *japonica* was domesticated in Southern China (Huang *et al.* 2012). Further diversification of the *O. sativa* complex into at least five distinct groups such as *indica, aus, aromatic, temperate japonica*, and *tropical japonica* have also been reported (Garris *et al*. 2005). The combined effects of natural and human induced selection may have played a significant role in genetic differentiation leading to morphological discontinuity, genetic incompatibility and eventually the evolution of different subspecies and diverse varieties (Wang *et al*. 1998). Cultural practices and consumer quality preferences may also have played a significant role in shaping the diversification of rice varieties.

Plant domestication and trait diversity

Domestication refers to a process of selecting wild varieties of organisms with traits preferred by human needs (Darwin 1859). In other words, plant domestication is a process of genetic selection of wild species to meet human needs (Doebley *et al*., 2006). The most important domestication related traits identified so far in rice with significant morphological and physiological modifications are reduction in grain shattering (Konishi *et al*. 2006; Li *et al*. 2006a), changes in grain coloration (Sweeney *et al*. 2006), grain size and shape (Yamanaka *et al*. 2004), grain fragrance and flavor (Bradbury *et al*. 2005), grain number (Ashikari *et al*. 2005), grain weight (Song *et al*. 2007) and grain stickiness (Yamanaka *et al*. 2004). Synchronization of seed maturation, reduction in tiller number, increase in tiller erectness, increase in panicle length and branches, and reduction in awn length are also important traits related to domestication (Bres-Patry *et al*. 2001; Thomson *et al*. 2003; Li *et al*. 2006b; Sang and Ge 2007a).

During the domestication of crop plants, many traits of ecological and economic importance have been selected while others may have been lost. This is because early farmers selected seeds only from what they considered as the 'best' plants, which formed the next generation and much of the genetic diversity in the progenitor was left behind (Doebley *et al*. 2006). Estimates suggest that cultivated rice maintained less than 25% of the genetic diversity found in its wild progenitors, depicting a severe genetic erosion during domestication (Zhu *et al*. 2007). Sakai and Itoh (2010) estimated loss of at least one thousand genes in cultivated *O. sativa* that are still preserved in the genomes of wild relatives. Out of the two major subspecies of rice, *O. sativa* ssp. *indica* is considered to maintain twice as much genetic diversity than *O. sativa* ssp. *japonica*, suggesting that the former had a larger founding population and/or may have been subject to a less severe bottleneck during domestication (Sang and Ge 2007a).

The history of rice domestication

The history of rice domestication is complex and has been reviewed by many authors (e.g. Vaughan *et al*. 2005; Doebley *et al*. 2006; Kovach *et al*. 2007; Sang and Ge 2007b; Izawa 2008, Fuller *et al.* 2010; McCouch *et al.* 2012). The recent archaeobotanical evidence suggests that the process of rice domestication occurred in the Lower Yangtze region of Zhejiang, China (Fuller *et al.* 2009). Phylogeographic studies suggest that *O. sativa* ssp. *indica* was domesticated from wild rice progenitors in a region South of the Himalayan mountain range, likely Eastern India, Myanmar and Thailand, whereas *O. sativa* ssp. *japonica* was domesticated in and around Southern China (Khush 1997; Londo *et al*. 2006). This was further supported by a recent genome-wide study (Huang *et al.* 2012). In general, the geographic region of rice domestication is considered to have started from NE India extending eastward to Nepal, Myanmar and the Southwest corner of China in Yunnan Province (Chang 1976).

Rice diversity in Northeast India

The diversity of traditional rice varieties in the Indian subcontinent is very high suggesting that this region may have played an important role in the domestication process of the crop. For instance, many studies show that the Jeypore tract of Orissa in Eastern India could be considered as a region that played a significant role in domestication of cultivated rice in India (Sampath and Govindaswami 1958; Oka 1964; Govindaswami *et al*. 1966; Akihama and Toshimitsu 1972). Similarly, the diversity of both indigenous varieties and wild relatives of rice is very high in the Eastern Himalayan region of NE India. The NE Indian region consists of seven states namely Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura (Figure 1.1) and covers an area of more than 255,000 sq. km. It is estimated that about 10,000 indigenous rice cultivars of agronomical, ecological and cultural importance are still preserved in NE India (Hore 2005). Such vast rice gene pools may possess many traits of agronomic and ecological significance.

Rice varieties cultivated at higher elevation areas (2,500-3,000 m asl) in the state of Arunachal Pradesh possess morphological features attributable to *O. sativa* ssp. *japonica* such as a globose grain, narrow, dark green and drooping flag leaves and a thin culm (Gupta *et al*. 1995). About 40% of the '*Jum*' (slash and burn agriculture) cultivated rice varieties in Nagaland state show morphological features intermediate between *japonica* and *indica*. Many rice varieties cultivated in Nagaland also show wide variation in grain size and shape, awn characters, glume and kernel color. Soft and sticky rice varieties are abundant in Meghalaya and at least 20 dominant landraces are still cultivated in Garo Hills district of the state. Lowland and deep water rice cultivation is common in Assam with numerous scented, glutinous and colored grain varieties. The state of Mizoram is rich in aromatic and sticky rice as well as a few drought and cold tolerant varieties.

Jum cultivation is the main land use practice in the hill region of NE India (Ramakrishnan 2006). Rice varieties with special adaptations to upland areas are widely cultivated in such agricultural systems with no surface water accumulation. *Jum* rice varieties cultivated in the upland areas of South East Asia are considered as *japonica* type. On the other hand, farmers residing at low-lying flood plains of Assam and adjoining states cultivate different varieties of rice in different seasons. The two major growing seasons of this region are cold and dry seasons (*Boro* type during Nov to May) and hot, humid and rainy seasons (*Sali* type during Jun-Dec). The *Sali* type of varieties grown during the rainy season is the major crop having higher yield, better grain quality and superior agronomic traits. Traditional classification system categorized *Sali* type as typical *indica* type. These are widely cultivated throughout tropical Asia.

The other varieties, commonly known as *Boro* are traditionally cultivated during the winter season (January to April) in low-lying areas where sufficient water is retained during the cold and dry spells of the year. *Boro* rice may have some degree of cold tolerance because of their adaptation for winter conditions. In addition to the cultivated rice, natural populations of many wild rice species such as *Oryza rufipogon*, *O. granulata*, *O. officinalis*, *O. nivara*, *O. meyeriana*, *Hygrorhiza aristata*, *Leersia hexandra* and *Zizenia latifolia* are also found in the northeastern region of India (Hore 2005).

Introduction of agronomically improved varieties, changes in agricultural practices and habitat loss are posing serious threat to the rice gene pool of the region. Therefore, strategic conservation of such genetic resources is urgently needed. A detailed knowledge of the levels of genetic diversity and genetic differentiation among different rice varieties in the Eastern Himalayan region is crucial for planning conservation, management and sustainable use of rice genetic resources in the region.

With this background, my study focused on investigating the population genetic structure of traditionally cultivated indigenous rice varieties in the Eastern Himalayan region of NE India. In Chapter 1, I report the results of a study focused on within and among variety genetic diversity and distribution of genetic diversity among different ecotypes and agronomically improved rice varieties from NE India using SSR markers. In Chapter 2, *indica* and *japonica*-specific insertion or deletion (indel) markers were used to identify the nature of genetic differentiation among different rice varieties or ecotypes in the region. In Chapter 3, I present the results of the analyses of DNA sequence variation of selected trait-specific genes in different phenotypic groups highlighting the nature of polymorphism and signatures of selection.

Chapter 1: Genetic Structure and Diversity of Indigenous Rice (*Oryza sativa*) Varieties in the Eastern Himalayan Region of Northeast India

Abstract: The Eastern Himalayan region of NE India is home to a large number of indigenous rice varieties, which may serve as a valuable genetic resource for future crop improvement to meet the ever-increasing demand for food production. However, these varieties are rapidly being lost due to changes in land-use and agricultural practices, which favor agronomically improved varieties. A detailed understanding of the genetic structure and diversity of indigenous rice varieties is crucial for efficient utilization of rice genetic resources and for developing suitable conservation strategies. To explore the genetic structure and diversity of rice varieties in NE India, I genotyped 300 individuals of 24 indigenous rice varieties representing *Sali*, *Boro*, *Jum* and glutinous types, 5 agronomically improved varieties, and one wild rice species (*O. rufipogon*) using seven SSR markers. A total of 85 alleles and a very high level of gene diversity (0.776) were detected among the indigenous rice varieties of the region. Considerable level of genetic variation was found within indigenous varieties whereas improved varieties were monoporphic across all loci. The comparison of genetic diversity among different types of rice revealed that *Sali* type possessed the highest gene diversity (0.747) followed by *Jum* (0.627), glutinous (0.602) and *Boro* (0.596) types of indigenous rice varieties, while the lowest diversity was detected in agronomically improved varieties (0.459). The AMOVA results showed that 66% of the variation was distributed among varieties indicating a very high level of genetic differentiation in rice varieties in the region. Two major genetically defined clusters corresponding to *indica* and *japonica* groups were detected in rice varieties of the region. Overall, traditionally cultivated indigenous rice varieties in NE India showed high levels of genetic diversity comparable to levels of genetic diversity reported from wild rice populations in various parts of the world. The efforts for conservation of rice germplasm in NE India should consider saving rice varieties representing different types with specific emphasis given to *Sali* and *Jum* types. The protection against the loss of vast genetic diversity found in indigenous rice varieties in NE India is crucial for maintaining future food security in the changing world.

Keywords: Conservation; Eastern Himalaya; Genetic diversity; Genetic structure; Indigenous rice varieties; NE India.

Introduction

The Asian cultivated rice (*Oryza sativa* L.) is one of the most important crops and a major food source for more than half of the global human population. Phylogeographical and archeological evidence suggest that rice was domesticated over 10000 years ago from its wild ancestor *O. rufipogon* in the region south of the Himalayan mountain range, likely in the present day Eastern and NE India, extending Eastward to Nepal, Myanmar and Thailand to Southern China (Chang 1976; Khush 1997; Londo *et al*. 2006). A recent study suggests that one of the two subspecies of Asian rice, *O. sativa* ssp. *indica* was domesticated in Southeast and South Asia while the other subspecies, *O. sativa* ssp. *japonica* was domesticated in Southern China (Huang *et al*. 2012). During the domestication process, individuals with desirable traits have been selected leaving most of the genetic diversity behind in the progenitors (Doebley *et al*. 2006). Zhu *et al*. (2007) estimated that the cultivated rice contains only about 25% of the genetic diversity found in its wild progenitors depicting severe genetic erosion during domestication. Furthermore, a considerable level of genetic diversity was lost during the agronomic improvement of commonly cultivated rice.

Studies have shown that indigenous crop varieties traditionally cultivated and maintained by farmers contain high levels of genetic diversity and can serve as potential genetic resources for improving yield, resistance to pests and pathogens, and agronomic performance (Brush 1995; Hoisington *et al*. 1999; Mandel *et al*. 2011). The Eastern Himalayan region of NE India, a geographical area of over 255,000 km^2 consisting of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura states (Figure 1.1), is home to a large number of indigenous rice varieties. These varieties are

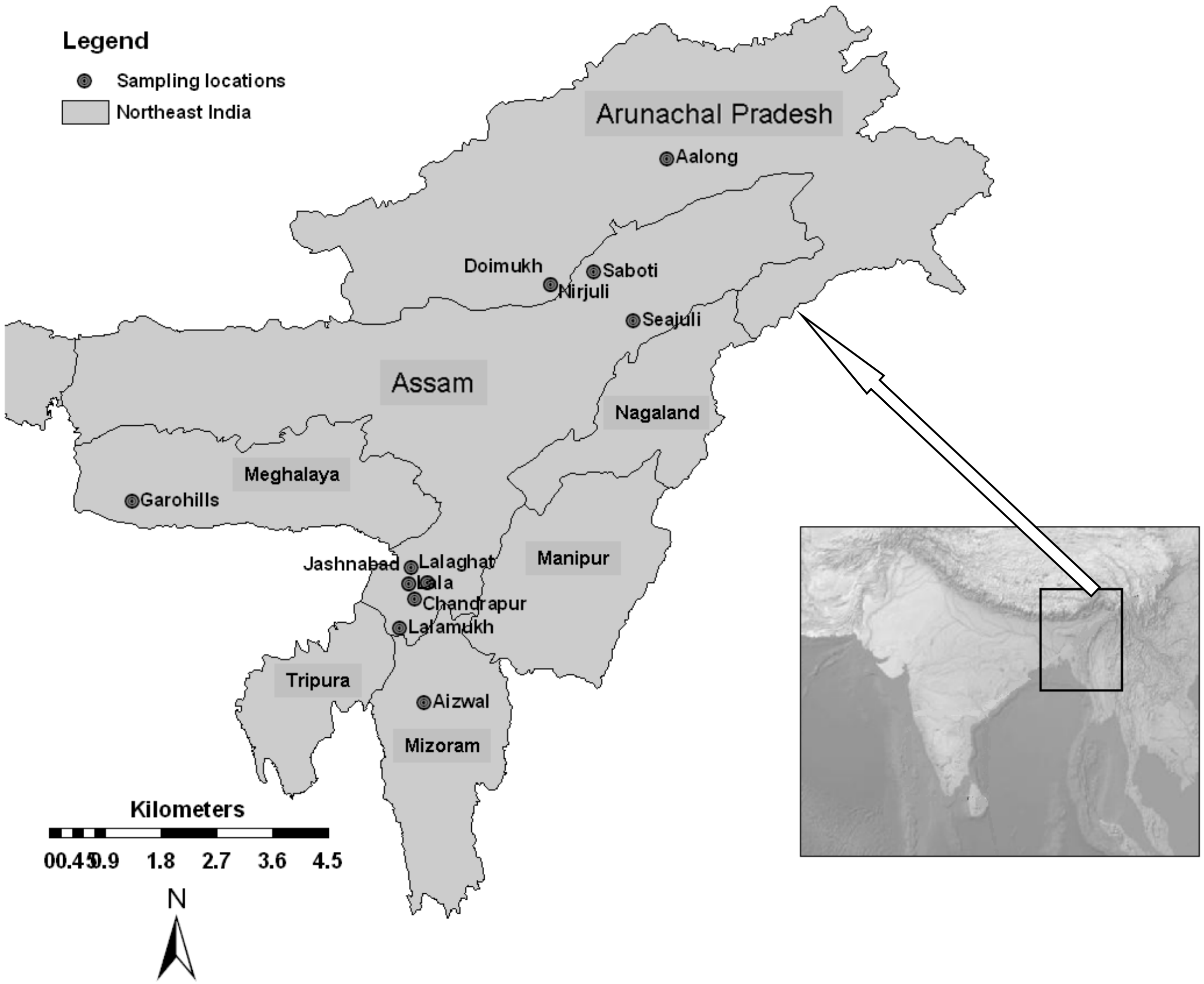

Figure 1.1: Map of northeast India showing sampling sites of traditionally cultivated indigenous rice varieties.

cultivated in diverse topographic and agroclimatic conditions, and normally classified into different types based on the season of cultivation, habitat conditions and the grain quality.

The *Sali* type, which comprises majority of rice varieties of the region is cultivated in low-lying flood plains of NE India, mainly in the Brahmaputra and Barak Valley regions. The *Boro* type is traditionally cultivated during the winter months (November through May) in low-lying areas where sufficient water is available during the cold and dry months of the year. Thus, *Boro* type rice varieties may contain genotypes suitable for cold adaptation. The dryland cultivated rice varieties, normally grown in slash and burn agriculture system, and locally known as *Jum* type, show adaptations to a wide range of ecological conditions including low levels of soil moisture in areas at high altitudes reaching over 3000 m above sea level. The glutinous grain type rice is commonly cultivated throughout the region as a source of grain for breakfast and dessert for many ethnic communities in the region. Figure 1.2 shows variation in grain morphology of representative varieties included in this study. In addition to cultivated indigenous rice varieties, natural populations of many wild rice species including *O. rufipogon*, *O. granulata*, *O. officinalis*, *O. nivara*, *O. meyeriana*, *Hygrorhizaaristata*, *Leersiahexandra* and *Zizenialatifolia* are also found in the northeastern region of India (Hore 2005).

The indigenous rice varieties cultivated by traditional farmers may contain a considerable genetic diversity that can serve as a source of germplasm for genetic improvements of cultivated varieties of rice. In general, diverse landraces traditionally cultivated by farmers around the centers of diversity and domestication of crops are

Figure 1.2: Variation in grain morphology of a few representative varieties included in this study. A, *Bherapawa*; B, *Lallatoi*; C, *Guaroi*; D, *Joha*; E, *Hatihali*; F, *Tilbora*.

considered as key natural resources (Pusadee *et al*. 2009) important for maintaining the future food security in light of the changing climate. Although a few studies have examined the population genetic structure of *O. sativa* germplasm at a global scale (Glaszmann 1987; Garris *et al*. 2005), region specific studies are limited. Earlier studies based on morphology and agronomic traits (Vairavan *et al*. 1973; Borkakati *et al*. 2000; Sarma and Pattanayak 2009) as well as molecular markers (isozyme, RAPD, ISSR) demonstrated a high level of genetic diversity among indigenous rice varieties in NE India (Glaszmann *et al*. 1989; Sarma and Bahar 2005; Bhuyan *et al*. 2007). However, these studies were limited either to a particular group of varieties (*e.g.* glutinous rice and lowland varieties) or to a narrow geographic region. In particular, no extensive studies have focused on the genetic structure of some of the widely cultivated indigenous types such as *Boro* (cultivated in low-lying perennial water bodies during winter season), *Jum* (cultivated in upland areas in hill-slopes and low soil moisture condition), *Sali* (most widely cultivated rice during monsoon season) and glutinous (sticky rice with cultural importance) covering the wider geographic area.

The ongoing rapid changes in agricultural practices that favor agronomically improved varieties has become a serious threat for the persistence of indigenous rice varieties in NE India. Thus, conservation and management strategies are urgently needed to prevent further loss of genetic diversity inherent to indigenous rice varieties in the region. A detailed understanding of the genetic structure and diversity is needed for the planning and implementation of effective conservation, management and utilization of rice germplasm in the whole region.

The objectives of Chapter 1 are to (a) assess genetic diversity among indigenous rice varieties in the Eastern Himalayan region of the NE India, (b) compare the genetic diversity in indigenous varieties with agronomically improved varieties (c) assess distribution of genetic diversity among different types and (d) infer the population genetic structure of rice varieties in NE India.

Materials and methods

Plant samples

A total of 29 varieties of cultivated rice (*Oryza sativa*) were collected from various regions of NE India (Figure 1.1). These samples included 24 indigenous varieties representing *Sali* (12), *Jum* (4), *Boro* (3), and glutinous (5) types and 5 agronomically improved varieties. The variety name, type and locality are given in Table 1.1. Wild rice (*O. rufipogon*) accessions originally collected from Eastern India were obtained from the International Rice Research Institute (IRRI), Philippines. Either grains or fresh leaf samples were collected from the field and morphological characters were noted based on direct observation or interviewing the farmers. The agronomically improved varieties, released by the regional and central rice research institutes and widely cultivated for their higher yield were obtained from farmers of the region. Seeds were germinated in Petri dishes and transferred to small pots and grown in a greenhouse. Leaf samples from seedlings were harvested, air dried, and used for the study. Genomic DNA was extracted following a modified cetyltrimethyl ammonium bromide extraction protocol (Doyle and Doyle 1987; Dayanandan *et. al.* 1997).

Table 1.1: Cultivation type, location and genetic diversity values of traditionally cultivated indigenous and agronomically improved rice varieties including the wild rice (*O. rufipogon*) in northeast India (AP, Arunachal Pradesh; AS, Assam, ML, Meghalaya, MZ, Mizoram)

Variety Name	Ecotype	Location	A	Na	Npo	Npe	R_A	*I*	H_e
Lahi	*Sali*	Doimukh (AP)	11	1.571	3	42.86	1	0.271	0.187
Local Basmati	*Sali*	Doimukh (AP)	9	1.286	2	28.57	-	0.148	0.105
Borjahinga	*Sali*	N. Lakhimpur, (AS)	10	1.429	2	28.57	-	0.187	0.130
Joha	*Sali*	Doimukh (AP)	8	1.143	1	14.29	-	0.096	0.076
Hati Hali	*Sali*	N. Lakhimpur, (AS)	13	1.857	5	71.43	1	0.377	0.263
Balam	*Sali*	Cachar (AS)	12	1.714	3	42.86	-	0.328	0.222
Lallatoi	*Sali*	Hailakandi (AS)	23	3.286	6	85.71	4	0.854	0.498
Arfa	*Sali*	Hailakandi (AS)	13	1.857	4	57.14	1	0.438	0.305
Mulahail	*Sali*	Hailakandi (AS)	20	2.857	5	71.43	1	0.719	0.435
Guaroi	*Sali*	Hailakandi (AS)	13	1.857	5	71.43	-	0.330	0.219
Harinarayan	*Sali*	Hailakandi (AS)	11	1.571	3	42.86	-	0.262	0.166
Bherapawa	*Sali*	Hailakandi (AS)	8	1.143	1	14.29	-	0.072	0.051
Papue	*Jum*	West Siang (AP)	9	1.286	2	28.57	-	0.143	0.105
Sorpuma	*Jum*	Doimukh (AP)	10	1.429	3	42.86	-	0.239	0.181
Kawanglawang	*Jum*	Aizwal, (MZ)	17	2.429	6	85.71	1	0.578	0.365
Mimutim	*Jum*	Garo Hills (ML)	17	2.429	5	71.43	3	0.595	0.384
Til Bora	Glutinous	N. Lakhimpur, (AS)	12	1.714	5	71.43	-	0.237	0.152
Kakiberoin	Glutinous	Hailakandi (AS)	12	1.714	4	57.14	-	0.306	0.207
Borua Beroin	Glutinous	Cachar (AS)	14	2.000	4	57.14	-	0.357	0.224
Ranga Borah	Glutinous	N. Lakhimpur, (AS)	13	1.857	3	42.86	1	0.239	0.135
Bas Beroin	Glutinous	Cachar (AS)	10	1.429	3	42.86	-	0.288	0.228
Aubalam	*Boro*	Cachar (AS)	15	2.143	5	71.43	1	0.569	0.394
Bashful	*Boro*	Cachar (AS)	11	1.571	3	42.86	-	0.315	0.232
Moircha	*Boro*	Cachar (AS)	11	1.571	3	42.86	-	0.167	0.098
Ranjit	Improved	Hailakandi (AS)	7	1	0	0	-	0	0.000
IR8	Improved	Hailakandi (AS)	7	1	0	0	-	0	0.000
Bahadur	Improved	Hailakandi (AS)	7	1	0	0	-	0	0.000
Pankaj	Improved	Hailakandi (AS)	7	1	0	0	-	0	0.000
Joya	Improved	Hailakandi (AS)	7	1	0	0	-	0	0.000
O. rufipogon	Wild	Eastern India	29	4.833	6	85.71	4	1.137	0.556

A = Observed no. of allele; Na = Average no. of alleles per 7 loci; Npo = No. of polymorphic loci; Npe = Percent polymorphic loci; R_A = Rare allele; I = Shannon information index; *H*e = Nei gene diversity.

PCR assay and genotyping

Seven SSR loci (RM302, RM341, RM130, RM307, RM169, RM204, RM264) with relatively high polymorphism and distributed across the rice genome were selected for the genetic diversity analyses (Table 1.2) (Chen *et al*. 1997; Temnykh *et al*. 2000). The forward primers were labeled with IRD700 or IRD800 dye for genotyping in LI-COR 4000 IR2 DNA analyzer (Li-Cor Biosciences, Lincoln, NE). The PCR amplifications were performed in 25 μL reaction mixture consisting of 0.2 mM dNTP, 2.5 mM $MgCl_2$, 2.5 μL of 10X buffer, 2.5 pmol of each primer and 0.2 U *Taq* polymerase. The thermocycling profile used was initial denaturation at 94° (3 min) followed by 35 cycles of 94° (2 min), 50° (1 min), 72° (2 min) and a final extension of 72° for 5 min. The amplified products were diluted (1:50) with loading dye (Formamide and Bromophenol blue), denatured at 94°C for 5 min and cooled on ice before loading to 6.0% denaturing polyacrylamide gels on a Li-COR automated DNA sequencer with a size standard (50-350 bp, IRDye700 or IRDye800) (Li-Cor Biosciences).

The size of each amplified fragment was determined by comparison with the size standard and scored to prepare the genotype matrix. To determine the optimum number of individuals per variety to be genotyped to capture the total diversity, the number of individuals analyzed were increased one by one until the number of alleles reached to a maximum with no further increase for a given locus. Figure 1.3 represents the correlation between the number of alleles detected with increasing number of individuals at the SSR locus RM302. Therefore, 300 individuals were genotyped at seven SSR loci for this study. Accordingly, I determined that 10 individuals per variety was sufficient to capture

Table 1.2: Details of SSR loci used in the present study and their genetic diversity parameters.

Primer name	Chr	SSR motif	Forward 5-3	Reverse 5-3	*N*a	H_e
RM302	1	(GT)30(AT)8	TCATGTCATCTACCATCACAC	ATGGAGAAGATGGAATACTTGC	10	0.805
RM341	2	(CTT)20	CAAGAAACCTCAATCCGAGC	CTCCTCCCGATCCCAATC	19	0.861
RM130	3	(GA)10	TGTTGCTTGCCCTCACGCGAAG	GGTCGCGTGCTTGGTTTGGTTC	4	0.419
RM307	4	(AT)14(GT)21	GTACTACCGACCTACCGTTCAC	CTGCTATGCATGAACTGCTC	9	0.749
RM169	5	(GA)12	TGGCTGGCTCCGTGGGTAGCTG	TCCCGTTGCCGTTCATCCCTCC	14	0.798
RM204	6	CT)44	GTGACTGACTTGGTCATAGGG	GCTAGCCATGCTCTCGTACC	18	0.866
RM264	8	(GA)27	GTTGCGTCCTACTGCTACTTC	GATCCGTGTCGATGATTAGC	21	0.884

Chr, Chromosome location; *N*a, Observed number of alleles; H_e, Nei (1973) genetic diversity.

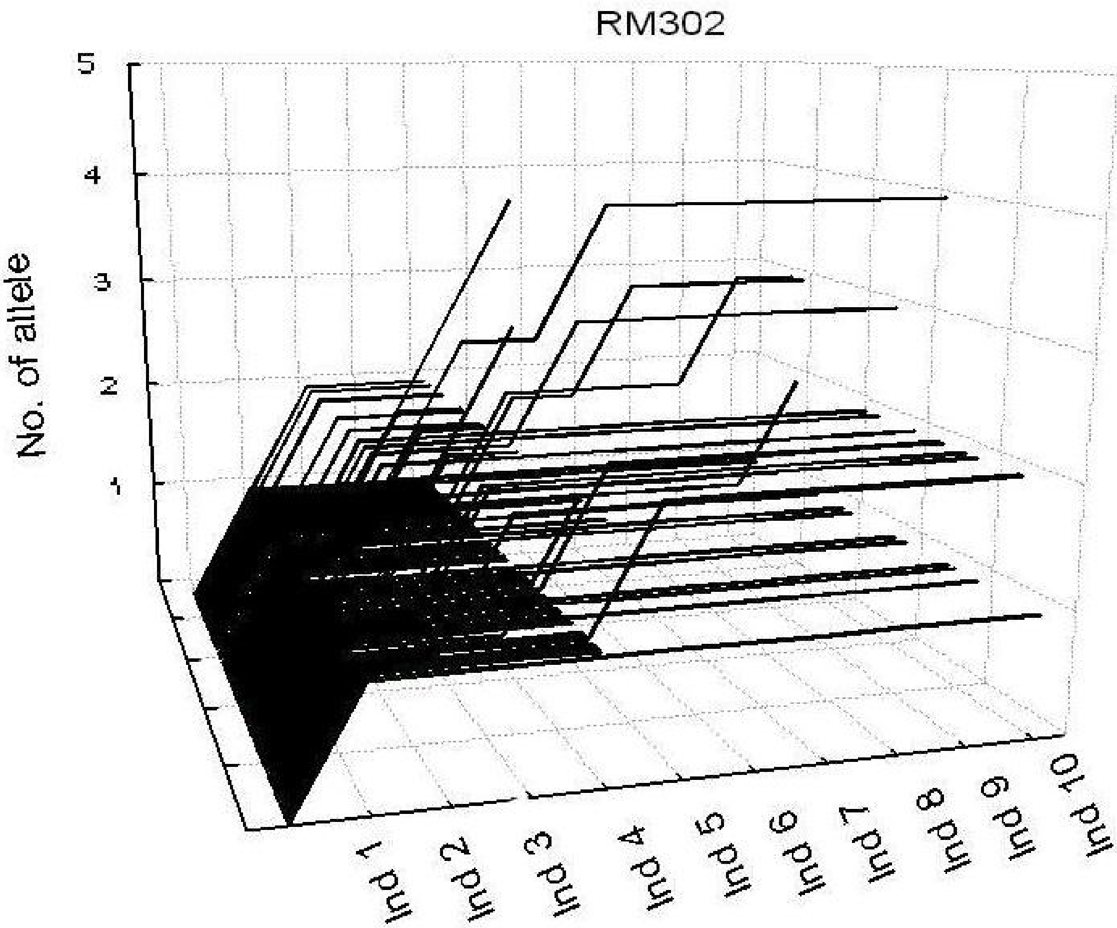

Figure 1.3: Graph showing number of genotyped individuals and corresponding numbers of alleles at the locus RM302.

the total genetic variation in a given variety. Therefore, I genotyped 300 individuals (10 individuals per variety for 30 varieties) at seven SSR loci for the present study.

Data analysis

The SSR genotype data matrix was used for assessing genetic diversity and structure in a hierarchical manner from overall (all indigenous varieties), through different types, and each variety. The among type genetic diversity was calculated by considering all genotyped individuals of a given type as one population while genetic parameters for among variety was calculated based on 10 genotyped individuals per variety. The observed average number of alleles per locus (Na), average allelic richness (R_S), population differentiation (F_{ST}) and Nei gene diversity (He) (Nei 1973) were calculated using FSTAT 2.9.2.3 (Goudet 2001). Allelic richness is the number of alleles for each population averaged over loci and standardized for the smallest population size. Average effective number of alleles (Ne) and Shannon information index (I) were calculated using PopGene version 1.31 (Yeh *et al*. 1999). Average pairwise genetic differences between varieties was calculated using Arlequin 3.5 (Excoffier *et al*. 2010). Analysis of Molecular Variance (AMOVA) (Excoffier *et al*. 1992) within variety, among variety and among types was performed in Arlequin 3.5 (Excoffier *et al*. 2010) to determine the distribution of variation at different hierarchical levels. The statistical significance of the variance components was tested with 1000 permutations.

Genetic distance among varieties were estimated using chord genetic distance method (Cavalli-Sforza and Edwards 1967). The genetic distance based clustering was performed with the unweighted pairgroup method with arithmetic mean (UPGMA) using

PowerMarker v3.25 (Liu and Muse 2005), and the dendrogram was constructed using MEGA software (Kumar *et al*. 2001). Principal component analysis (PCA) of pairwise genetic distance between individuals was performed using GenALEx v. 6.4 (Peakall and Smouse 2006). The Bayesian model-based clustering analysis was used for determining the optimal number of genetic clusters found among rice varieties using the software STRUCTURE 2.3.3 (Pritchard *et al*. 2000), which partitions individuals into number of clusters (*K*) based on the multilocus genotypic data. The admixture model and correlated allele frequencies were applied for each run with 10,000 burn-in period (iteration) and 100,000 Markov Chain Monte Carlo (MCMC) replication. The optimum *K* value, which indicates the number of genetically distinct clusters in the data, was determined from 10 replicate runs for each value of *K* (Evanno *et al*. 2005). The ΔK was based on the change in the log probability of the data between successive *K* values. Software program Structure Harvester v6.0 (Earl and von Holdt, 2012) was used for calculating parameters of Evanno *et al*. (2005). The results of five independent runs were consistently converged to the same values.

Results

Overall microsatellite diversity

The seven selected SSR loci amplified DNA fragments from 29 *O. sativa* varieties and *O. rufipogon* with consistent reproducibility. A total of 96 alleles with an average of 13.57 alleles per locus were detected among all studied samples. The highest number of alleles (21) was detected in the locus RM264 and the lowest (4) was in the locus RM130. The indigenous rice varieties were genetically variable, while agronomically improved varieties were monomorphic within varieties at all loci. The highest gene diversity value of 0.884 was detected at RM264 and the lowest value of 0.419 detected in RM130 (Table 1.2).

Indigenous rice varieties in NE India showed high level of genetic diversity with an overall allelic richness of 10.205 per locus and a gene diversity value of 0.776, while the agronomically improved varieties had significantly lower average allelic richness of 2.857 per locus and gene diversity was 0.459. A very high level of differentiation (F_{ST} = 0.754) was also detected among the rice varieties.

Within variety genetic diversity

The average observed number of alleles among indigenous rice varieties ranged from 1.14 (*Joha* and *Bherapawa*) to 3.29 (*Lallatoi*) while the corresponding value was only 1.00 for the agronomically improved varieties. Some of the elite traditional rice varieties (including *Lallatoi*, *Mulahail*, *Aubalam*, *Mimutim*) showed very high levels of genetic diversity as measured in average numbers of alleles, rare alleles and Nei gene diversity. Two of these varieties exhibited relatively high numbers of rare alleles (*Lallatoi* = 4; *Mimutim* = 3). Nei's gene diversity values ranged from 0.051 (*Bherapawa*) to 0.498 (*Lallatoi*) with an average of 0.223 across all indigenous varieties. Shannon information content varied widely across varieties from 0.072 (*Bherapawa*) to 0.854 (*Lallatoi*) and the average was 0.338 across varieties. The diversity parameters across varieties are presented in Table 1.1. The pairwise genetic differentiation among varieties (F_{ST}) ranged from 0.375 to 1.000 and highly significant (p<0.001). The pairwise F_{ST} values are given in Table 1.3.

Table 1.3: Pairwise F_{ST} values among different rice varieties of eastern Himalayan region in northeast India and *O. rufipogon*

	Papue	Sorpuma	Kawanglawang	Mimutim	Lahi	Local Basmati	Borjahinga	Joha	Hati Hali	Balam	Lal-latoi	Arfa	Mulahail	Guaroi	Harinarayan
Papue	0.000														
Sorpuma	0.634	0.000													
Kawanglawang	0.703	0.581	0.000												
Mimutim	0.633	0.690	0.739	0.000											
Lahi	0.789	0.691	0.543	0.830	0.000										
Local Basmati	0.834	0.726	0.714	0.887	0.831	0.000									
Borjahinga	0.789	0.684	0.754	0.771	0.843	0.870	0.000								
Joha	0.742	0.731	0.658	0.867	0.746	0.875	0.884	0.000							
Hati Hali	0.622	0.656	0.585	0.709	0.651	0.818	0.763	0.663	0.000						
Balam	0.758	0.668	0.713	0.807	0.806	0.819	0.797	0.859	0.770	0.000					
Lal-latoi	0.594	0.519	0.582	0.655	0.674	0.610	0.566	0.720	0.603	0.598	0.000				
Arfa	0.724	0.608	0.595	0.772	0.667	0.742	0.766	0.742	0.679	0.718	0.545	0.000			
Mulahail	0.573	0.529	0.542	0.564	0.603	0.658	0.585	0.680	0.558	0.617	0.393	0.488	0.000		
Guaroi	0.781	0.657	0.615	0.843	0.681	0.791	0.830	0.730	0.718	0.788	0.610	0.621	0.640	0.000	
Harinarayan	0.837	0.746	0.709	0.880	0.785	0.864	0.859	0.855	0.735	0.827	0.678	0.739	0.672	0.719	0.000
Bherapawa	0.884	0.778	0.706	0.925	0.792	0.896	0.914	0.883	0.800	0.871	0.728	0.681	0.719	0.737	0.830
Aubalam	0.635	0.571	0.628	0.706	0.725	0.721	0.710	0.777	0.689	0.425	0.430	0.600	0.502	0.703	0.740
Bashful	0.772	0.612	0.667	0.817	0.802	0.817	0.760	0.854	0.743	0.726	0.504	0.704	0.571	0.782	0.822
Moircha	0.844	0.743	0.767	0.869	0.863	0.871	0.826	0.916	0.811	0.783	0.611	0.783	0.593	0.847	0.887
Til Bora	0.698	0.677	0.738	0.802	0.831	0.831	0.804	0.863	0.731	0.789	0.537	0.751	0.652	0.815	0.856
Kakiberoin	0.711	0.679	0.674	0.798	0.748	0.797	0.804	0.838	0.704	0.763	0.490	0.698	0.536	0.780	0.830
Borua Beroin	0.652	0.615	0.707	0.757	0.797	0.822	0.793	0.831	0.731	0.649	0.543	0.721	0.566	0.797	0.831
Ranga Borah	0.779	0.602	0.740	0.805	0.837	0.864	0.727	0.878	0.754	0.778	0.555	0.756	0.567	0.824	0.862
Bas Beroin	0.724	0.665	0.694	0.741	0.762	0.766	0.757	0.826	0.735	0.721	0.469	0.645	0.466	0.735	0.818
Ranjit	0.842	0.758	0.810	0.880	0.906	0.928	0.840	0.953	0.806	0.869	0.607	0.832	0.702	0.892	0.932
IR8	0.864	0.795	0.810	0.932	0.909	0.940	0.926	0.961	0.856	0.843	0.633	0.829	0.742	0.892	0.933
Bahadur	0.884	0.783	0.805	0.913	0.894	0.884	0.865	0.950	0.849	0.857	0.501	0.822	0.693	0.872	0.921
Pankaj	0.780	0.695	0.724	0.824	0.818	0.694	0.761	0.858	0.757	0.766	0.375	0.731	0.570	0.786	0.831
Joya	0.864	0.802	0.798	0.915	0.896	0.935	0.900	0.958	0.838	0.853	0.641	0.826	0.588	0.895	0.935
O. rufipogon	0.635	0.537	0.548	0.682	0.644	0.677	0.623	0.698	0.570	0.561	0.418	0.573	0.444	0.621	0.656

	Harinarayan	Bherapawa	Aubalam	Bashful	Moircha	Til Bora	Kakiberoin	Borua Beroin	Ranga Borah	Bas Beroin	Ranjit	IR8	Bahadur	Pankaj	Joya	O. rufipogon
Papue																
Sorpuma																
Kawanglawang																
Mimutim																
Lahi																
Local Basmati																
Borjahinga																
Joha																
Hati Hali																
Balam																
Lal-latoi																
Arfa																
Mulahail																
Guaroi																
Harinarayan	0.000															
Bherapawa	0.830	0.000														
Aubalam	0.740	0.789	0.000													
Bashful	0.822	0.866	0.644	0.000												
Moircha	0.887	0.929	0.720	0.739	0.000											
Til Bora	0.856	0.901	0.639	0.779	0.830	0.000										
Kakiberoin	0.830	0.848	0.645	0.750	0.824	0.743	0.000									
Borua Beroin	0.831	0.884	0.570	0.741	0.805	0.725	0.739	0.000								
Ranga Borah	0.862	0.909	0.682	0.715	0.808	0.793	0.796	0.782	0.000							
Bas Beroin	0.818	0.846	0.619	0.727	0.749	0.749	0.657	0.741	0.736	0.000						
Ranjit	0.932	0.975	0.753	0.840	0.917	0.738	0.878	0.857	0.876	0.848	0.000					
IR8	0.933	0.975	0.665	0.868	0.943	0.840	0.863	0.878	0.918	0.860	1.000	0.000				
Bahadur	0.921	0.962	0.741	0.827	0.898	0.836	0.841	0.859	0.884	0.797	0.953	0.980	0.000			
Pankaj	0.831	0.875	0.645	0.722	0.775	0.695	0.731	0.712	0.772	0.670	0.761	0.871	0.602	0.000		
Joya	0.935	0.976	0.710	0.846	0.919	0.895	0.829	0.890	0.885	0.789	1.000	1.000	0.981	0.849	0.000	
O. rufipogon	0.656	0.709	0.499	0.566	0.643	0.639	0.616	0.625	0.554	0.576	0.687	0.724	0.683	0.582	0.684	0.000

Significance level: $p<0.0001$

Genetic diversity among types

Different levels of genetic variation were observed in different types of indigenous rice from NE India. The highest diversity was detected among the *Sali* type with an average allelic richness and gene diversity of 7.585 (±3.604) and 0.747 (±0.127) respectively. The next level of genetic diversity was detected among the *Jum* type followed by the glutinous and *Boro* types (Table 1.4). On the other hand, agronomically improved types showed the lowest levels of diversity (average allelic richness 2.798±1.438; average gene diversity 0.459±0.251). All types showed very high inbreeding coefficient ranging from 0.936 to 1.000, which could be attributable to the selfing mating system of the cultivated rice. Among indigenous rice varieties, the highest average gene diversity within type ($H_{S(W)}$) was observed in *Jum* (0.259) and the lowest was in glutinous type (0.189). Population differentiation study within different types showed very low F_{ST} values ranging from 0.023 in *Sali* type to 0.036 in *Boro* type (Table 1.4). The AMOVA results showed statistically significant differentiation ($p<0.001$) with 25% variation among individuals, 66% among varieties and 9% among cultivation types (Table 1.5).

Genetic structure analysis

The UPGMA clustering based on chord genetic distance grouped rice varieties into two distinct groups (Figure 1.4). The Group-I in the UPGMA tree consists of both indigenous and the agronomically improved varieties. All agronomically improved varieties clustered within Group-I which could be considered as *indica* subspecies.

Table 1.4: Population structure and F-statistics of different types of indigenous and agronomically improved rice varieties in NE India

Type	Allelic richness	Gene diversity	Inbreeding coefficient	$H_{S(W)}$	$F_{ST(W)}$
Sali	7.585 (3.604)	0.747 (0.127)	0.984	0.222	0.023
Jum	5.056 (3.061)	0.627 (0.187)	1.000	0.259	0.032
Glutinous	4.727 (1.901)	0.602 (0.261)	0.936	0.189	0.029
Boro	3.857 (1.864)	0.596 (0.280)	0.980	0.241	0.036
Improved	2.798 (1.438)	0.459 (0.251)	1.000	0	0.029

Allelic richness is based on minimum sample size of 30 diploid individuals. $H_{S(W)}$ = average genetic diversity within type; $F_{ST(W)}$ = genetic differentiation within type. Values in parenthesis represent standard deviation.

Table 1.5: Analysis of molecular variance (AMOVA) based on 7 SSR loci of traditional and agronomically improved rice varieties in northeast India

Amova analysis	df	SS	MS	% of variation	P-value
Among type	4	294.45	129.78	8	>0.001
Among varieties	24	912.96	76.54	66	>0.001
Within varieties	270	366.05	2.80	26	>0.001

df, degree of freedom; SS, sum of square; MS, Means of square.

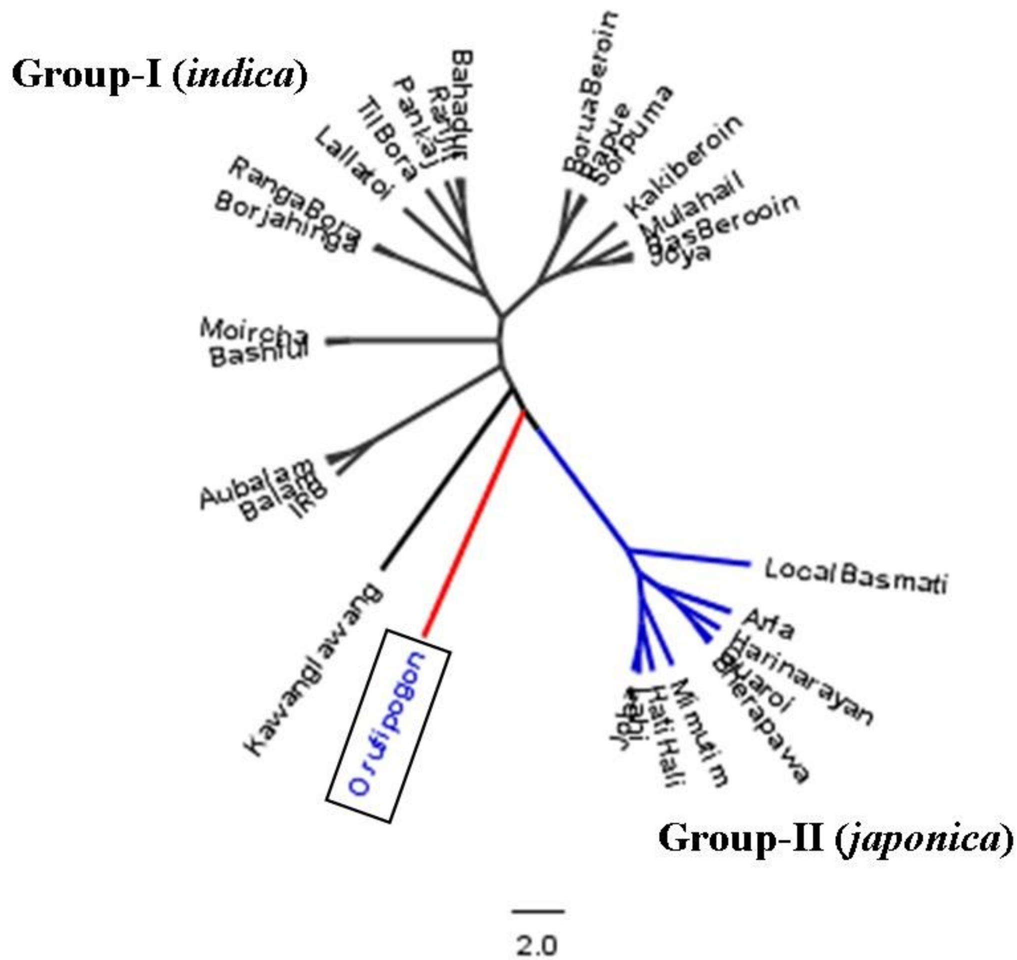

Figure 1.4: UPGMA tree based on chord genetic distance (Cavalli-Sforza and Edwards 1967) showing genetic relationships among 29 rice varieties in northeast India.

The other group (Group-II) consisted of a few indigenous varieties belonging to *Sali* and *Jum* types and could be considered as the *japonica* subspecies. *O. rufipogon* accessions appeared intermediate between *indica* and *japonica* groups (Figure 1.4). This analysis revealed that 62.5% of the traditional rice varieties in Eastern Himalayan region of NE India are of subspecies *indica* while 37.5% are *japonica* subspecies.

The UPGMA tree revealed that rice varieties clustered into smaller subgroups based on type, grain quality or geographic origin. For example, *Boro*, *Jum*, glutinous, and agronomically improved varieties clustered together into smaller sub-groups within Group-I (*indica*) while the Group-II (*japonica*) formed two sub-groups corresponding the geographic locations (Figure 1.5). A few sub-groups and varieties (marked with double asterisk), however, did not cluster with respective types or grain quality (Figure 1.5).

The PCA analysis using pairwise genetic distances revealed that the first three principal components explained 59.91% of the total variation and showed similar clustering of rice varieties into Group-I (*indica*) and Group-II (*japonica*) (Figure 1.6). Three of the agronomically improved varieties (*Pankaj*, *Bahadur* and *Ranjit*) formed a distinct group but showed closer affinity to the Group-I (*indica*). *O. rufipogon* accessions showed intermediate position between the two groups (Figure 1.5) similar to clustering in the UPGMA tree.

The Bayesian based analysis of population structure showed that the highest log likelihood is at $K = 2$ (Figure 1.7) suggesting two major groups corresponding to two distinct clusters. Individual assignments into two clusters revealed that Group-I (green color, Figure 1.8) consists of 34% of varieties and include subspecies *japonica* with

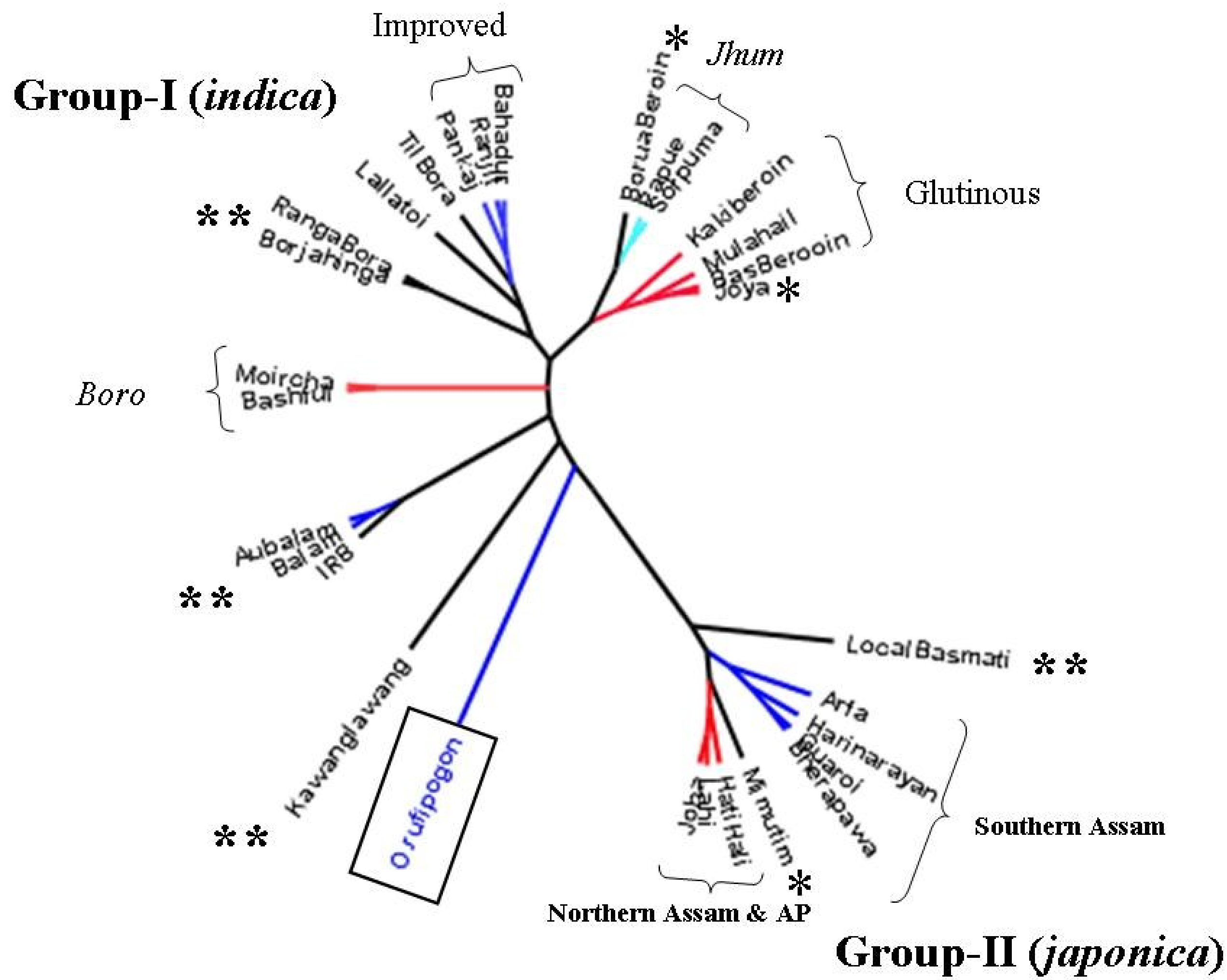

Figure 1.5: Sub-groups of rice varieties within group-I (*indica*) and group-II (*japonica*) based on cultivation type, grain characteristics and geographic origin.

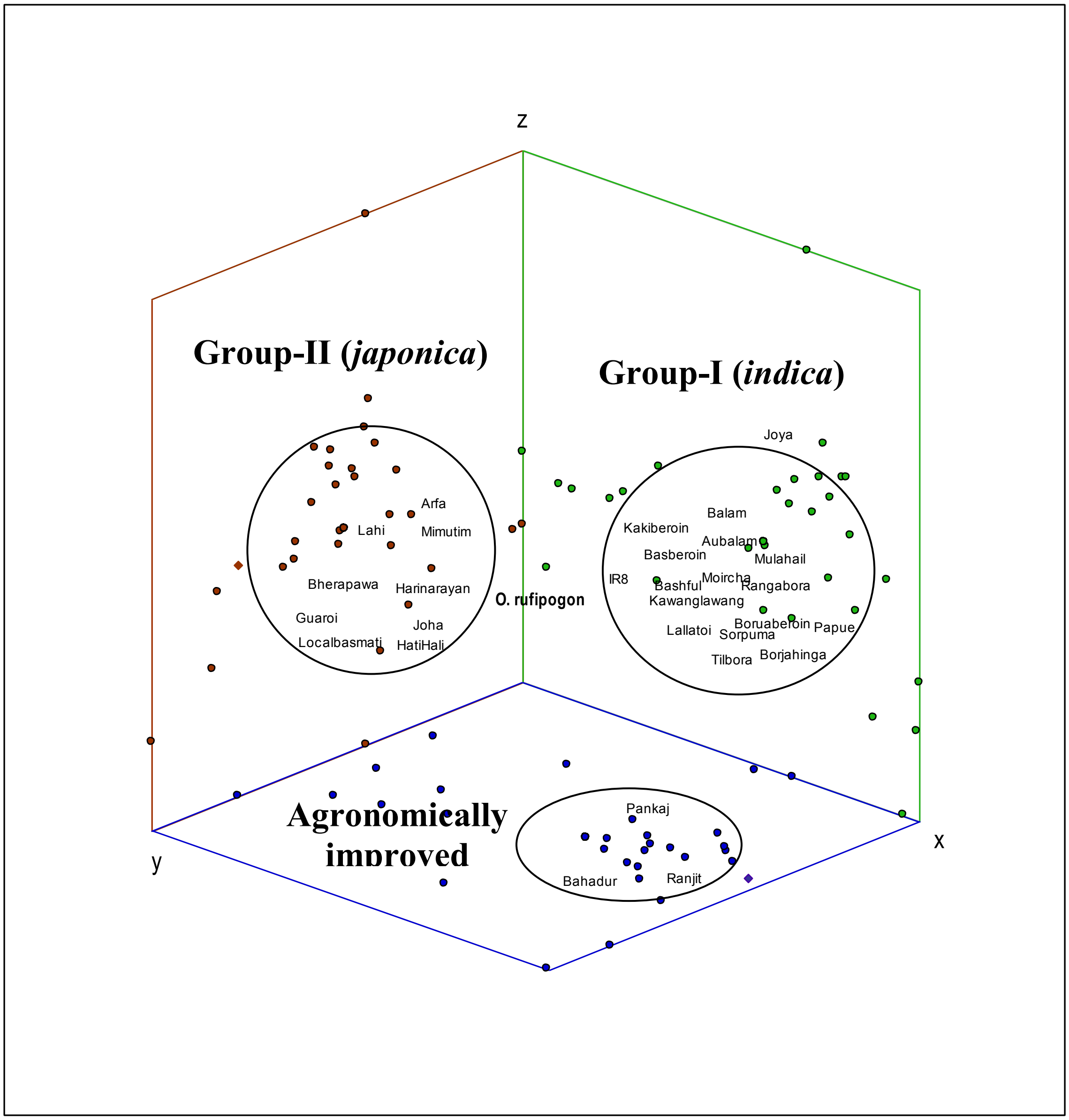

Figure 1.6: Principal component analysis of indigenous and agronomically improved rice varieties based on 7 SSR loci. Different varieties grouped together corresponding to two subspecies (*indica* and *japonica*).

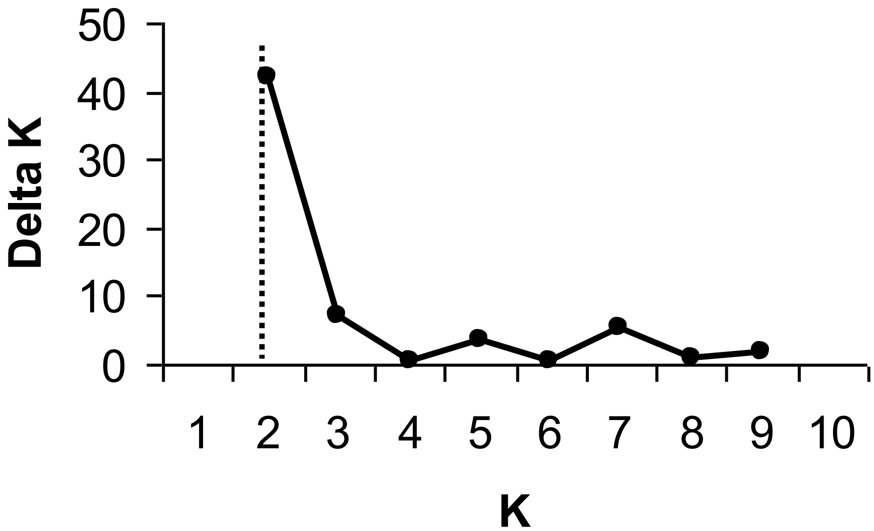

Figure 1.7: The relationship between ΔK and K showing the highest value at K = 2.

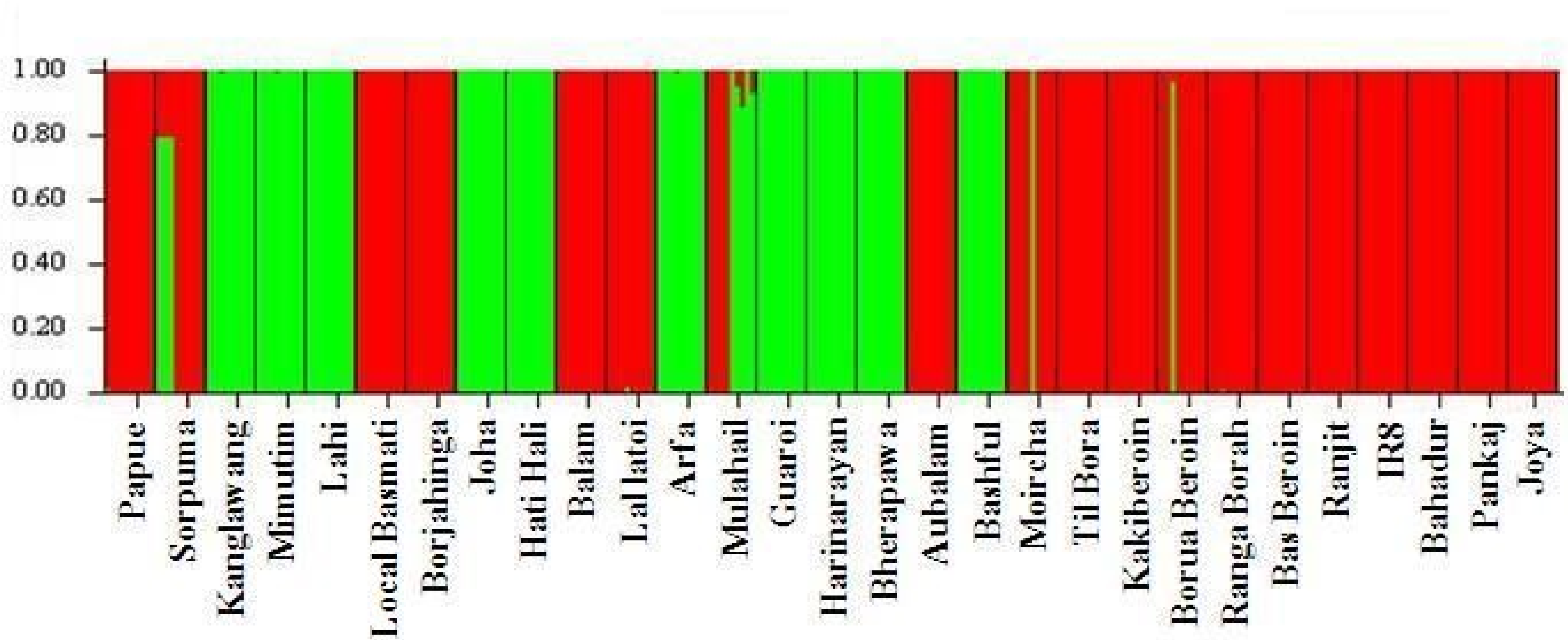

Figure 1.8: Population structure of traditionally cultivated indigenous and agronomically improved rice varieties in the Eastern Himalayan region. The optimal value of K = 2.

more than 95% ancestry. The other 52% of varieties including agronomically improved accessions formed Group-II (red color, Figure 1.8) corresponding to the subspecies *indica* with more than 95% ancestry. However, 14% of the indigenous varieties showed mixed ancestry of both *indica* and *japonica* types.

The comparison of STRUCTURE results with UPGMA and PCA results revealed that three varieties (*Kawanglawang*, *Local Basmati* and *Bashful*; varieties 3, 6, and 18 marked with asterisk; Figure 1.9a) interchanged between Group-I (*indica*) and Group-II (*japonica*). However, independent STRUCTURE runs without agronomically improved varieties grouped these varieties into the groups concordant with UPGMA and PCA analyses (Figure 1.9b). Thus, it could be concluded that the results of model based STRUCTURE analysis is in agreement with the UPGMA and PCA based clustering, and grouping of rice varieties is consistent with the classification of *indica* and *japonica* types.

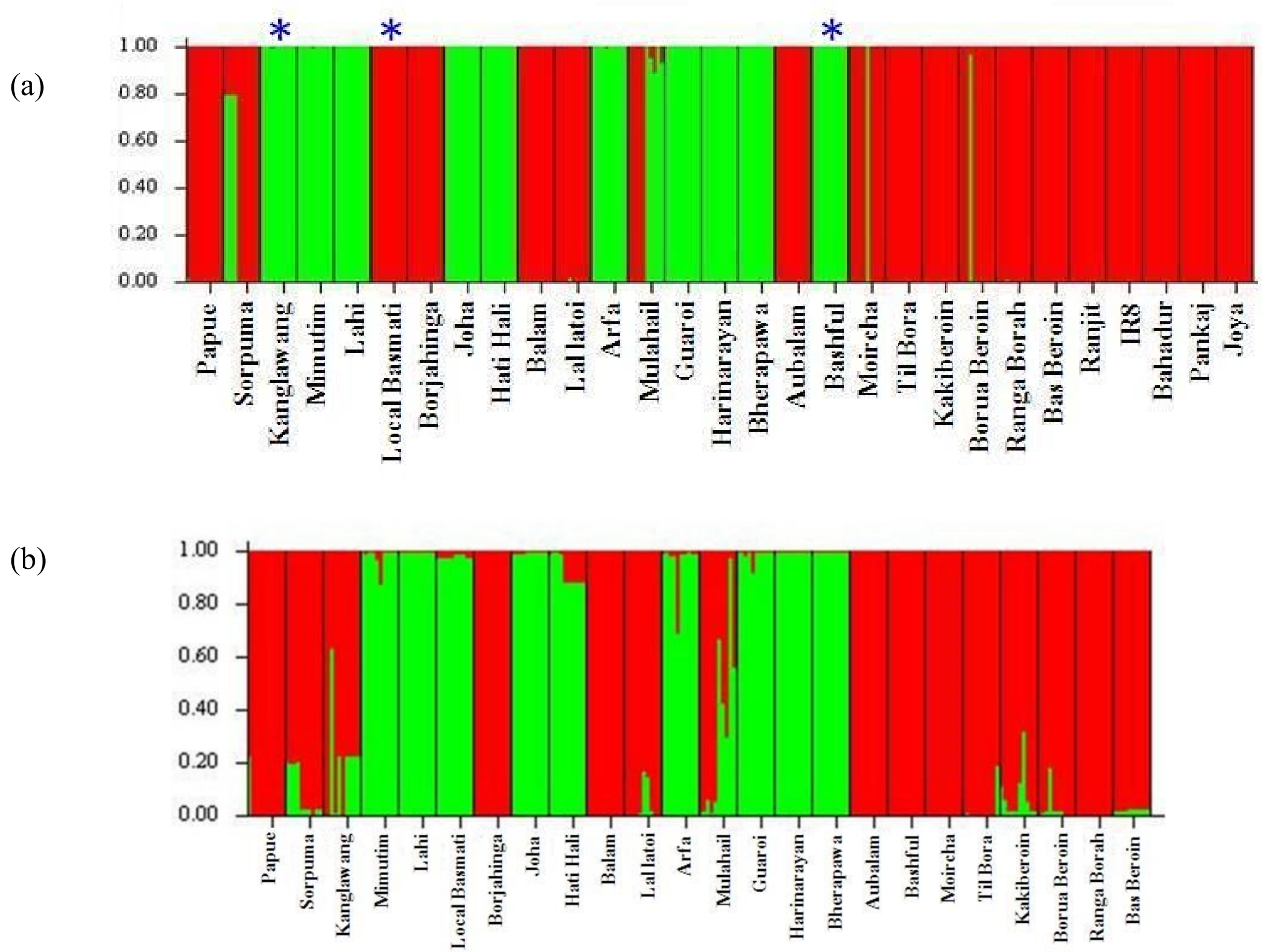

Figure 1.9: STRUCTURE output (a) including agronomically improved varieties and (b) without agronomically improved varieties. Note that three varieties (*Kawanglawang*, *Local Basmati* and *Bashful*; 3, 6, and 18 marked with asterisk) interchanged between group-I (*indica*) and group-II (*japonica*) groups (a) while all varieties of group-I (*indica*) and group-II (*japonica*) found in UPGMA and PCA analysis clustered together (b)

Discussion

Genetic diversity

The present study revealed exceptionally high genetic variation, with an average allelic richness of 10.205 and an overall Nei's gene diversity of 0.776 among indigenous rice varieties in NE India as compared to significantly low average allelic richness (2.798) and gene diversity (0.459) in agronomically improved types. The levels of genetic diversity were also variable across different varieties and much higher than the agronomically improved varieties (Table 1.1). Although the varieties represent only a sub-set of total rice varieties in the region, the gene diversity detected is higher than the overall gene diversity of rice varieties reported from Yunnan province in China (0.706) (Tu *et al*. 2007) and Indonesia (0.68) (Thomson *et al*. 2007). The gene diversity detected in my study is comparable to the overall gene diversity of wild rice *O. rufipogon* (0.77) and *O. nivara* (0.64) populations of the Vientiane Plain of Laos (Kuroda *et al*. 2007) and the gene diversity of *O. rufipogon* in China (0.670) (Gao 2004). A previous study based on allozyme markers revealed a moderate genetic variability (Nei gene diversity = 0.341) among 289 rice varieties from NE India (Glaszmann *et al*. 1989). The higher gene diversity values detected in the present study could be attributable to high resolving power of microsatellite markers.

The present study revealed several indigenous rice varieties with high genetic diversity, which includes *Lallatoi*, *Mulahail*, *Aubalam* and *Mimutim* (Table 1.1). Despite the low yield, the traditional farmers in Hailakandi area (Barak Valley region of Assam) have been cultivating *Lallatoi*, *Mulahail* and *Aubalam* for over many generations presumably for its superior nutritional quality and better taste (personal communication).

The local tribal group members in the Garo Hills of Meghalaya pointed out the superior agronomical qualities of *Mimutim*. Our study revealed high genetic diversity in *Mimutum*, one of the highly valued rice varieties by native tribal groups. This reflects the importance of traditional knowledge in evaluation and conservation of indigenous crop genetic resources (Brush and Meng 1998).

Most of the indigenous rice varieties are maintained and cultivated by traditional farmers in narrow geographic regions. However, traditional farming practices are in decline due to preference for agronomically improved varieties for higher yield. Therefore, appropriate conservation measures should be taken to promote the cultivation of indigenous varieties with local traditional knowledge.

The genetic diversity maintained in a species is considered as a function of its ecological and evolutionary history (Hamrick and Godt 1996). The high genetic diversity among NE Indian rice varieties have been described in relation to morpho-physiological characters (Vairavan *et al*. 1973), enzymatic characters (Glaszmann *et al*. 1989), agro-morphological traits (Borkakati *et al*. 2000) and molecular markers including RAPD (Sarma and Bahar 2005) and ISSR (Bhuyan *et al*. 2007). The high genetic diversity among rice varieties in the NE Indian region could be attributable to combined effect of wide eco-geographical conditions, diverse agro-ecosystems associated with various rice farming practices and diverse human cultural preferences. High genetic diversity is also reported for other crop plants such as *Zingiber officinale* (Sajeev *et al*. 2011), Chilli (Yumnam *et al*. 2012), *Curcuma* species (Das *et al*. 2011), *Citrus* species (Hazarika 2012) commonly cultivated in NE India, highlighting the importance of the region for germplasm conservation of many crop plants.

I compared the levels of genetic diversity among different types of rice cultivated in NE India, and found that *Sali* type possessed the highest gene diversity value of 0.747 and average allelic richness of 7.585. The majority of *Sali* varieties are maintained by traditional farmers for specific traits such as aroma, grain size and shape, and tolerance to drought, insects and pests, which may contribute to the maintenance of high genetic variation. *Jum* type also showed high level of heterogeneity with gene diversity of 0.627 and average allelic richness of 5.056. The traditional farming systems and local environment associated with adaptation to diverse conditions including water deficient habitats on the slopes of hilly regions may have contributed to the maintenance of high genetic variability among the *Jum* type. Due to their inherent high genetic diversity, *Sali* and *Jum* types should be prioritized to include in conservation and management plans and future breeding programs.

The high inbreeding coefficient values among rice varieties of the region (Table 1.4) could be due to predominantly selfing breeding system with a very low outcrossing in *O. sativa* species (Oka 1988). The F_{ST} results (Table 1.4) are also supported by AMOVA (Table 1.5) which indicated that 66% of the total variation was due to differentiation among varieties. This indicates that rice varieties of the Eastern Himalayan region are highly differentiated.

Population structure

The UPGMA analyses using genetic distance data clustered rice varieties into two groups, which corresponded to *O. sativa* subspecies *indica* and *japonica* (Glaszmann 1987; Oka 1988; Khush 1997). These results agree with the previous isozyme data based finding that showed the occurrence of two major groups of rice varieties in NE India (Glaszmann 1987). The PCA analysis and Model-based clustering method implemented in the STRUCTURE software also suggested the existence of two major groups corresponding to *indica* and *japonica* subspecies. The majority of varieties including agronomically improved rice varieties clustered as one group within the subspecies *indica*. Most of the varieties were grouped into *indica* subspecies cluster while few varieties clustered into *japonica* subspecies. Vairavan *et al*. (1973) also reported similar results on the basis of amylose content, agronomic, and morphological characteristics. The findings were similar to the study involving Indonesian landraces where 68% of the varieties were assigned as *indica* and 32% as *japonica* (Thomson *et al*. 2007). However, a study of European rice collection revealed that 89% of the accessions belonged to *japonica* type (Courtois *et al*. 2012). The *O. rufipogon* showed intermediate position between *indica* and *japonica* types suggesting a possible common ancestry of both *indica* and *japonica* types.

Although there was no clear differentiation among *Jum*, *Sali*, *Boro*, and glutinous varieties in the UPGMA and STRUCTURE analysis, the PCA analysis separated the agronomically improved varieties into a distinct group (Figure 1.6) closely associated with the *indica* type. This is expected as agronomically improved varieties included in the present study were derived from *indica* type. The STRUCTURE analysis did not show evidence for admixture between the *indica* and *japonica* types in almost all varieties. This could be attributable to predominantly selfing or autogamous nature of the breeding system and associated restricted gene flow among populations. Only a few varieties showed mixed ancestry of *indica* and *japonica* type (Figure 1.8), which may be either due to partial differentiation or rare introgression between the two types. Similar structuring reported among Asian cultivated rice *Oryza sativa* could be due to partial sharing of their ancestral genetic polymorphism and/or recent gene flow (Gao and Innan 2008).

Glaszmann *et al*. (1989) identified seven groups using isozyme markers and reported typical *indica* and *japonica* subspecies, suggesting that varieties mostly grown in mountainous areas of Meghalaya and Arunachal Pradesh belong to *japonica*. However, the present study revealed that varieties in the mountainous areas of Meghalaya and Arunachal Pradesh represent both *japonica* and *indica* types. My results did not correspond to the five major groups described in Garris *et al*. (2005).

Conclusion

In summary, high genetic diversity detected among traditional rice varieties in the Eastern Himalayan region of NE India is comparable to genetic diversity detected in wild rice populations in various parts of the world. Several varieties with high genetic diversity and cultural importance were found in Barak Valley region of Assam and Garo Hills of Meghalaya. The *Sali* and *Jum* type showed significantly higher levels of genetic diversity compared to agronomically improved types. Rice varieties in NE India clustered into two major groups corresponding to two subspecies, namely *indica* and *japonica*. The findings highlights the importance of conservation of rice varieties in NE India as a means of preserving genetic diversity to maintain food security in the changing world.

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Chapter 2: Genetic Characterization of Indigenous Rice Varieties in the Eastern Himalayan Region of Northeast India

Abstract: The Eastern Himalayan region of NE India is home to a large number of indigenous rice varieties, which are traditionally classified as *Oryza sativa* subspecies *indica*, *japonica* or as intermediate types. The traditional method of classification using morphological traits based *Cheng index* is often inconclusive due to phenotypic plasticity of morphological characters, which are influenced by environmental conditions. In the present study, I used molecular markers specific for *indica* and *japonica* subspecies to assess the genetic relatedness of indigenous rice varieties in NE India. The results revealed that the majority of upland cultivated (*Jum*) and glutinous rice varieties, which were traditionally considered as *japonica* are genetically akin to the subspecies *indica.* All varieties of *Boro* ecotype cultivated during winter season were found to be *indica* type, and only a few lowland and upland cultivated varieties were found to be *japonica* type. Some of the lowland varieties within the *Sali* ecotype were intermediate between *indica* and *japonica*, and showed a closer affinity to *Oryza rufipogon*, the wild progenitor of the cultivated Asian rice.

Keywords: Classification, genetic characterization, indel, *indica*, *japonica*, *Oryza sativa*.

Introduction

The cultivars of *Oryza sativa*, commonly known as Asian rice are classified into two major groups namely *indica* and *japonica*, which are often considered as subspecies based on morphological, physiological and biochemical traits (Oka, 1988; Glaszmann, 1987; Zhang *et al*. 1992; Yang *et al*. 1994). The genomic data also support the division of rice cultivars into of two major groups or subspecies of *O. sativa* corresponding to *indica* and *japonica* types with relatively distinct genomes that may have originated from a common ancestor about 200,000 to 440,000 years ago (Ma and Bennetzen, 2004; Tang *et al*. 2004). The traditional classification of *indica* and *japonica* subspecies is based on morphological traits combined with physiological and biochemical characteristics. The *Cheng index*, one of the widely used methods to distinguish these two groups is based on six key characters, namely (1) lemna hairiness, (2) response of rice grains to phenol, (3) inter-node length of panicle axes, (4) color of grain husks, (5) hairiness of leaf-blades, and (6) length to width ratio of grains (Cheng *et al*. 1984). Based upon *Cheng index*, cultivars grown in temperate regions (e.g. Japan, Korea and Northern China) are considered exclusively as *japonica* while the cultivars in tropical and subtropical regions are considered as *indica* (Zhang, 2009). The rice varieties grown in mountain slopes and high elevations in South and South East Asia are considered as *japonica* while rice varieties cultivated in the lowland tropical Asia are considered as *indica* (Oka, 1988; Matsuo *et al*. 1997). Rice varieties with glutinous or “sticky” grains, which are commonly cultivated in South Asia are also classified as *japonica* (Oka, 1988).

The rice varieties in NE India are further divided into *Sali*, *Boro* and *Jum* ecotypes based upon the season of cultivation and land-use system. Nursery grown seedlings of the

Sali ecotype are transplanted during the onset of monsoon (Jun-Jul) and harvested during winter (Nov-Dec). The *Boro* ecotype is cultivated in low-lying areas during the dry winter season (Nov-Dec to Apr-May). The *Jum* varieties are cultivated on mountain slopes under dry soil conditions. Based on *Cheng index*, *Sali* varieties are considered as typical *indica* whereas few *Jum* varieties and glutinous grain type varieties are considered as *japonica*. The majority of the *Jum* rice varieties in the region are considered as intermediate between *indica* and *japonica* types. At present, the *Boro* ecotype has not been classified into *indica* or *japonica* types.

Since the feature of key characters used in *Cheng index* based classification may vary greatly due to environmental conditions leading to inconclusive distinction between *indica* and *japonica* varieties (Lu *et al*. 2009), molecular marker-based studies are gaining popularity in the characterization of *indica-japonica* types (Zhang *et al*. 1992; Long and Xu, 2002; Qi *et al*. 2009; Zhang *et al*. 2009). Shen *et al*. (2004) developed a genome-wide DNA polymorphism database for *indica* cv 93-11 and *japonica* cv Nipponbare and identified large number of polymorphic regions including single nucleotide polymorphisms (SNPs) and insertion and deletions (indel) between the genomes of two subspecies. These reflect the gain and loss of a piece of DNA sequence at a particular location of the genome respectively. Indels may vary in size ranging from single nucleotide to several kilobases, and are distributed throughout the genome (Nasu *et al*. 2002; Feltus *et al*. 2004). The genotyping based upon indel markers is a relatively simple procedure, which capitalizes on the size difference of the PCR amplification products. Indel markers have been successfully utilized in the identification of rice varieties and in evolutionary studies (Cai *et al*. 2007; Lu *et al*. 2009; Liu *et al*. 2012).

The objectives of the present study were to (i) genetically characterize *Sali*, *Boro*, *Jum* and glutinous rice varieties cultivated in NE India to classify them into *indica*, *japonica* or intermediate types and (ii) determine the genetic relatedness among these rice varieties. I hypothesize that the ecotypes genetically similar to *indica* subspecies may possess more indel markers specific for the *indica* subspecies and ecotypes closely related to the *japonica* subspecies may possess more indel markers unique for *japonica* subspecies. The intermediate varieties may have indel genotypes specific for each variety proportionate to their degree of genetic relatedness to *indica* or *japonica* subspecies.

Materials and methods

Plant sample

A total of 90 individuals representing 29 rice varieties and one wild rice species were genotyped for 11 markers that discriminate *indica* and *japonica* types. These samples included three different ecotypes (*Sali*, *Jum* and *Boro*), which comprised glutinous and nonglutinous grain types and agronomically improved varieties from different parts of NE India (Table 2.1).

Wild rice (*O. rufipogon*) accessions originally collected from NE India were obtained from the International Rice Research Institute (IRRI), Philippines. Samples of grains or fresh leaves were obtained from farmers in NE India. Morphological characters were noted on the basis of direct observations as well as communications with farmers. Seeds were grown in the green house in small pots and watered regularly. Leaf samples from seedlings were harvested, air-dried and used for the study. Genomic DNA was

Table 2.1: List of rice varieties collected from NE India, their location, cultivation type, (*Fi*) frequency of *indica* allele (maximum, minimum and average) and classification using indel marker system (AP, Arunachal Pradesh; AS, Assam, ML, Meghalaya, MZ, Mizoram).

Variety	Ecotype	Cultivation type	Grain type	*Fi* (max)	*Fi* (min)	*Fi* (Average)	Subspecies
Aubalam	*Boro*	Lowland	Nonglutinous	0.91	0.91	0.91	Typical *indica*
Bashful	*Boro*	Lowland	Nonglutinous	0.91	0.91	0.91	Typical *indica*
Moircha	*Boro*	Lowland	Nonglutinous	0.91	0.91	0.91	Typical *indica*
Borua Beroin	*Boro*	Lowland	Glutinous	0.80	0.78	0.79	*indica*
Papue	*Jum*	Upland	Nonglutinous	0.91	0.90	0.90	Typical *indica*
Sorpuma	*Jum*	Upland	Nonglutinous	1.00	1.00	1.00	Typical *indica*
Kawanglawang	*Jum*	Upland	Nonglutinous	0.73	0.68	0.71	Close to *indica*
Mimutim	*Jum*	Upland	Nonglutinous	0.20	0.10	0.16	*japonica*
Lahi	*Sali*	Lowland	Nonglutinous	0.09	0.09	0.09	*japonica*
Local Basmati	*Sali*	Lowland	Nonglutinous	0.91	0.90	0.90	Typical *indica*
Borjahinga	*Sali*	Lowland	Nonglutinous	0.90	0.90	0.90	Typical *indica*
Joha	*Sali*	Lowland	Nonglutinous	0.50	0.45	0.48	Intermediate
Hati Hali	*Sali*	Lowland	Nonglutinous	0.50	0.50	0.50	Intermediate
Balam	*Sali*	Lowland	Nonglutinous	1.00	0.91	0.95	Typical *indica*
Lallatoi	*Sali*	Lowland	Nonglutinous	0.73	0.68	0.70	Close to *indica*
Arfa	*Sali*	Lowland	Nonglutinous	0.90	0.90	0.90	Typical *indica*
Mulahail	*Sali*	Lowland	Nonglutinous	0.91	0.90	0.90	Typical *indica*
Guaroi	*Sali*	Lowland	Nonglutinous	0.55	0.55	0.55	Intermediate
Harinarayan	*Sali*	Lowland	Nonglutinous	0.36	0.18	0.27	Close to *japonica*
Bherapawa	*Sali*	Lowland	Nonglutinous	0.20	0.18	0.19	*Japonica*
Til Bora	*Sali*	Lowland	Glutinous	0.90	0.89	0.90	Typical *indica*
Kakiberoin	*Sali*	Lowland	Glutinous	0.90	0.89	0.89	*indica*
Ranga Borah	*Sali*	Lowland	Glutinous	0.91	0.90	0.91	Typical *indica*
Bas Beroin	*Sali*	Lowland	Glutinous	0.96	0.91	0.93	Typical *indica*
Ranjit	*Sali* (Improved)	Lowland	Nonglutinous	0.91	0.89	0.90	Typical *indica*
IR8	*Sali* (Improved)	Lowland	Nonglutinous	0.90	0.90	0.90	Typical *indica*
Bahadur	*Sali* (Improved)	Lowland	Nonglutinous	0.82	0.78	0.80	*indica*
Pankaj	*Sali* (Improved)	Lowland	Nonglutinous	0.91	0.88	0.89	*indica*
Joya	*Sali* (Improved)	Lowland	Nonglutinous	0.80	0.78	0.79	*indica*
O. rufipogon	Wild	Lowland	Nonglutinous	0.56	0.42	0.47	Intermediate

>0.90=Typical *indica*, 0.75-0.89=*indica*; 0.61-0.74=close to *indica*; 0.40-0.60=intermediate; 0.26-0.39=close to *japonica*; 0.11-0.25=*japonica*; <0.10= Typical *japonica*.

extracted following a modified cetyltrimethyl ammonium bromide extraction protocol and is given in Chapter 1.

PCR assay and genotyping

Oligonucleotide primer pairs flanking the Insertion-deletion (indel) sites specific for *indica* (cv 93-11) and *japonica* (cv Nipponbare) were selected from available literature (Shen *et al*. 2004). Eleven indel loci (R1M7, R2M24, R3M23, R4M13, R5M13, R6M30, R7M7, R8M33, R9M20, R10M17, R11M17) distributed throughout the rice genome were selected to genotype the rice varieties including the wild rice, *O. rufipogon*. The name of the primers, their map positions on the rice genome and annotation is given in Table 2.2. The forward primers were synthesized with a universal M13 tail sequence (5'CACGACGTTGTAAAACGAC) added to the 5' end of the oligonucleotide for labeling. The 25 μL PCR reaction mixture contained 0.2 mM dNTP, 2.5 mM $MgCl_2$, 2.5 μL of 10X buffer, 2.5 pmol of each primer, 1 pmol of the M13 forward primer labeled with either IRD700 or IRD800, 1 pmol of the reverse primer and 0.2 U of *Taq* polymerase. Cycling conditions were 94° (3 min) followed by 35 cycles of 94° (2 min), 50° (30 Sec), 72° (2 min) and a final extension of 72° for 4 min.

The amplified products were diluted (1:5) with loading dye (Formamide and Bromophenol blue), denatured at 94°C for 5 min and cooled on ice. The diluted PCR products were loaded on 6.0% denaturing polyacrylamide gels on a Li-COR 4000 automated DNA sequencer with a size standard (50-350 bp, IRD-700 and IRD-800) (Li-Cor Biosciences). The migration distance of each allele was compared with the size standard and scored based on the allele sizes. The indel markers were codominant and the

Table 2.2: List of indel markers, their map positions** and annotation in the rice genome.

Locus	Chr	Position in the genome (*indica*)	Annotation	Position in the genome (*japonica*)	Annotation	Indel size (bp)
R1M7	1	11647111-11647263 (153)	IGR	10608641 - 10608831 (191)	IGR	38
R2M24	2	12156089-12156185 (97)	IGR	11338788 - 11338915 (128)	IGR	31
R3M23	3	17449222-17449415 (194)	ESTR, EST	15684664 - 15684818 (155)	UTR (conserved peptide uORF), ESTR, EST	39
R4M13	4	107453–107602 (150)	IGR	8210327 - 8210495 (169)	IGR	19
R5M13	5	6231232–6231438 (207)	IGR	5992637 - 5992811 (175)	IGR	32
R6M30	6	19409928–19410072 (157)	IGR	18189560 - 18189740 (181)	IGR	24
R7M7	7	6780445–6780577 (133)	IGR	6717062 - 6717261 (200)	IGR	67
R8M33	8	22118785-22118914 (130)	IGR	20794118 - 20794285 (168)	UTR, ESTR, EST	38
R9M20	9	8257287–8257432 (146)	IGR	9453900 - 9453994 (95)	IGR	51
R10M17	10	7539062–7539244 (183)	Exon (Putative uncharacterized protein), EST	9088615 - 9088766 (152)	Exon of gene (LOC_Os10g18070) EST	31
R11M17	11	5437582-5437667 (86)	IGR	5890341 - 5890457 (117)	IGR	31

Chr = Chromosome number; *indica* = 93-11; *japonica* = Nipponbare; values in parenthesis means fragment size (bp); IGR = Intergenic region on the basis of GRAMENE rice genome database; ESTR = Expressed sequence tag (GRAMENE rice genome database); EST = Expressed sequence tag (NCBI database); UTR = Untranslated region.

**on the basis of GRAMENE rice genome database (Release #32), December 2010, Data recovered on January 20, 2011 (Website: http://www.gramene.org/).

banding patterns were scored as II for homozygous *indica*, JJ for homozygous *japonica* and IJ for heterozygous *indica*-*japonica* (Lu *et al*. 2009). The band size (bp) was compared with typical *indica* (cv 93-11) or typical *japonica* (cv Nipponbare) cultivars from published literature and the corresponding alleles (II, JJ or IJ) were assigned for each individual. A sample gel image with seven genotyped individuals at three different loci is given in Figure 2.1. In this image, all individuals except individual 2 are homozygous for *indica* type (hence scored as II) at the locus R6M30 and individual 2 is heterozygous for *indica* and *japonica* allele (and hence scored as IJ). Similarly, for the locus R7M7, individuals 2,3, and 4 are homozygous for the *japonica* allele (JJ); individuals 1,5, and 6 are homozygous for *indica* allele (II); individual 7 is heterozygous for the *indica*-*japonica* allele (IJ); for locus R8M33, individuals 1,3,4 and 6 are homozygous for the *indica* allele; and individuals 2 and 7 are homozygous for the *japonica* allele. Average allele frequency of the three genotyped individuals per variety was calculated for accurate identification of the *indica* and *japonica* subspecies.

Data analysis

To characterize a given rice variety as *indica* or *japonica* type, I calculated the average *indica* specific allelic frequency (*Fi*) of the three genotyped individuals for each variety out of the total number (N) of indel loci examined. The allelic frequency was calculated based on the genotype scores (II, JJ, and IJ) using the formula given in Lu *et al*. (2009) as follows:

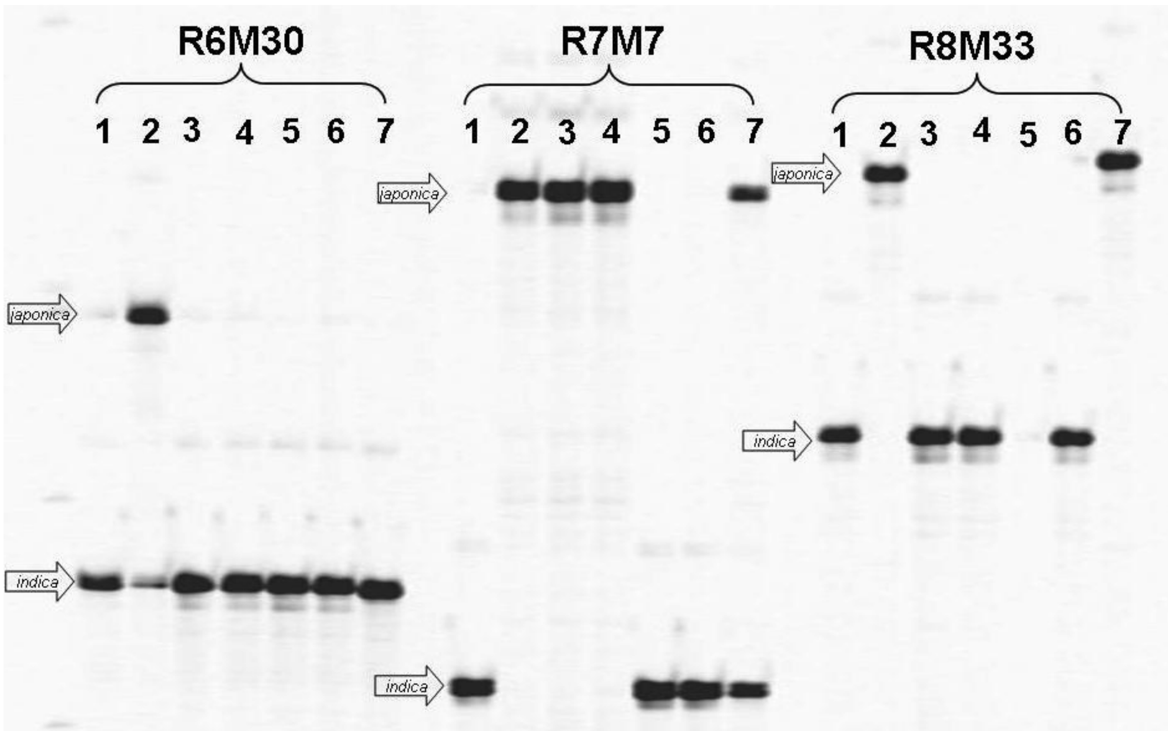

Figure 2.1: Polyacrylamide gel electrophoresis image of 7 rice varieties genotyped with 3 indel markers (R6M30, R7M7, R8M33) showing *indica* and *japonica* specific bands.

$$\text{Frequency of } \textit{indica} \text{ alleles } (F_i) = \frac{2\sum_1^N Xii + \sum_1^N Xij}{2N}$$

where, X_{ii} indicates the homozygous *indica* genotype and X_{ij} indicates the heterozygous *indica-japonica* genotype at a given indel locus of a particular rice variety; N is the total number of indel loci examined. I calculated the average allele frequency from three genotyped individuals per variety and classified them as typical *indica*, *indica*, close to *indica* (largely as *indica*) and close to *japonica*, *japonica* and typical *japonica* (largely as *japonica*). When the frequency of *indica* alleles for a particular variety is >0.90, it is categorized as typical *indica* type and if the frequency is <0.10, the particular variety is characterized as the typical *japonica* type. The varieties with *indica* type allele frequencies between 0.40 and 0.60 were classified as intermediate types.

Principal Component Analysis (PCA) was conducted to detect the patterns of genetic differentiation and relationship among the different rice varieties using the software program GenALEx v. 6.4 (Peakall and Smouse, 2006). PCA is a method of detecting patterns of variation in complex data and group individuals based on similarities and dissimilarities to understand the contribution of individuals to the variance of the whole data set. In this analysis, the indel genotype data matrix was used to generate a scatterplot based on the correlation coefficient values and plotted along the different component axes.

To study the genetic structure and relationships among the rice varieties, I applied Bayesian model-based clustering approach using genotype data to determine the optimum number of genetic clusters among the rice varieties using the software STRUCTURE 2.3.3 (Pritchard *et al*. 2000). The program STRUCTURE divides individuals into a number(s) of clusters (*K*) based on multilocus genotypic data without any prior population information. The admixture model and correlated allele frequencies were applied for each run with 10,000 burn-in period (iteration) and 100,000 Markov Chain Monte Carlo (MCMC) replication. The optimum K value, which indicates the actual number of clusters in the data, was determined from 10 replicate runs for each value of K (Evanno *et al*. 2005). The ΔK was based on the rate of change in the log probability of the data between successive K values.

The indel genotype data were used for calculating Nei's (Nei 1972) genetic distance using the software program PopGene version 1.31 (Yeh *et al*. 1999). The pairwise distance matrix was used to construct the UPGMA tree using in PHYLIP 3.69 (Felsenstein 2005).

Results

Differentiation of indica and japonica

All selected indel loci amplified detectable DNA fragments corresponding to either the *indica* or *japonica* type (Figure 2.1). The results indicated that the majority of the rice varieties included in the present study were *indica* type (typical *indica* = 52%; *indica* = 17%; close to *indica* = 7%) while only about 14% of the varieties were *japonica* type (10% *japonica* and 4% close to *japonica*). Another 10% of rice varieties showed intermediate allele frequencies between *indica* and *japonica* types. *O. rufipogon* showed more *indica-japonica* heterozygous loci than *O. sativa* species and classified as intermediate between *indica* and *japonica* type. The genotypic frequency of each type is given in Table 2.1.

Eco-geographically, *indica* rice is grown primarily throughout tropical Asia at low latitudes and low elevations and *japonica* types are grown in temperate regions of

East, South East, and South Asia at high latitudes and high elevations (Garris *et al*. 2005, Cai *et al*. 2007). Accordingly, all the *Sali* rice varieties of NE India are generally classified as *indica* type and all the *Jum* varieties as *japonica* type. While the majority of the *Sali* rice varieties were *indica* (typical *indica*, *indica* or close to *indica*), about 10% of the varieties were found to be intermediate type. Interestingly, three out of the four indel marker based *japonica* type rice varieties belonged to *Sali* ecotype. These were formerly classified as *indica* type using *Cheng index*. Only one out of four *Jum* varieties (*Mimutim*) was classified as *japonica* type using the indel marker system. Glutinous rice varieties, which are traditionally classified as *japonica* type (Oka, 1988) possessed indel markers typical of *indica* type. The indel marker based analyses revealed that the *Boro* ecotype varieties, which are cultivated in limited areas of Assam and its adjoining flood plains in NE India are *indica* type. The indel markers of all agronomically improved varieties showed affinity to *indica* type as expected. The wild rice species (*O. rufipogon*) shared indel markers with both *indica* and *japonica* types and classified as intermediate type.

Genetic structure and relationships

Genetic structure of different rice varieties were assessed using PCA, UPGMA and model based STRUCTURE analysis. The PCA analyses of *indica* and *japonica* specific indel genotype data revealed that 51% and 16% of the total variance were in the first two axes respectively. Therefore, the PCA should well represent the genetic structure of the different rice ecotypes in NE India. As shown in the Figure 2.2, four *japonica* varieties (*Bherapawa*, *Harinarayan*, *Lahi* and *Mimutim*) formed a distinct group at the positive side of the x-axis and the *indica* types including the agronomically improved varieties

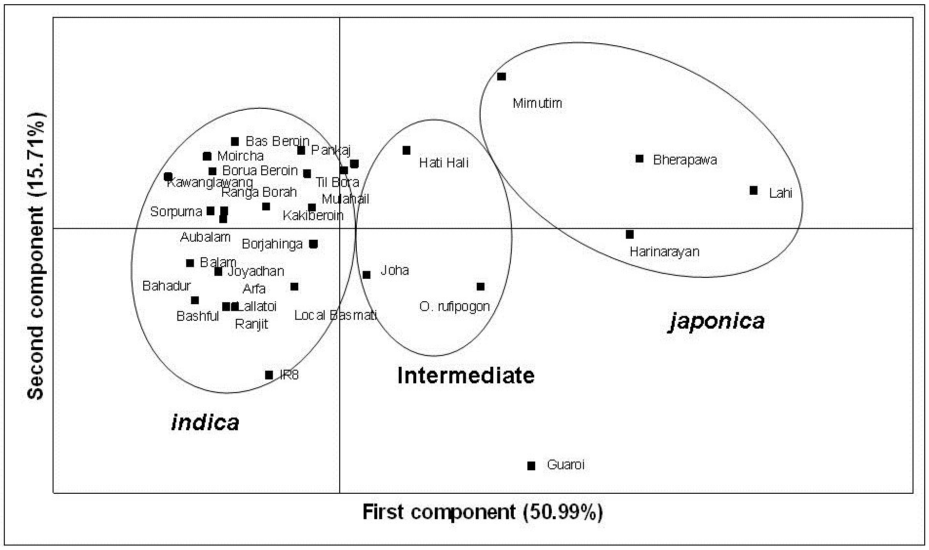

Figure 2.2: The scatter plot of indigenous rice varieties based on principal component analysis (PCA) showing significant genetic differentiation into *indica*, *japonica* and intermediate rice genotypes in NE India.

formed a separate group on the negative side of the - axis. Moreover, the intermediate varieties with indel genotypes shared between *indica* or *japonica* varieties were scattered between the *indica* and *japonica* groups in the centre of the scatter plot along with the wild rice (O. *rufipogon*).

The STRUCTURE analysis revealed that the highest log likelihood value at $K = 2$, clearly showing genetic differentiation into two major types of rice varieties in the eastern Himalayan region of NE India. Individual assignments into two clusters demonstrated that the first group (Figure 2.3, shown in green) corresponds to the *japonica* and intermediate types and the second group (shown in red) corresponds to the *indica* type. Both PCA and STRUCTURE analyses revealed congruent results implying distinct genetic composition corresponding to *indica* and *japonica* subspecies. Most of the *japonica* varieties classified using molecular genetic markers belonged to *Sali* and glutinous types except for one of the *Jum* varieties, suggesting a different degree of genetic differentiation among indigenous rice varieties in NE India. Only one intermediate type of variety (*Guaroi*) did not cluster with the *japonica* type in the UPGMA tree. Rice varieties of *Boro* ecotype clustered with *indica* type in all analyses. On the other hand, three varieties of *Sali* ecotypes (*Joha*, *Hati Hali* and *Guaroi*) did not show differentiation into *indica*-*japonica* types in the PCA method. These varieties also showed admixed ancestry in STRUCTURE analysis. The UPGMA tree based on Nei's (1972) genetic distance values showed that *japonica* and intermediate type of varieties were clustered together while *indica* types including all agronomically improved varieties formed a separate group (Figure 2.4).

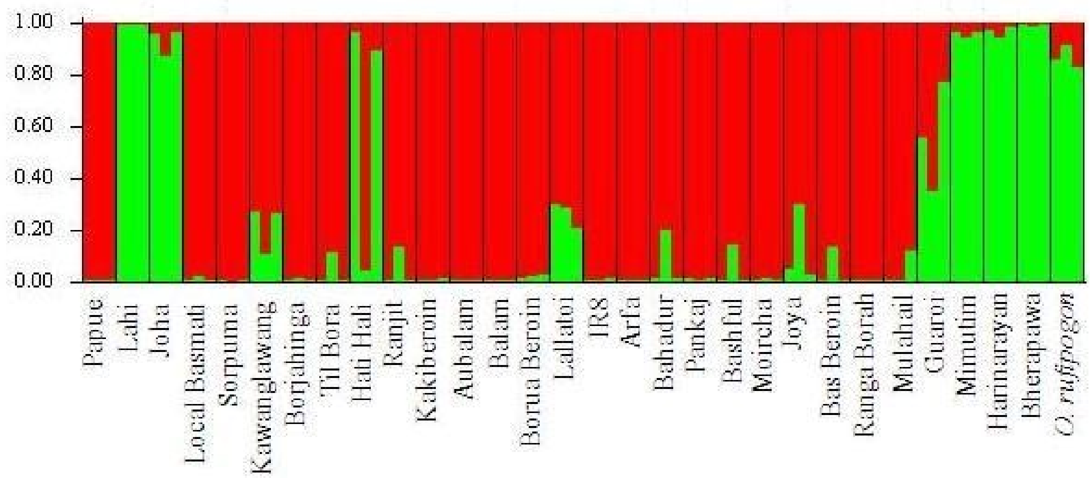

Figure 2.3: Results of *STRUCTURE* analysis showing 2 major groups of rice varieties corresponding to *indica* (red colored segment) and *japonica* (green colored segment) types. The intermediate varieties with admixed ancestry are indicated in red and green color bars.

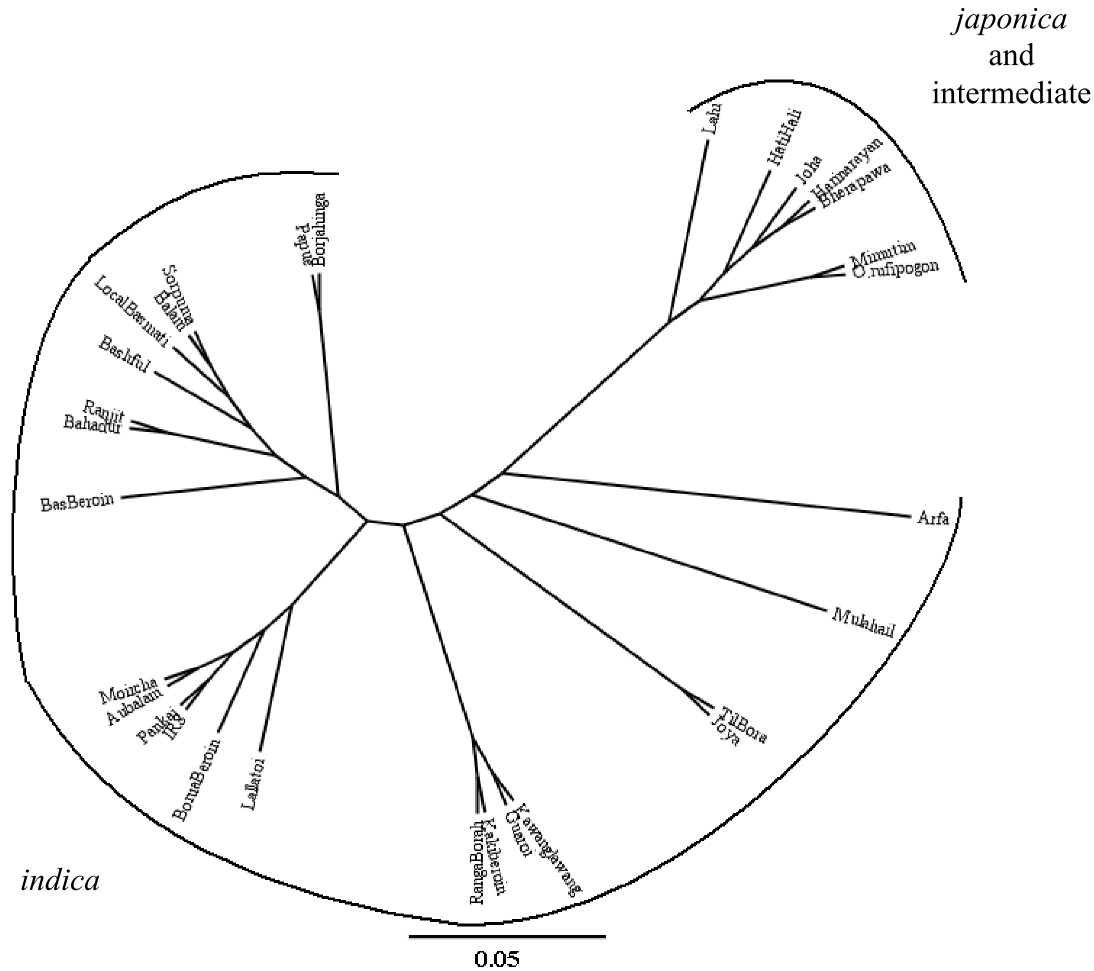

Figure 2.4: UPGMA tree based on genetic distance (Nei 1972) among rice varieties.

Discussion

The traditional classification of *O. sativa* varieties into *indica* and *japonica* subspecies based on *Cheng index* is often inconclusive due to phenotypic plasticity associated with environmental heterogeneity and differential growth conditions. I used indel based molecular markers to distinguish rice varieties of *indica*, *japonica* and intermediate types. In addition, the indel genotype data were used for investigating the population genetic structure of representative rice varieties in NE India. The molecular data based on 11 indel loci separated indigenous rice varieties in the Eastern Himalayan region into *indica*, *japonica* and intermediate types. The majority of varieties were *indica* type while few varieties showed *japonica* type genotypes. A few varieties showed allele frequencies intermediate between the two types indicating genetic admixture of *indica* and *japonica* types. Similar results were also reported based on amylose content, agronomic, and morphological characteristics (Vairavan *et al*. 1973). The wild progenitor of cultivated rice, *O. rufipogon,* showed genotypes intermediate between *indica* and *japonica* types as reported earlier (Oka 1988; Sano and Morishima 1992; Xiong *et al*. 2010). This confirmed the effectiveness of indel marker based classification and the ancestral status of *O. rufipogon*, from which both *indica* and *japonica* types may have derived.

In general, rice varieties grown in low latitudes and low elevation areas in tropical Asia are considered as *indica* type and the varieties grown in temperate East Asia, Southeast Asia, and South Asia at high latitudes and high elevations are considered as *japonica* type (Matsuo *et al*. 1997; Garris *et al*. 2005). However, the present study showed that *indica* and *japonica* types cannot be differentiated solely based on altitudinal distribution, cultivation type or grain qualities. For example, *Bherapawa*, *Harinarayan* and *Lahi* varieties, which are cultivated at low elevation in flood plain areas of Assam showed *japonica* type genotypes while three of the four *Jum* varieties (*Kawanglawang*, *Papue* and *Sorpuma*) showed *indica* type genotypes. Only one *Jum* variety (*Mimutim*) possessed genotypes relating it to *japonica* type. All genetically improved varieties showed *indica* type genotypes as expected based upon their ancestry, confirming the effectiveness of the indel marker based classification method. On the other hand, three *Sali* varieties (*Guaroi*, *Hati Hali* and *Joha*) showed intermediate genotypes, which could be attributable to maintenance of either primitive or admixed rice varieties by traditional farmers. The indel molecular marker based classification of wild rice species into intermediate type further demonstrates that both *indica* and *japonica* rice types may have evolved from *O. rufipogon* as a progenitor.

The PCA and STRUCTURE analyses supported the pattern of differentiation and genetic divergence of the rice varieties in NE India. The majority of rice varieties included in the present study showed *indica* characteristics while only a few varieties showed *japonica* characteristics. This may be explained by the fact that *indica* rice was domesticated from a broad geographic region of South and South East Asia (Huang *et al*. 2012) and is still widely cultivated in these areas. The putative ancestral wild rice species, *O. rufipogon,* showed intermediate type between *indica* and *japonica* in PCA analysis and admixed ancestry in STRUCTURE analyses support the idea that both rice subspecies may have evolved from *O. rufipogon* through continuous human selection (Oka, 1988; Khush, 1997; Huang *et al*. 2012). The UPGMA tree (Figure 2.4) showed that the *japonica* and intermediate type varieties are genetically more closely related to each other than to the *indica* type. This suggests a broad genetic differentiation of the indigenous rice varieties in the NE Indian region. Sano and Morishima (1992) also reported nonrandom association in characters and gametic disequilibrium among the traditional rice varieties in hilly areas of Asia. The resulting information on genetic relatedness of rice varieties is invaluable for choosing rice germplasm for future breeding programs to develop varieties of rice with improved agronomic traits or adaptability to changing climatic conditions.

Conclusion

The indigenous rice varieties cultivated in the Eastern Himalayan region of NE India are genetically diverse, and comprise predominately *indica* type with few *japonica* and intermediate types. In contrary to the traditional view that rice varieties of *Sali* ecotype are *indica* type, the indel marker based analyses revealed that some of the *Sali* varieties are *japonica* type. Similarly, indel based molecular markers revealed that rice varieties with glutinous grains, which are traditionally classified as *japonica* type, are genetically akin to *indica* type. Furthermore, the indel marker based analyses revealed that the *Boro* rice varieties are *indica* type. The genetic polymorphism found in intermediate type varieties could be attributable either to the maintenance of ancient polymorphism, or alternatively to recent hybridization and introgression of *japonica* and *indica* types. The resulting information on genetic polymorphism and relatedness among indigenous rice varieties in NE India are invaluable for choosing germplasm for breeding programs targeted to improve agronomic traits and adaptability to a variety of climatic conditions.

CHAPTER 3: Patterns of Nucleotide Diversity and Phenotypes of Two Domestication Related Genes (*OsC1* and *Wx*) in Indigenous Rice Varieties in Northeast India

Abstract: The cultivated crops are a result of plant domestication from their wild progenitors through selection of individuals with specific traits desirable for human needs. Thus, genetic and nucleotide diversity of genes associated with selected traits in crop plants are expected to be lower than their counterparts in the progenitors. In the present study, I surveyed the pattern of nucleotide diversity of two trait specific genes, *Wx* and *OsC1*, which regulate amylose content and apiculus coloration respectively in cultivated rice varieties. The samples analyzed were collected from a wide geographic area in NE India, and included contrasting phenotypes considered to be associated with selected genes, namely glutinous and nonglutinous and colored and colorless apiculus. The results revealed that mutations of these two genes believed to be associated with specific phenotypes do not necessarily correspond to the phenotypes in indigenous rice varieties in NE India. This suggests that genomic regions other than those previously reported may also be involved determination of these phenotypes. Overall, no statistically significant selection signatures were detected in the sequences. However, of either gene, a low level of selection that varied across the length of each gene was evident. The glutinous type varieties showed higher levels of nucleotide diversity at the *Wx* locus (π_{tot} = 0.0053) than nonglutinous type varieties (π_{tot} = 0.0043). The *OsC1* gene revealed low levels of selection among the colorless apiculus varieties with lower nucleotide diversity (π_{tot} = 0.0010) than in the colored apiculus varieties (π_{tot} = 0.0023).

Keywords: Indigenous, Nucleotide diversity, NE India, Rice, Trait specific genes

Introduction

The domestication of plants and animals, considered as one of the most important events in the human history, increased the food security to support the increasing human population. The process of domestication is complex and involves selection of individuals from wild progenitors to fulfill human needs (Doebley *et al.* 2006). The Asian cultivated rice is one of the earliest domesticated crop species in the world that was selected for many traits related to human consumption and large-scale agriculture. The most important domestication-related traits and corresponding genes identified so far in rice with significant morphological and physiological modifications include reduction in grain shattering (Konishi *et al*. 2006; Li *et al*. 2006a), changes in grain coloration (Sweeney *et al*. 2006), grain size and shape (Yamanaka *et al*. 2004), grain fragrance and flavor (Bradbury *et al*. 2005), grain number (Ashikari *et al*. 2005), grain weight (Song *et al*. 2007) and grain stickiness (Yamanaka *et al*. 2004). The genes that control these traits are often called 'domestication genes' in crop plants. In addition to human mediated selection for specific traits, the environment where crops are grown also may have played a major role in selection and changes in genetic diversity during crop domestication.

Domestication is often associated with reduction in genetic variation in domesticated plants compared to their wild progenitors (Doebley *et al*. 2006). This is mainly due to population bottlenecks and artificial selection of domestication genes for desirable traits. Domesticated plants are also a product of relatively small founder populations, in which only a sub-sample of the wild progenitor population contributes to the genomes of cultivated plants (Eyre-Walker *et al*. 1998). As a result, genome-wide loss of genetic variation occurs in cultivated plants (Doebley *et al*. 2006). The artificial selection targeted to specific desirable traits controlled by domestication genes also reduces the genetic diversity in crop plants as compared to their wild ancestors (Tanksley & McCouch 1997). Many traits generally suitable for human needs have been targets of selection during the domestication of crops. These traits and associated genes have subsequently undergone changes due to local environment and cultural preferences (e.g., grain color, taste) (Simmonds 1976). Thus, analyses of nucleotide sequences of domestication genes at the DNA level is invaluable to gain insights into types of selection that has occurred during domestication.

Several studies have demonstrated the selective sweep in domestication genes and genomic regions in domesticated crops (Buckler *et al*. 2001; Wang *et al*. 1999). Olsen *et al*. (2006) showed one to two fold increase in selection pressure in domestication genes compared to genes under strong natural selection. However, the reduction in genetic diversity in different regions within a trait gene may vary depending on the importance of a given region on determining trait.

Indigenous rice varieties cultivated in the Eastern Himalayan region of NE India are phenotypically diverse and many of which are intricately associated with local cultural and traditional practices. One of the most important culinary and cultural practices found throughout NE India is the use of glutinous rice as a food of choice during festival seasons (Roder *et al.* 1996). Thus, along with nonglutinous rice varieties, numerous glutinous rice varieties are widely cultivated in NE India. The glutinous and nonglutinous nature of rice is primarily determined by the composition of starch in the endosperm tissue. Starch is one of the important components of cereal grains and has been under selection during domestication and subsequent crop diversification (Whitt *et al.* 2002; Wilson *et al*. 2004). Starch in rice endosperm contains two types of polysaccharides namely amylose and amylopectin. Rice varieties with high amylose levels (~20-30%)

tend to form discrete, noncohesive (non-sticky) grains when cooked, whereas varieties with lower amylose levels form cohesive (sticky) cooked grains, commonly known as glutinous (Olsen *et al.* 2006). Previous studies have shown that a mutation in the *Waxy* (*Wx*) gene that encodes granule-bound starch synthase drastically reduces (<1%) synthesis of amylose in the endosperm of glutinous rice (Sano 1984). The point mutation from G to T at the 5' splice site of the *Wx* intron 1 is known to cause incomplete post-transcriptional processing of the pre-mRNA in glutinous rice varieties (Sano 1984; Hirano *et al.* 1998; Isshiki *et al.* 1998). On the other hand, nonglutinous rice varieties possesses multiple *Wx* alleles and show wide variation in amylose content (Ayres *et al.* 1997). A highly variable microsatellite (CT_n) in the 5' untranslated exon 1 of the *Wx* gene is known to contain many alleles and the size of the allele is correlated with the amylose content in rice varieties (Ayres *et al.* 1997; Wan *et al.* 2007). Some nonglutinous and low-amylose containing varieties also known to carry the G to T mutation at the 5' splice site of *Wx* gene suggesting that mutation in the *Wx* gene may not necessarily be responsible for the glutinous phenotype (*Wang et al*. 1995; Cai *et al.* 1998; Olsen and Purugganan 2002).

Another morphological variation found among indigenous rice varieties in NE India is the apiculus coloration. The wild ancestor of cultivated rice, *O. rufipogon,* possesses invariant pigmentation in apiculus whereas the apiculus in cultivated rice varieties may be colored or colorless. The colored apiculus phenotype is attributable to anthocyanin pigments, which are known to be associated with coloration in various plant parts. Anthocyanins perform multiple biological functions in plants including protection against UV radiation, defense responses and signal molecules in plant-microbe interactions (Dooner *et al*. 1991; Koes *et al*. 1994). Saitoh *et al*. (2004) identified and mapped the

OsC1 gene in rice responsible for anthocyanin pigmentation and apiculus coloration in rice. Comparative sequence analysis revealed that colorless lines differed from their colored counterpart by a 10 bp deletion located in the R3 repeat within the third exon of the *OsC1* gene (Saitoh *et al*. 2004).

In this study, I explored (a) mutations in *Wx* and *OsC1* genes in indigenous rice varieties in NE India, and their corresponding phenotypes, and (b) nucleotide diversity patterns in these genes across rice varieties to discern signature of selection in domestication related genes.

Materials and methods

Plant samples

In the present study, altogether 29 cultivated rice varieties (including 5 agronomically improved varieties) and one wild rice species (*O. rufipogon*) from different parts of NE India were included (Figure 1.1). Two trait specific genes were chosen to study different varieties with contrasting phenotypes. The samples studied included five glutinous and 24 nonglutinous varieties, and 8 colored apiculus and 21 colorless apiculus varieties (Table 3.1). The wild rice species (*O. rufipogon*), which is nonglutinous and has a colored apiculus was used as an outgroup. Plant morphology and grain characteristics were noted based on direct observation or interviewing the farmers in the field. Protocol for seed germination, seedling growth, leaf harvesting and genomic DNA extraction is given in Chapter 1.

Loci studied, PCR amplification and sequencing

I analyzed nucleotide polymorphism in two trait specific genes, waxy (*Wx*), the gene associated with granule bound starch synthesis and *OsC1*, the gene associated with anthocyanin biosynthesis and apicule coloration. Nucleotide sequences of oligonucleotide primers used for amplification and sequencing are given in Table 3.2. A portion of the *Wx* gene (~2.7-kb region) including the previously identified intron 1 splice donor site mutation, promoter sequence, entire exon 1, intron 1, the 5′ end of exon 2, and the entire noncoding region within exon 2 (Figure 3.1A) were sequenced following the protocol of Olsen and Purugganan (2002). The *OsC1* gene region (~1.3-kb region) (Figure 3.1B) was amplified and sequenced following Saitoh *et al*. (2004).

Table 3.1: Rice variety names, phenotype, and functional mutations at the *Wx* and *OsC1* gene regions

Variety	Grain quality	*Wx* 5' splice site	*Wx* CTn	Apiculus color	*OsC1* 10 bp deletion
Bas Beroin	Glutinous	T	17	Colored	No
Til Bora	Glutinous	T	17	Colored	No
Ranga Borah	Glutinous	G	11	Colorless	Yes
Kakiberoin	Glutinous	G	11	Colorless	Yes
Borua Beroin	Glutinous	T	17	Colorless	No
Joha	Non Glutinous	G	18	Colored	No
Bherapawa	Non Glutinous	G	17	Colored	No
Lallatoi	Non Glutinous	G	11	Colored	Yes
Kawanglawang	Non Glutinous	T	17	Colored	No
Hati Hali	Non Glutinous	G	18	Colored	No
Balam	Non Glutinous	G	11	Colored	No
Bashful	Non Glutinous	G	10	Colorless	No
Lahi	Non Glutinous	G	17	Colorless	No
Borjahinga	Non Glutinous	G	11	Colorless	No
Moircha	Non Glutinous	G	11	Colorless	Yes
Aubalam	Non Glutinous	G	11	Colorless	Yes
Papue	Non Glutinous	G	20	Colorless	Yes
Sorpuma	Non Glutinous	G	10	Colorless	Yes
Mimutim	Non Glutinous	G	18	Colorless	Yes
Local Basmati	Non Glutinous	G	11	Colorless	Yes
Arfa	Non Glutinous	G	11	Colorless	Yes
Mulahail	Non Glutinous	G	10	Colorless	Yes
Guaroi	Non Glutinous	G	17	Colorless	Yes
Harinarayan	Non Glutinous	G	17	Colorless	Yes
Ranjit	Non Glutinous	G	11	Colorless	Yes
IR8	Non Glutinous	G	11	Colorless	Yes
Bahadur	Non Glutinous	G	11	Colorless	Yes
Pankaj	Non Glutinous	G	12	Colorless	Yes
Joya	Non Glutinous	G	11	Colorless	Yes
O. rufipogon	Non Glutinous	G	7	Colored	No

Abbreviations: Wx, Waxy gene; CTn, number of CT repeats

Table 3.2: List of genes surveyed and primer sequences used in the study

Gene Name	Primer name	Primer sequence (5' - 3')	Functional association
Waxy (Olsen and Purugganan 2002)	WxU1F	GCCGAGGGACCTAATCTGC	Granule-bound starch synthase
	Wx1R	TGGTGTGGGTGGCTATTTGTAG	
	Wx2FaF	GCCCCGCATGTCATCGTC	
	Wx2R	GTTGTCTAGCTGTTGCTGTGGA	
	Wx1Fint	TTGTCAGCACGTACAAGCA	
	Wx2Rint	GCTATATACATTTTCCTTTGACCAA	
OsC1 (Saitoh *et al.* 2004)	OsC1F1	ATCGCTCAGTCTCACACCGCA	Anthocyanin biosynthesis
	OsC1F3	GAGGGA GAATGGGGAGGAGAGC	
	OsCF4	TAATTGTGATCTGTATGGATGCTG	
	OsC1F5	GATCGATCGTGTATATATGTTGTCAGGT	
	OsC1R6	GTTGCTGTGTCGGTGT CGGCG	
	OsC1R7	ATGGCCGTCTCCTAATTCCCCTGC	
	OsC1R2	CGTACGGACGACGAACTAATGTCAC	

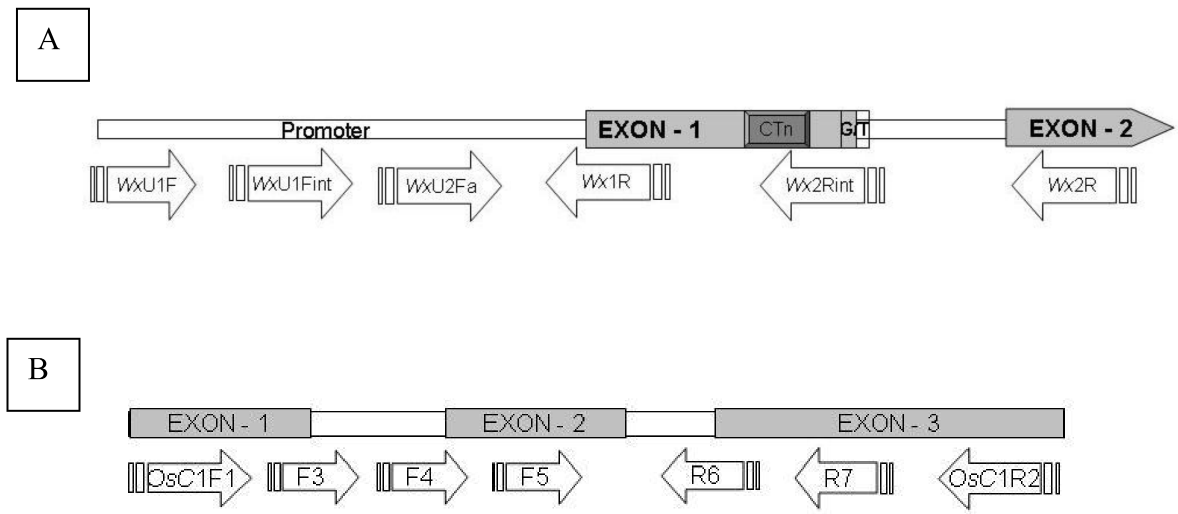

Figure 3.1: The locations of the coding and non-coding regions of *Wx* (A) and *OsC1* (B) genes. Arrows at the bottom indicate primers used for PCR amplification.

PCR amplifications were performed in an Applied Biosystems thermal cycler in a total volume of 25 μL reaction mixture consisting of 0.25 mM dNTP, 2.0 mM $MgCl_2$, 2.5 μL of 10X buffer, 1.5 pmol of each primer and 0.2 U *Taq* polymerase. The thermal cycling profiles as described in previous publications (*Wx*: Olsen and Purugganan 2002, and *OsC1*: Saitoh *et al*. 2004) were followed. The amplified DNA products were separated through electrophoresis on 1% agarose gels containing with 0.33 μg/ml ethidium bromide. The electrophoresis was performed at 90 V for 40 minutes in a 24 cm long electrophoretic apparatus containing 1 X TBE electrode buffer. DNA fragments on agarose gels were visualized using an ultraviolet (302 nm) transilluminator (UVP Inc), and the size of the amplified DNA fragments was determined using GeneRuler 1kb DNA ladder (Fermentas) as a size standard. The PCR products were either directly sequenced or sequenced after purification using Bio-Basic PCR product purification kit (Bio-Basic inc.). DNA sequences of the two genes (*Wx* and *OsC1*) obtained for this study are given in appendix 1 and 2.

Data analysis

DNA sequence chromatograms were analyzed using the software program Geneious version 5.4.6 (http://www.geneious.com/) and visually inspected for any ambiguities. The resulting consensus DNA sequences were aligned using the software program ClustalW v2 (Larkin *et al.* 2007). The coding and non-coding regions of the gene were identified by comparison with annotated DNA sequences of corresponding genes downloaded from the genbank.

In order to examine the patterns of nucleotide diversity resulting from evolutionary changes in DNA sequences in relation to neutral expectations and signatures of selection during the domestication process, several analyses as described below were performed using the software program DnaSP version 5.1 (Librado and Rozas 2009). The θ_w based on the number of segregating sites (Watterson 1975), π based on mean pairwise nucleotide differences among sequences (Nei, 1987), Tajima's *D* (Tajima 1989), Fu and Li's *D** and *F** (Fu and Li 1993) were calculated, and McDonald and Kreitman (1991) analysis was performed. *D** and *F** are more sensitive than Tajima's *D* in detecting deviations from neutrality based on low-frequency polymorphisms, population expansion and positive selection (Fu and Li 1993). The McDonald Kreitman (1991) test is insensitive to demographic histories and geographic structuring of the populations. Thus, use of a variety of approaches that differ in underlying assumptions provides a means to discern the historical processes associated with shaping the patterns of nucleotide diversity. The changes in nucleotide diversity and associated statistic in different regions of the gene was examined using the sliding-window analysis approach. The rates of synonymous (*dS*) and non-synonymous (*dN*) substitution in each of the selected genes among different rice types were calculated. The ratio of *dN/dS* provides an insight into the long-term selective pressure and purifying selection during the domestication process.

Results

A total of 53 indel polymorphisms with an average length of 3.525 were detected from the two sequenced regions (Table 3.3). The size of indels varied in length and ranged from one to 20 nucleotides and distributed along both coding and noncoding regions. Single nucleotide polymorphisms (SNP) were more frequent than indels. Total numbers of SNPs found among the sequenced regions were 91 with an average of 1 SNP at every 44.33 nucleotides.

Polymorphism of the Wx gene

The aligned length, including both coding and non-coding regions of the *Wx* gene was 2770 nucleotides. A total of 50 indels were detected with an average length of 2.12 nucleotides across all samples. The exon 1 (5' untranslated region) of the *Wx* gene contained a highly variable microsatellites (CT_n). A total of seven alleles of this microsatellite (n = 7, 10, 11, 12, 17, 18, and 20) were detected among rice varieties included in the present study. Alleles CT_{10}, CT_{11}, CT_{17}, and CT_{18} were found in 3, 13, 8 and 3 cultivated varieties respectively. The CT_{12} and CT_{20} alleles were found in one cultivated variety each. A unique CT_7 allele was found in the wild rice *O. rufipogon*. The number of SNPs was higher than the number of indels, with a total of 84 SNPs resulting in average 1 SNP for 32.98 bp among all samples. Relatively fewer SNP (1) and indels (6) were found in glutinous varieties than in the nonglutinous varieties (17 indels and 7 SNPs). The total number of mutations was also higher among the nonglutinous varieties than in the glutinous varieties (Table 3.4).

The G to T mutation at the 5' splice donor site of the *Wx* intron 1, which is known to be associated with drastic reduction in amylose synthesis in glutinous rice varieties

Table 3.3: Lengths of aligned gene regions (bp) and site categories

Gene region	Total length including indels	Total no. of sites excluding indels	No. of indels sites	No. of indel polymorphisms	Length of coding region excluding indels	Length of coding region including indels	Length of noncoding region excluding indels	Length of noncoding region including indels	SNP
Waxy	2770	2574	195	50	177	197	2574	2593	84
OsC1	1296	1284	12	3	809	824	475	476	7

(Sano 1984) was not consistently present among glutinous rice varieties included in the present study. The results revealed that T nucleotide was present in four varieties, while G nucleotide was found in the remaining 25 cultivated rice varieties and in the wild rice. The T nucleotide was found in three of the five glutinous varieties (*Borua Beroin*, *Bas Beroin* and *Til Bora*), and G nucleotide was present in other two glutinous (*Ranga Borah* and *Kakiberoin*) varieties. On the contrary, the T nucleotide at this site was found in one of the nonglutinous (*Kawanglawang*) varieties.

The nucleotide diversity analyses results showed that nucleotide diversity of glutinous varieties was higher (π_{tot} = 0.0053; θ_{tot} = 0.0043) than the nonglutinous varieties (π_{tot} = 0.0043; θ_{tot} = 0.0033). The sliding window analysis of the *Wx* gene revealed high nucleotide diversity at three regions located at 1 to 600, 1150 to 2000 and 2300 to 2500 bp of the gene. This analysis further revealed that polymorphic sites were mostly located at the beginning and end of the promoter region, the exon 1 carrying the microsatellite and the first part of intron 1 (Figure 3.2).

Neutrality analysis at the Wx locus

The estimates of Tajima's *D* and Fu and Li's *D** and *F** showed positive values for glutinous and nonglutinous varieties at the *Wx* locus (Table 3.4), indicating overdominant selection or population size reduction. The sliding window analyses of Tajima's *D* showed that glutinous varieties had only positive values while nonglutinous varieties had both positive and negative values at different regions of the gene (Figure 3.3). Negative *D* values were detected in the regions between 1357-1432, 1575-1655, 2400-2476, 2659-2735 bp only in nonglutinous varieties. These regions are located in the

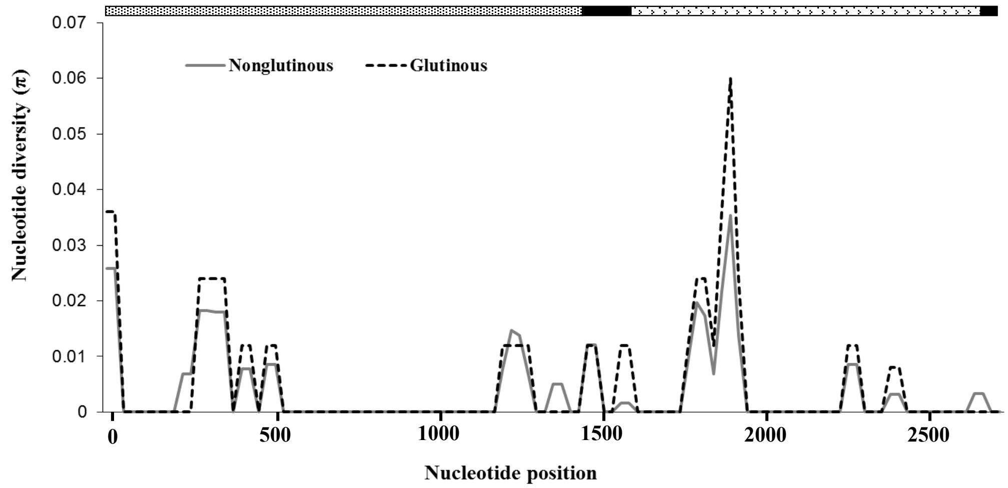

Figure 3.2: Nei's Nucleotide diversity (π) patterns along *Wx* gene (promoter region; exon; intron) in sliding window among glutinous and nonglutinous grain types. Analysis was performed using a window length of 50 bp and steps of 25 bp (■ promoter region; ▥ exon; ⬚ intron).

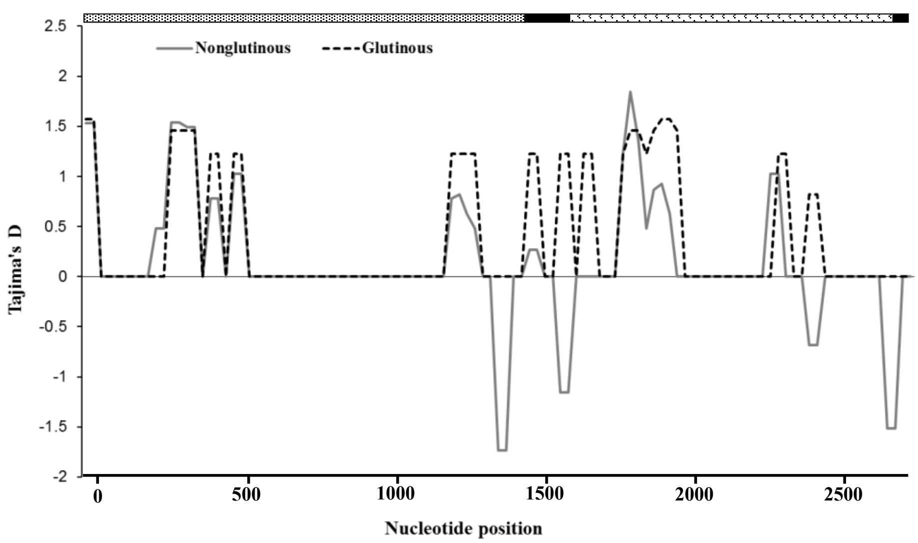

Figure 3.3: Tajima's *D* statistics in sliding window analysis for the *Wx* locus among glutinous and nonglutinous rice varieties. Computation was performed using a window length of 50 bp and steps of 25 bp (▥ promoter; ■ exon; ⬚ intron).

Table 3.4: Levels of nucleotide variation at the two studied gene regions

Gene	Ecotype	Indel	SNP	S	π_{tot}	θ_{tot}	dN/dS	*D*	*D**	*F**
Wx	Glutinous	6	1	23	0.0053	0.0043	-	1.7295	1.7295	1.8583
	Nonglutinous	17	7	31	0.0043	0.0033		1.1825	0.9145	1.369
OsC1	Colored	2	1	6	0.0023	0.0020	-	0.8109	1.0088	1.1449
	Colorless	3	8	10	0.0010	0.0021	1.00	-1.7683	-1.2847	-1.7178

S, number of segregating sites; π, average number of nucleotide differences per site between two sequences (Nei 1987) calculated on the total number of polymorphic sites (π_{tot}); silent sites (π_{sil}); synonymous sites (π_{syn}); nonsynonymous sites (π_{nonsyn}); θ, Watterson's estimator of nucleotide polymorphism per base pair (Watterson 1975) calculated on the total number of segregating sites (θ_{tot}); silent sites (θ_{sil}); synonymous sites (θ_{syn}); nonsynonymous sites (θ_{nonsyn}); D, Tajima's *D* (Tajima 1989); *D**, Fu and Li's *D**; *F**, Fu and Li's *F** (Fu and Li 1993).

§Tajima's *D*, *Fu and Li's *D** and *F** not significant (P> 0.10).

intron-1 and 2 and the exon-1 of the *Wx* gene. However, the values of *D* or *D** and *F** did not differ significantly from zero. Therefore, the observed pattern of variability is not significantly different from expected variability under the neutral model of evolution and neutrality hypothesis cannot be rejected. The McDonald and Kreitman test did not show departure from neutrality for the glutinous and non-glutinous varieties (Table 3.5) indicating no signature of positive selection at the *Wx* locus.

Polymorphism at the OsC1 gene

The aligned *OsC1* gene region was 1296 bp long and included both exons and introns. The results of the present study showed that 62% of the sequenced samples contained the 10 bp deletion in the R3 repeat region of the *OsC1* gene known to cause a frameshift leading to colorless apiculus in rice (Saitoh *et al*. 2004). In congruent with the expected phenotype of the genotype, the 10 bp deletion was found in 17 colorless apiculus varieties included in the present study and the corresponding deletion was absent in seven colored apiculus varieties and *O. rufipogon* (Table 3.1). However, there were incongruences between the genotype and the phenotype of several varieties examined in the present study. The 10 bp deletion was not found in four colorless apiculus varieties (*Bashful*, *Borua Beroin*, *Lahi* and *Borjahinga*), and the corresponding 10 bp deletion was found in one of the colored apiculus varieties (*Lallatoi*).

Three non-synonymous substitutions were detected in the coding regions of the *OsC1* gene. One single nucleotide polymorphism (SNP) was detected in the exon-1 with a mutation of G to C at the position 60 resulting in an amino acid change from positively charged Lysine to negatively charged Aspartic acid. Another SNP was detected in the exon-1 with a mutation of C to G at the position 122 in the variety *Bashful*, resulting in an amino acid change of non-polar Proline to positively charged Arginine. The other non-synonymous substitution was at the position 845 in the exon 3 with a mutation of G to T resulting in an amino acid change of Alanine to Valine (both hydrophobic). Other than these, eight SNPs were detected in the intronic regions of the *OsC1* gene among different cultivated varieties and wild rice.

The analyses of nucleotide sequences of the *OsC1* gene revealed three indels (average 3.22 bp long) and seven SNPs (average one SNP for every 185.14 bp) among sequenced samples. More indels and SNPs were found in colorless apiculus varieties than in the colored apiculus varieties (Table 3.4). However, the nucleotide diversity (π: Nei 1987) was higher in the colored apiculus rice varieties than in the colorless apiculus varieties (Table 3.4). The sliding window analysis of the *OsC1* gene showed that parts of the intron 2 and exon 3 at 400 to 625, 800 to 900 and 1050 to 1250 bp are polymorphic, and the nucleotide diversity in colored apiculus varieties are higher than the colorless apiculus rice varieties (Figure 3.4).

Neutrality analysis

The overall values of Tajima's *D* and Fu and Li's *D** and *F** were negative in colorless apiculus rice varieties, and positive in colored apiculus varieties (Table 3.4). The sliding window analyses of Tajima's *D* showed mostly negative values in colorless apiculus varieties and mostly positive values in the colored apiculus rice varieties (Figure 3.5). The negative D values in colorless apiculus varieties were detected at 25-150, 400-475, 525-700, 811-886 and 1161-1237 bp positions a positive value was observed at 475-

525 bp position. On the contrary, colored apiculus varieties showed positive *D* values in most regions (400-475, 525-625, 811-886 and 1161-1237 bp) and negative values at the 475-525 bp region (Figure 3.5). In general, the colorless apiculus varieties showed negative D values in the exon-1, intron-2 and exon-3, and positive D value in the intron-2. Interestingly, an opposite trend was observed in colored apiculus varieties with positive *D* values in intron-2 and exon-2 and negative *D* in value in intron-2. However, the D values were not significantly different from zero, and therefore neutrality hypothesis cannot be rejected. The McDonald and Kreitman test did not show evidence of selection in the *OsC1* gene (Table 3.5).

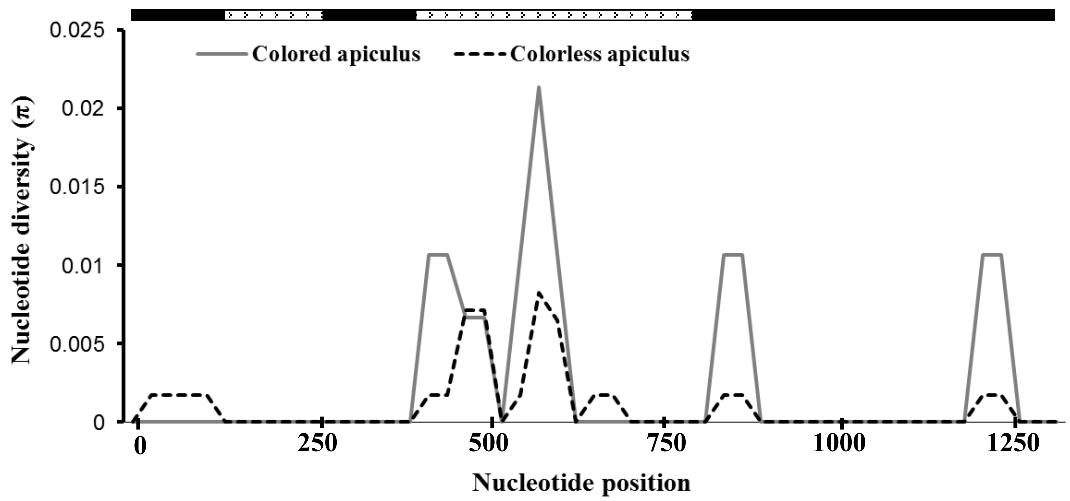

Figure 3.4: Nei's Nucleotide diversity (π) patterns along *OsC1* gene in sliding window among red and colorless colored apiculus in rice. Analysis was performed using a window length of 50 bp and steps of 25 bp. (exon; intron).

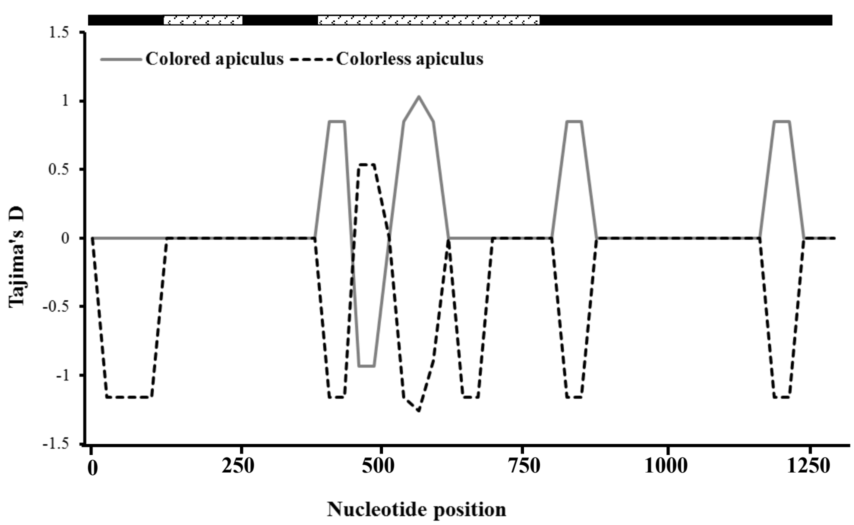

Figure 3.5: Tajima's D statistics in sliding window analysis for the *OsC1* locus among the colored and colorless apiculus rice grains. Computation was performed using a window length of 50 bp and steps of 25 bp. (■ exon; □ intron).

Table 3.5: McDonald-Kreitman test for the *Wx* and *OsC1* genes between different types and *O. rufipogon*

Locus	Ecotypes and grain qualities	Silent		Non Synonymous	
		[a]Fixed	Polymorphic	Fixed	Polymorphic
Wx	Glutinous	80	22	2	2
	Nonglutinous	80	25	2	3
OsC1	Red apiculus	3	6	1	0
	Colorless apiculus	3	8	1	2

[a]Fixed differences in comparison with *O. rufipogon*.

Discussion

The present study reports the findings of the analyses of DNA sequence variability of two trait specific genes in indigenous rice varieties in the Eastern Himalayan region of NE India. The *Wx* gene is associated with amylose synthesis, which determines the glutinous or nonglutinous nature of rice grains. The *OsC1* gene is involved in the synthesis of anthocyanin and associated with coloration of the apiculus in rice grains. The rice varieties used in this study include glutinous and nonglutinous as well as colored and colorless apiculus types collected from a broad geographic area covering most of the NE India.

The present study revealed that previously identified mutations do not exclusively contribute to the corresponding phenotypes in rice varieties. For example, the glutinous nature in most rice varieties is considered to be a result of a G to T mutation at the 5' splice donor site of exon 2 of the *Wx* gene (Wang *et al.* 1995; Hirano *et al*. 1998). In the present study, three of the five glutinous varieties carried the G to T mutation at the *Wx* gene, while this mutation was not detected in two of the five glutinous rice varieties. On the other hand, one of the 25 non-glutinous rice varieties carried the G to T mutation, while maintaining the non-glutinous phenotypes. This finding suggests that alternative genes or genomic regions other than the ones previously reported are associated with the glutinous and nonglutinous phenotype of the cultivated rice. Similarly, several reports indicated a correlation between variation in amylose content and the number of repeats in the microsatellite region within the *Wx* gene (Shu *et al*. 1999; Bao *et al*. 2006). Although the present study also reports the occurrence of highly variable microsatellite locus within the *Wx* gene, there was no direct correlation between the number of repeats and the glutinous nature of rice grains.

Analyses of the *OsC1* locus also revealed similar patterns. The colorless apiculus in rice varieties is often ascribed to a 10 bp deletion in the *OsC1* gene (Saitoh *et al*. 2004). Although 17 of 21 varieties with colorless apiculus included in the present study were associated with the 10 bp deletion in the *OsC1* gene, five varieties without the corresponding 10 bp deletion showed the colorless phenotype. Similarly, eight varieties without the 10 bp deletion showed colored apiculus phenotype as expected, whereas one of the varieties with the 10 bp deletion showed the colored apiculus phenotype. Thus, apiculus color phenotype of 18% of indigenous rice varieties in NE India did not correspond with the reported apiculus color determining genotype of the *OsC1* gene.

One of the varieties with colorless apiculus phenotype (*Mimutim*) had the 10bp deletion in the R3 region, however, showed the G to C nucleotide change resulting a substitution from Lysine to Aspartic acid and could have suppressed the phenotype. Another colorless apiculus variety (*Bashful*) without the 10 bp deletion showed an amino acid change from Proline to Arginine in exon-1 suggests that this mutation could be associated with the coloration of the apiculus. However, the other three colorless apiculus varieties (*Borua Beroin*, *Lahi* and *Borjahinga*), which lack the 10 bp deletion in exon-3, did not carry the Proline to Arginine amino acid change suggesting that other genomic regions also play a role in determination of the phenotype of the apiculus color. The mutation at the position 845 of the exon-3, which substitutes Alanine to Valine in three varieties and (*Tilbora*, *Kawanglawang* and *Balam*) and *O. rufipogon* showed no effect on the phenotype of the apiculus color, suggesting that the substitution of an amino acid with similar hydrophobicity at this position does not affect the apiculus color phenotype. Overall, these observations suggest that multiple genomic regions are involved in determining a particular phenotype. There are several examples of involvement of multiple genes or interacting loci in determination of the phenotype have been reported (Doebley *et al.* 1990; Olsen and Purugganan 2002, Zhu *et al.* 2012). Two of the SNPs, C to G mutation at position 122 in exon 1 and G to T mutation at position 845, had been previously identified (Saitoh *et al.* 2004). However, the mutation G to C at position 60 in exon 1 is reported for the first time in this study.

It is well known that the domestication process reduces the nucleotide diversity at domestication related genes that control specific traits selected during the domestication. In other words, genes that regulate particular trait under positive selection during domestication and improvement process may imprint 'signatures of selection' in the form of typical patterns of reduced nucleotide diversity (Tanksley and McCouch 1997). This is evidenced by much lower levels of nucleotide diversity among glutinous rice at the *Wx* gene as compared to the nonglutinous rice varieties (Olsen and Purugganan 2002; Wei-Hua *et al.* 2012). Similar observations of significantly reduced levels of nucleotide sequence polymorphism in the nonshattering *sh4* allele in the cultivated rice varieties as compared to wild progenitors (Zhang *et al.* 2009), and reduced diversity in the *ramosa1* gene in cultivated maize as compared to the wild teosintes that control branching architecture in the tassel and ear (Sigmon and Vollbrecht 2010) have been reported. However, the present study revealed higher levels of nucleotide diversity (π_{tot} = 0.0053) in the glutinous type varieties than in the nonglutinous type varieties (π_{tot} = 0.0043) at the *Wx* locus. This could be attributable to the fact that *Wx* gene, which has been associated with the glutinous nature of rice, may not be the sole gene that determines the glutinous phenotype. This phenotype is likely controlled by multiple loci which is further evidenced by the fact that the *Wx* intron 1 splice donor site mutation (G to T) is also found in some nonglutinous rice varieties reflecting that this mutation is not necessarily responsible for the expression of glutinous phenotype (Inukai *et al.* 2000; Yamanaka *et al.* 2004). Although selective sweeps may drastically reduce nucleotide diversity in target genes such as *Wx* locus (Olsen *et al.* 2006), the diversifying selection due to environmental heterogeneity and local cultural preferences may increase nucleotide diversity (Mikami *et al.* 2008). The existence of diverse agroclimatic conditions, and various cultural traditions of indigenous communities may have played a significant role in the maintenance of high levels of diversity in glutinous varieties of rice in NE India.

In the present study, positive values of Tajima D values were detected for the glutinous and non-glutinous varieties (Table 3.4) except for small regions of the *Wx* gene that showed negative values among nonglutinous varieties (Figure 3.3). Since the values of Tajima's *D* were not significantly different from zero, the overall distribution of nucleotide diversity falls within the neutral expectations (Table 3.4), and variability of Tajima D values could be considered only as general trends. Since demographic changes including population expansion or reduction may influence all regions of the genome equally, the differences in Tajima D within and between loci could be attributable to selection trends during the domestication process. Therefore, regions of the gene that show positive Tajima D values could be attributable to balancing or overdominant selection, whereas the regions of the gene with negative Tajima D value could be associated with the purifying selection. Signature of positive selection shown in the

McDonald and Kreitman test at the *Wx* gene may be linked to some traits of ecological adaptation into diverse agroclimatic conditions.

The *OsC1* gene showed lower levels of polymorphism and reduced nucleotide diversity among the colorless apiculus varieties as compared to colored apiculus varieties. The low level of nucleotide diversity is common in genes related to selected phenotypes (Olsen and Purugganan, 2002; Zhang *et al.* 2009). Sliding window analysis of the nucleotide diversity showed that most regions of reduced nucleotide diversity in *OsC1* gene were same between colored and colorless apiculus phenotypes (Figure 3.4). Such concordant loss of diversity could be attributable to population bottleneck during the domestication (Liu and Burke, 2006).

The evidence for selection among colorless apiculus varieties is detected through high dN/dS ratio at the *OsC1* locus (Table 3.4). As the gene is associated with synthesis of anthocyanins, which have multiple functions including plant defense responses and signal molecules in plant-microbe interactions (Dooner *et al*. 1991; Koes *et al*. 1994), selection of the gene among the cultivated rice varieties can not be ruled out. The negative values of the Tajima *D* values indicate an excess of rare alleles (Table 3.4) at the *OsC1* locus among the colorless apiculus varieties suggesting a possibility of purifying selection. In the present study, it has been found that colorless apiculus varieties possessed more negative *D* values in the coding regions compared to the colored apiculus counterpart. These patterns are consistent with a recent selective sweep at the *OsC1* gene among the colorless apiculus rice varieties. Translation of the coding regions of *OsC1* gene revealed that the sequences having the 10 bp deletion within the third exon drastically reduces the protein size from 272 amino acids to 206 amino acids. This might have significant impact in expression of the *OsC1* gene and regulation of apiculus coloration in rice.

Conclusion

The present study based on two trait specific genes, *Wx* and *OsC1* reported to be associated with amylose content and apiculus coloration respectively, showed that mutations considered to be associated with a given phenotype of the trait do not necessarily correspond to the phenotypes in indigenous rice varieties of NE India. This suggests that alternative genomic regions are also involved in controlling the amylose content and apiculus coloration in rice. Although statistically significant signatures of selection were not detected in either genes, low level of selection that varied across the length of each gene was evident.

General Conclusion

Indigenous rice varieties in the Eastern Himalayan region of NE India are cultivated in diverse eco-climatic condition in different seasons of the year. A wide range of morphological variation and grain qualities exist among the indigenous rice varieties of the region. However, preference for cultivation of high yielding agriculturally improved varieties is posing a threat to the indigenous rice gene pool of the region. Understanding the genetic diversity and population structure is important for developing conservation strategies and sustainable utilization of rice genetic resources.

In Chapter 1, genetic diversity and population structure of indigenous rice varieties were studied using SSR markers. Very high levels of genetic diversity, comparable to that of wild rice populations from other regions of the world, were detected among rice varieties traditionally cultivated in the Eastern Himalayan region of NE India. *Sali* ecotype showed the highest genetic diversity among ecotypes. Genetic diversity among indigenous varieties was much higher than the agronomically improved counterparts. Within variety genetic diversity among different indigenous rice varieties was also revealed in this study. This demonstrated the need for conservation of multiple individuals of the same variety to maintain the genetic variation among the traditional varieties. The study showed two major groups of rice varieties among the indigenous varieties. Though different ecotypes such as *Boro*, *jhum* and *Sali* were included in the present study, no detectable genetic clustering among or within these types was found.

The traditional method of rice classification into *indica* and *japonica* is largely based on morphology or cultivation type. However, such classification is often influenced by growing and local environmental conditions. In Chapter 2, I used indel markers specifically designed from *indica* and *japonica* whole genome sequences and classified rice varieties to two groups based on allele frequency data. The study showed that different ecotypes such as *Sali*, *Boro* and *jhum* primarily fall into either *indica* or *japonica* subspecies. A few indigenous varieties were found intermediate between the two groups. It demonstrated that indigenous rice varieties of Eastern Himalayan region in NE India are predominately *indica* type. Morphology or ecotype based classification did not correspond with the indel marker based classification in this study.

In Chapter 3, I studied two genes (*Wx* and *OsC1*) that regulate two important traits in rice. It was found that nucleotide mutations at a particular gene do not exclusively contribute for the corresponding trait phenotype, suggesting that alternative genomic regions may also be involved in determining the phenotype. Statistical analysis revealed no significant selection signatures in the sequences of either gene. However, low level of selection at certain regions of each gene was evident.

This study demonstrated very high level of genetic diversity among the indigenous rice varieties of Eastern Himalayan region in NE India. Such a rich genepool could serve as a repository of unique genes that might be harnessed to maintain the future food security in light of the changing climate. Therefore, urgent need for conservation of indigenous rice varieties is warranted before they are lost forever. Further studies based on genome wide patterns of nucleotide diversity are needed to better understanding the nature of rice gene pools of NE India for future use and conservation.

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APPENDICES

Appendix 1: Aligned nucleotide sequence data matrix of the *Wx* gene

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[                               10        20        30        40        50]
[                               .         .         .         .         .]
Papue               GGTTTTGCGGTTGAAGGACGGAAATTGGATTTATTGACAAGTCAAGGGAC   [50]
Lahi                GGTTTTGCGGTTGAAGGACGGAAATTGGATTTATTGACAAGTCAAGGGAC   [50]
Joha                GGTTTTGCGGTTGAAGGACGGAAATTGGATTTATTGACAAGTCAAGGGAC   [50]
Local Basmati       GGTTTTGCGGTTGAAGGACGGAAATTGGATTTATTGACAAGTCAAGGGAC   [50]
Sorpuma             GGTTTTGCGGTTGAAGGACGGAAATTGGATTCGTTGACAAGTTAAGGGAC   [50]
Kawanglawang        GGTTTTGCGGTTGAAGGACGGAAATTGGATTTATTGACAAGTCAAGGGAC   [50]
Borjahinga          GGTTTTGCGGTTGAAGGACGGAAATTGGATTCGTTGACAAGTTAAGGGAC   [50]
Til Bora            GGTTTTGCGGTTGAAGGACGGAAATTGGATTTATTGACAAGTCAAGGGAC   [50]
Hati Hali           GGTTTTGCGGTTGAAGGACGGAAATTGGATTCGTTGACAAGTTAAGGGAC   [50]
Ranjit              GGTTTTGCGGTTGAAGGACGGAAATTGGATTCGTTGACAAGTTAAGGGAC   [50]
Kakiberoin          GGTTTTGCGGTTGAAGGACGGAAATTGGATTTATTGACAAGTCAAGGGAC   [50]
Aubalam             GGTTTTGCGGTTGAAGGACGGAAATTGGATTCGTTGACAAGTTAAGGGAC   [50]
Balam               GGTTTTGCGGTTGAAGGACGGAAATTGGATTCGTTGACAAGTTAAGGGAC   [50]
Borua Beroin        GGTTTTGCGGTTGAAGGACGGAAATTGGATTCGTTGACAAGTTAAGGGAC   [50]
Lallatoi            GGTTTTGCGGTTGAAGGACGGAAATTGGATTCGTTGACAAGTTAAGGGAC   [50]
IR8                 GGTTTTGCGGTTGAAGGACGGAAATTGGATTCGTTGACAAGTTAAGGGAC   [50]
Arfa                GGTTTTGCGGTTGAAGGACGGAAATTGGATTCGTTGACAAGTTAAGGGAC   [50]
Bahadur             GGTTTTGCGGTTGAAGGACGGAAATTGGATTCGTTGACAAGTTAAGGGAC   [50]
Pankaj              GGTTTTGCGGTTGAAGGACGGAAATTGGATTCGTTGACAAGTTAAGGGAC   [50]
Bashful             GGTTTTGCGGTTGAAGGACGGAAATTGGATTCGTTGACAAGTTAAGGGAC   [50]
Moircha             GGTTTTGCGGTTGAAGGACGGAAATTGGATTCGTTGACAAGTTAAGGGAC   [50]
Joya                GGTTTTGCGGTTGAAGGACGGAAATTGGATTCGTTGACAAGTTAAGGGAC   [50]
Bas Beroin          GGTTTTGCGGTTGAAGGACGGAAATTGGATTTATTGACAAGTCAAGGGAC   [50]
Ranga Borah         GGTTTTGCGGTTGAAGGACGGAAATTGGATTCGTTGACAAGTTAAGGGAC   [50]
Mulahail            GGTTTTGCGGTTGAAGGACGGAAATTGGATTCGTTGACAAGTTAAGGGAC   [50]
Guaroi              GGTTTTGCGGTTGAAGGACGGAAATTGGATTCGTTGACAAGTTAAGGGAC   [50]
Mimutim             GGTTTTGCGGTTGAAGGACGGAAATTGGATTTATTGACAAGTCAAGGGAC   [50]
Harinarayn          GGTTTTGCGGTTGAAGGACGGAAATTGGATTTATTGACAAGTCAAGGGAC   [50]
Bherapawa           GGTTTTGCGGTTGAAGGACGGAAATTGGATTCGTTGACAAGTTAAGGGAC   [50]
O. rufipogon        GGTTTTGCGGTTGAAGGACGGAAATTGGATTCGTTGACAAGTCAAGGGAC   [50]

[                               60        70        80        90        100]
[                               .         .         .         .         .]
Papue               CTTAGATGAACTTATTCCTT-TTTATATTTGC-ACAGGCCTAATTT-CAA   [97]
Lahi                CTTAGATGAACTTATTCCTT-TTTATATTTGC-ACAGGCCTAATTT-CAA   [97]
Joha                CTTAGATGAACTTATTCCTT-TTTATATTTGC-ACAGGCCTAATTT-CAA   [97]
Local Basmati       CTTAGATGAACTTATTCCTT-TTTATATTTGC-ACAGGCCTAATTT-CAA   [97]
Sorpuma             CTTAGATGAACTTATTCCTT-TTTATATTTGC-ACAGGCCTAATTT-CAA   [97]
Kawanglawang        CTTAGATGAACTTATTCCTT-TTTATATTTGC-ACAGGCCTAATTT-CAA   [97]
Borjahinga          CTTAGATGAACTTATTCCTT-TTTATATTTGC-ACAGGCCTAATTT-CAA   [97]
Til Bora            CTTAGATGAACTTATTCCTT-TTTATATTTGC-ACAGGCCTAATTT-CAA   [97]
Hati Hali           CTTAGATGAACTTATTCCTT-TTTATATTTGC-ACAGGCCTAATTT-CAA   [97]
Ranjit              CTTAGATGAACTTATTCCTT-TTTATATTTGC-ACAGGCCTAATTT-CAA   [97]
Kakiberoin          CTTAGATGAACTTATTCCTT-TTTATATTTGC-ACAGGCCTAATTT-CAA   [97]
Aubalam             CTTAGATGAACTTATTCCTTATTTATATTTGC-ACAGGCCTAATTT-CAA   [98]
Balam               CTTAGATGAACTTATTCCTTATTTATATTTGC-ACAGGCCTAATTT-CAA   [98]
Borua Beroin        CTTAGATGAACTTATTCCTT-TTTATATTTGC-ACAGGCCTAATTT-CAA   [97]
Lallatoi            CTTAGATGAACTTATTCCTT-TTTATATTTGC-ACAGGCCTAATTT-CAA   [97]
IR8                 CTTAGATGAACTTATTCCTT-TTTATATTTGC-ACAGGCCTAATTT-CAA   [97]
Arfa                CTTAGATGAACTTATTCCTT-TTTATATTTGC-ACAGGCCTAATTT-CAA   [97]
Bahadur             CTTAGATGAACTTATTCCTT-TTTATATTTGC-ACAGGCCTAATTT-CAA   [97]
Pankaj              CTTAGATGAACTTATTCCTT-TTTATATTTGC-ACAGGCCTAATTT-CAA   [97]
Bashful             CTTAGATGAACTTATTCCTT-TTTATATTTGC-ACAGGCCTAATTT-CAA   [97]
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Moircha          CTTAGATGAACTTATTCCTT-TTTATATTTGC-ACAGGCCTAATTT-CAA   [97]
Joya             CTTAGATGAACTTATTCCTT-TTTATATTTGC-ACAGGCCTAATTT-CAA   [97]
Bas Beroin       CTTAGATGAACTTATTCCTT-TTTATATTTGC-ACAGGCCTAATTT-CAA   [97]
Ranga Borah      CTTAGATGAACTTATTCCTT-TTTATATTTGC-ACAGGCCTAATTT-CAA   [97]
Mulahail         CTTAGATGAACTTATTCCTT-TTTATATTTGC-ACAGGCCTAATTT-CAA   [97]
Guaroi           CTTAGATGAACTTATTCCTT-TTTATATTTGC-ACAGGCCTAATTT-CAA   [97]
Mimutim          CTTAGATGAACTTATTCCTT-TTTATATTTGC-ACAGGCCTAATTT-CAA   [97]
Harinarayn       CTTAGATGAACTTATTCCTT-TTTATATTTGC-ACAGGCCTAATTT-CAA   [97]
Bherapawa        CTTAGATGAACTTATTCCTT-TTTATATTTGC-ACAGGCCTAATTT-CAA   [97]
O. rufipogon     CTTAGATGAACTTATTCCTT-TTTATATTTGCTACAGGCCTAATTTGCAA   [99]

[                         110        120        130        140        150]
[                           .          .          .          .          .]
Papue            GTCCAGCCCAGCTTTCTTCAGCCTGTTTGATAATTCTCTC-TAGCTTATT   [146]
Lahi             GTCCAGCCCAGCTTTCTTCAGCCTGTTTGATAATTCTCTC-TAGCTTATT   [146]
Joha             GTCCAGCCCAGCTTTCTTCAGCCTGTTTGATAATTCTCTC-TAGCTTATT   [146]
Local Basmati    GTCCAGCCCAGCTTTCTTCAGCCTGTTTGATAATTCTCTC-TAGCTTATT   [146]
Sorpuma          GTCCAGCCCAGCTTTCTTCAGCCTGTTTGATAATTCTCTC-TAGCTTATT   [146]
Kawanglawang     GTCCAGCCCAGCTTTCTTCAGCCTGTTTGATAATTCTCTC-TAGCTTATT   [146]
Borjahinga       GTCCAGCCCAGCTTTCTTCAGCCTGTTTGATAATTCTCTC-TAGCTTATT   [146]
Til Bora         GTCCAGCCCAGCTTTCTTCAGCCTGTTTGATAATTCTCTC-TAGCTTATT   [146]
Hati Hali        GTCCAGCCCAGCTTTCTTCAGCCTGTTTGATAATTCTCTC-TAGCTTATT   [146]
Ranjit           GTCCAGCCCAGCTTTCTTCAGCCTGTTTGATAATTCTCTC-TAGCTTATT   [146]
Kakiberoin       GTCCAGCCCAGCTTTCTTCAGCCTGTTTGATAATTCTCTC-TAGCTTATT   [146]
Aubalam          GTCCAGCCCAGCTTTCTTCAGCCTGTTTGATAATTCTCTC-TAGCTTATT   [147]
Balam            GTCCAGCCCAGCTTTCTTCAGCCTGTTTGATAATTCTCTC-TAGCTTATT   [147]
Borua Beroin     GTCCAGCCCAGCTTTCTTCAGCCTGTTTGATAATTCTCTC-TAGCTTATT   [146]
Lallatoi         GTCCAGCCCAGCTTTCTTCAGCCTGTTTGATAATTCTCTC-TAGCTTATT   [146]
IR8              GTCCAGCCCAGCTTTCTTCAGCCTGTTTGATAATTCTCTC-TAGCTTATT   [146]
Arfa             GTCCAGCCCAGCTTTCTTCAGCCTGTTTGATAATTCTCTC-TAGCTTATT   [146]
Bahadur          GTCCAGCCCAGCTTTCTTCAGCCTGTTTGATAATTCTCTC-TAGCTTATT   [146]
Pankaj           GTCCAGCCCAGCTTTCTTCAGCCTGTTTGATAATTCTCTC-TAGCTTATT   [146]
Bashful          GTCCAGCCCAGCTTTCTTCAGCCTGTTTGATAATTCTCTC-TAGCTTATT   [146]
Moircha          GTCCAGCCCAGCTTTCTTCAGCCTGTTTGATAATTCTCTC-TAGCTTATT   [146]
Joya             GTCCAGCCCAGCTTTCTTCAGCCTGTTTGATAATTCTCTC-TAGCTTATT   [146]
Bas Beroin       GTCCAGCCCAGCTTTCTTCAGCCTGTTTGATAATTCTCTC-TAGCTTATT   [146]
Ranga Borah      GTCCAGCCCAGCTTTCTTCAGCCTGTTTGATAATTCTCTC-TAGCTTATT   [146]
Mulahail         GTCCAGCCCAGCTTTCTTCAGCCTGTTTGATAATTCTCTC-TAGCTTATT   [146]
Guaroi           GTCCAGCCCAGCTTTCTTCAGCCTGTTTGATAATTCTCTC-TAGCTTATT   [146]
Mimutim          GTCCAGCCCAGCTTTCTTCAGCCTGTTTGATAATTCTCTC-TAGCTTATT   [146]
Harinarayn       GTCCAGCCCAGCTTTCTTCAGCCTGTTTGATAATTCTCTC-TAGCTTATT   [146]
Bherapawa        GTCCAGCCCAGCTTTCTTCAGCCTGTTTGATAATTCTCTC-TAGCTTATT   [146]
O. rufipogon     GTCCAGCCCAGCTTTCTTCAGCCTGTTTGATAAGTCTCTCATAGCTTATT   [149]

[                         160        170        180        190        200]
[                           .          .          .          .          .]
Papue            ACAGCCG-TGGGAGAGGAGATATACAGCTACAAGATTACAAGTCGATGTA   [195]
Lahi             ACAGCCG-TGGGAGAGGAGATATACAGCTACAAGATTACAAGTCGATGTA   [195]
Joha             ACAGCCG-TGGGAGAGGAGATATACAGCTACAAGATTACAAGTCGATGTA   [195]
Local Basmati    ACAGCCG-TGGGAGAGGAGATATACAGCTACAAGATTACAAGTCGATGTA   [195]
Sorpuma          ACAGCCG-TGGGAGAGGAGATATACAGCTACAAGATTACAAGTCGATGTA   [195]
Kawanglawang     ACAGCCG-TGGGAGAGGAGATATACAGCTACAAGATTACAAGTCGATGTA   [195]
Borjahinga       ACAGCCG-TGGGAGAGGAGATATACAGCTACAAGATTACAAGTCGATGTA   [195]
Til Bora         ACAGCCG-TGGGAGAGGAGATATACAGCTACAAGATTACAAGTCGATGTA   [195]
Hati Hali        ACAGCCG-TGGGAGAGGAGATATACAGCTACAAGATTACAAGTCGATGTA   [195]
Ranjit           ACAGCCG-TGGGAGAGGAGATATACAGCTACAAGATTACAAGTCGATGTA   [195]
Kakiberoin       ACAGCCG-TGGGAGAGGAGATATACAGCTACAAGATTACAAGTCGATGTA   [195]
Aubalam          ACAGCCG-TGGGAGAGGAGATATACAGCTACAAGATTACAAGTCGATGTA   [196]
Balam            ACAGCCG-TGGGAGAGGAGATATACAGCTACAAGATTACAAGTCGATGTA   [196]
Borua Beroin     ACAGCCG-TGGGAGAGGAGATATACAGCTACAAGATTACAAGTCGATGTA   [195]
Lallatoi         ACAGCCG-TGGGAGAGGAGATATACAGCTACAAGATTACAAGTCGATGTA   [195]
IR8              ACAGCCG-TGGGAGAGGAGATATACAGCTACAAGATTACAAGTCGATGTA   [195]
Arfa             ACAGCCG-TGGGAGAGGAGATATACAGCTACAAGATTACAAGTCGATGTA   [195]
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Bahadur          ACAGCCG-TGGGAGAGGAGATATACAGCTACAAGATTACAAGTCGATGTA   [195]
Pankaj           ACAGCCG-TGGGAGAGGAGATATACAGCTACAAGATTACAAGTCGATGTA   [195]
Bashful          ACAGCCG-TGGGAGAGGAGATATACAGCTACAAGATTACAAGTCGATGTA   [195]
Moircha          ACAGCCG-TGGGAGAGGAGATATACAGCTACAAGATTACAAGTCGATGTA   [195]
Joya             ACAGCCG-TGGGAGAGGAGATATACAGCTACAAGATTACAAGTCGATGTA   [195]
Bas Beroin       ACAGCCG-TGGGAGAGGAGATATACAGCTACAAGATTACAAGTCGATGTA   [195]
Ranga Borah      ACAGCCG-TGGGAGAGGAGATATACAGCTACAAGATTACAAGTCGATGTA   [195]
Mulahail         ACAGCCG-TGGGAGAGGAGATATACAGCTACAAGATTACAAGTCGATGTA   [195]
Guaroi           ACAGCCG-TGGGAGAGGAGATATACAGCTACAAGATTACAAGTCGATGTA   [195]
Mimutim          ACAGCCG-TGGGAGAGGAGATATACAGCTACAAGATTACAAGTCGATGTA   [195]
Harinarayn       ACAGCCG-TGGGAGAGGAGATATACAGCTACAAGATTACAAGTCGATGTA   [195]
Bherapawa        ACAGCCG-TGGGAGAGGAGATATACAGCTACAAGATTACAAGTCGATGTA   [195]
O. rufipogon     ACAGCCGCTGGGAGAGGAGATATACAGCTACAAGATTACAAGTCGATGTA   [199]

[                         210       220       230       240       250]
[                           .         .         .         .         .]
Papue            TACAGCAAACCCATGAGCTGATTGCCTGATTAGACG--GTAAGAATGCAT   [243]
Lahi             TACAGCAAACCCATGAGCTGATTGCCTGATTAGACG--GTAAGAATGCAT   [243]
Joha             TACAGCAAACCCATGAGCTGATTGCCTGATTAGACG--GTAAGAATGCAT   [243]
Local Basmati    TACAGCAAACCCATGAGCTGATTGCCTGATTAGACG--GTAAGAATGCAT   [243]
Sorpuma          TACAGCAAACCCATGAGCTGATTGCCTGATTAGACGCGGTAAGAATGCAT   [245]
Kawanglawang     TACAGCAAACCCATGAGCTGATTGCCTGATTAGACG--GTAAGAATGCAT   [243]
Borjahinga       TACAGCAAACCCATGAGCTGATTGCCTGATTAGACGCGGTAAGAATGCAT   [245]
Til Bora         TACAGCAAACCCATGAGCTGATTGCCTGATTAGACG--GTAAGAATGCAT   [243]
Hati Hali        TACAGCAAACCCATGAGCTGATTGCCTGATTAGACG--GTAAGAATGCAT   [243]
Ranjit           TACAGCAAACCCATGAGCTGATTGCCTGATTAGACGCGGTAAGAATGCAT   [245]
Kakiberoin       TACAGCAAACCCATGAGCTGATTGCCTGATTAGACG--GTAAGAATGCAT   [243]
Aubalam          TACAGCAAACCCATGAGCTGATTGCCTGATTAGACGCGGTAAGAATGCAT   [246]
Balam            TACAGCAAACCCATGAGCTGATTGCCTGATTAGACGCGGTAAGAATGCAT   [246]
Borua Beroin     TACAGCAAACCCATGAGCTGATTGCCTGATTAGACGCGGTAAGAATGCAT   [245]
Lallatoi         TACAGCAAACCCATGAGCTGATTGCCTGATTAGACGCGGTAAGAATGCAT   [245]
IR8              TACAGCAAACCCATGAGCTGATTGCCTGATTAGACGCGGTAAGAATGCAT   [245]
Arfa             TACAGCAAACCCATGAGCTGATTGCCTGATTAGACGCGGTAAGAATGCAT   [245]
Bahadur          TACAGCAAACCCATGAGCTGATTGCCTGATTAGACGCGGTAAGAATGCAT   [245]
Pankaj           TACAGCAAACCCATGAGCTGATTGCCTGATTAGACGCGGTAAGAATGCAT   [245]
Bashful          TACAGCAAACCCATGAGCTGATTGCCTGATTAGACG--GTAAGAATGCAT   [243]
Moircha          TACAGCAAACCCATGAGCTGATTGCCTGATTAGACGCGGTAAGAATGCAT   [245]
Joya             TACAGCAAACCCATGAGCTGATTGCCTGATTAGACGCGGTAAGAATGCAT   [245]
Bas Beroin       TACAGCAAACCCATGAGCTGATTGCCTGATTAGACG--GTAAGAATGCAT   [243]
Ranga Borah      TACAGCAAACCCATGAGCTGATTGCCTGATTAGACGCGGTAAGAATGCAT   [245]
Mulahail         TACAGCAAACCCATGAGCTGATTGCCTGATTAGACG--GTAAGAATGCAT   [243]
Guaroi           TACAGCAAACCCATGAGCTGATTGCCTGATTAGACG--GTAAGAATGCAT   [243]
Mimutim          TACAGCAAACCCATGAGCTGATTGCCTGATTAGACG--GTAAGAATGCAT   [243]
Harinarayn       TACAGCAAACCCATGAGCTGATTGCCTGATTAGACG--GTAAGAATGCAT   [243]
Bherapawa        TACAGCAAACCCATGAGCTGATTGCCTGATTAGACG--GTAAGAATGCAT   [243]
O. rufipogon     TACAGCAAACCCATGAGCTGATTGCCTGATTAGACG--GTAAGAATGCAT   [247]

[                         260       270       280       290       300]
[                           .         .         .         .         .]
Papue            CCCTGAGAAGCAAATGCATCACCAAATTTGTAGCTTAGATAAATGCTGTG   [293]
Lahi             CCCTGAGAAGCAAATGCATCACCAAATTTGTAGCTTAGATAAATGCTGTG   [293]
Joha             CCCTGAGAAGCAAATGCATCACCAAATTTGTAGCTTAGATAAATGCTGTG   [293]
Local Basmati    CCCTGAGAAGCAAATGCATCACCAAATTTGTAGCTTAGATAAATGCTGTG   [293]
Sorpuma          CCCTGAGAAGCAAATGCATCACCAAATTTGTAGCTTAGATAAATGCTGTG   [295]
Kawanglawang     CCCTGAGAAGCAAATGCATCACCAAATTTGTAGCTTAGATAAATGCTGTG   [293]
Borjahinga       CCCTGAGAAGCAAATGCATCACCAAATTTGTAGCTTAGATAAATGCTGTG   [295]
Til Bora         CCCTGAGAAGCAAATGCATCACCAAATTTGTAGCTTAGATAAATGCTGTG   [293]
Hati Hali        CCCTGAGAAGCAAATGCATCACCAGATTTGTAGCTTAGATAAATGCTGTG   [293]
Ranjit           CCCTGAGAAGCAAATGCATCACCAAATTTGTAGCTTAGATAAATGCTGTG   [295]
Kakiberoin       CCCTGAGAAGCAAATGCATCACCAAATTTGTAGCTTAGATAAATGCTGTG   [293]
Aubalam          CCCTGAGAAGCAAATGCATCACCAAATTTGTAGCTTAGATAAATGCTGTG   [296]
Balam            CCCTGAGAAGCAAATGCATCACCAAATTTGTAGCTTAGATAAATGCTGTG   [296]
Borua Beroin     CCCTGAGAAGCAAATGCATCACCAAATTTGTAGCTTAGATAAATGCTGTG   [295]
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Lallatoi          CCCTGAGAAGCAAATGCATCACCAAATTTGTAGCTTAGATAAATGCTGTG   [295]
IR8               CCCTGAGAAGCAAATGCATCACCAAATTTGTAGCTTAGATAAATGCTGTG   [295]
Arfa              CCCTGAGAAGCAAATGCATCACCAAATTTGTAGCTTAGATAAATGCTGTG   [295]
Bahadur           CCCTGAGAAGCAAATGCATCACCAAATTTGTAGCTTAGATAAATGCTGTG   [295]
Pankaj            CCCTGAGAAGCAAATGCATCACCAAATTTGTAGCTTAGATAAATGCTGTG   [295]
Bashful           CCCTGAGAAGCAAATGCATCACCAGATTTGTAGCTTAGATAAATGCTGTG   [293]
Moircha           CCCTGAGAAGCAAATGCATCACCAAATTTGTAGCTTAGATAAATGCTGTG   [295]
Joya              CCCTGAGAAGCAAATGCATCACCAAATTTGTAGCTTAGATAAATGCTGTG   [295]
Bas Beroin        CCCTGAGAAGCAAATGCATCACCAAATTTGTAGCTTAGATAAATGCTGTG   [293]
Ranga Borah       CCCTGAGAAGCAAATGCATCACCAAATTTGTAGCTTAGATAAATGCTGTG   [295]
Mulahail          CCCTGAGAAGCAAATGCATCACCAGATTTGTAGCTTAGATAAATGCTGTG   [293]
Guaroi            CCCTGAGAAGCAAATGCATCACCAGATTTGTAGCTTAGATAAATGCTGTG   [293]
Mimutim           CCCTGAGAAGCAAATGCATCACCAAATTTGTAGCTTAGATAAATGCTGTG   [293]
Harinarayn        CCCTGAGAAGCAAATGCATCACCAAATTTGTAGCTTAGATAAATGCTGTG   [293]
Bherapawa         CCCTGAGAAGCAAATGCATCACCAGATTTGTAGCTTAGATAAATGCTGTG   [293]
O. rufipogon      CCCTGAGAAGCAAATGCATCACCAAATTTGTAGCTTAGATAAATGCTGTG   [297]

[                          310       320       330       340       350]
[                          .         .         .         .         .]
Papue             ACCTGCAAGAAAATAAAATTAAAATCAAAATAAAAGAAAAGCGCAGGTAA   [343]
Lahi              ACCTGCAAGAAAATAAAATTAAAATCAAAATAAAAGAAAAGCGCAGGTAA   [343]
Joha              ACCTGCAAGAAAATAAAATTAAAATCAAAATAAAAGAAAAGCGCAGGTAA   [343]
Local Basmati     ACCTGCAAGAAAACAAAATTAAAATCAAAAGAAAAGAAAAGCGCAGGTAA   [343]
Sorpuma           ACCTGCAAGAAAACAAAATTAAAATCAAAAGAAAAGAAAAGCGCAGGTAA   [345]
Kawanglawang      ACCTGCAAGAAAATAAAATTAAAATCAAAATAAAAGAAAAGCGCAGGTAA   [343]
Borjahinga        ACCTGCAAGAAAACAAAATTAAAATCAAAAGAAAAGAAAAGCGCAGGTAA   [345]
Til Bora          ACCTGCAAGAAAATAAAATTAAAATCAAAATAAAAGAAAAGCGCAGGTAA   [343]
Hati Hali         ACCTGCAAGAAAATAAAATTAAAATCAAAAGAAAAGAAAAGCGCAGGTAA   [343]
Ranjit            ACCTGCAAGAAAACAAAATTAAAATCAAAAGAAAAGAAAAGCGCAGGTAA   [345]
Kakiberoin        ACCTGCAAGAAAATAAAATTAAAATCAAAATAAAAGAAAAGCGCAGGTAA   [343]
Aubalam           ACCTGCAAGAAAACAAAATTAAAATCAAAAGAAAAGAAAAGCGCAGGTAA   [346]
Balam             ACCTGCAAGAAAACAAAATTAAAATCAAAAGAAAAGAAAAGCGCAGGTAA   [346]
Borua Beroin      ACCTGCAAGAAAACAAAATTAAAATCAAAAGAAAAGAAAAGCGCAGGTAA   [345]
Lallatoi          ACCTGCAAGAAAACAAAATTAAAATCAAAAGAAAAGAAAAGCGCAGGTAA   [345]
IR8               ACCTGCAAGAAAACAAAATTAAAATCAAAAGAAAAGAAAAGCGCAGGTAA   [345]
Arfa              ACCTGCAAGAAAACAAAATTAAAATCAAAAGAAAAGAAAAGCGCAGGTAA   [345]
Bahadur           ACCTGCAAGAAAACAAAATTAAAATCAAAAGAAAAGAAAAGCGCAGGTAA   [345]
Pankaj            ACCTGCAAGAAAACAAAATTAAAATCAAAAGAAAAGAAAAGCGCAGGTAA   [345]
Bashful           ACCTGCAAGAAAATAAAATTAAAATCAAAAGAAAAGAAAAGCGCAGGTAA   [343]
Moircha           ACCTGCAAGAAAACAAAATTAAAATCAAAAGAAAAGAAAAGCGCAGGTAA   [345]
Joya              ACCTGCAAGAAAACAAAATTAAAATCAAAAGAAAAGAAAAGCGCAGGTAA   [345]
Bas Beroin        ACCTGCAAGAAAATAAAATTAAAATCAAAATAAAAGAAAAGCGCAGGTAA   [343]
Ranga Borah       ACCTGCAAGAAAACAAAATTAAAATCAAAAGAAAAGAAAAGCGCAGGTAA   [345]
Mulahail          ACCTGCAAGAAAATAAAATTAAAATCAAAAGAAAAGAAAAGCGCAGGTAA   [343]
Guaroi            ACCTGCAAGAAAATAAAATTAAAATCAAAAGAAAAGAAAAGCGCAGGTAA   [343]
Mimutim           ACCTGCAAGAAAATAAAATTAAAATCAAAATAAAAGAAAAGCGCAGGTAA   [343]
Harinarayn        ACCTGCAAGAAAATAAAATTAAAATCAAAATAAAAGAAAAGCGCAGGTAA   [343]
Bherapawa         ACCTGCAAGAAAATAAAATTAAAATCAAAAGAAAAGAAAAGCGCAGGTAA   [343]
O. rufipogon      ACCTGCAAGAAAATAAAATTAAAATCAAAATAAAAGAAAAGCGCAGGTAA   [347]

[                          360       370       380       390       400]
[                          .         .         .         .         .]
Papue             TTGACACCCCACGCATATAAGTGTAGATACATAACACGTTCATCTAATCA   [393]
Lahi              TTGACACCCCACGCATATAAGTGTAGATACATAACACGTTCATCTAATCA   [393]
Joha              TTGACACCCCACGCATATAAGTGTAGATACATAACACGTTCATCTAATCA   [393]
Local Basmati     TTGACACCCCACGCATACAAGTGTAGATGCATAACACGTTCATCTAATCA   [393]
Sorpuma           TTGACACCCCACGCATACAAGTGTAGATGCATAACACGTTCATCTAATCA   [395]
Kawanglawang      TTGACACCCCACGCATATAAGTGTAGATACATAACACGTTCATCTAATCA   [393]
Borjahinga        TTGACACCCCACGCATACAAGTGTAGATGCATAACACGTTCATCTAATCA   [395]
Til Bora          TTGACACCCCACGCATATAAGTGTAGATACATAACACGTTCATCTAATCA   [393]
Hati Hali         TTGACACCCCACGCATACAAGTGTAGATACATAACACGTTCATCTAATCA   [393]
Ranjit            TTGACACCCCACGCATACAAGTGTAGATGCATAACACGTTCATCTAATCA   [395]
Kakiberoin        TTGACACCCCACGCATATAAGTGTAGATACATAACACGTTCATCTAATCA   [393]
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Aubalam              TTGACACCCCACGCATACAAGTGTAGATGCATAACACGTTCATCTAATCA   [396]
Balam                TTGACACCCCACGCATACAAGTGTAGATGCATAACACGTTCATCTAATCA   [396]
Borua Beroin         TTGACACCCCACGCATACAAGTGTAGATGCATAACACGTTCATCTAATCA   [395]
Lallatoi             TTGACACCCCACGCATACAAGTGTAGATGCATAACACGTTCATCTAATCA   [395]
IR8                  TTGACACCCCACGCATACAAGTGTAGATGCATAACACGTTCATCTAATCA   [395]
Arfa                 TTGACACCCCACGCATACAAGTGTAGATGCATAACACGTTCATCTAATCA   [395]
Bahadur              TTGACACCCCACGCATACAAGTGTAGATGCATAACACGTTCATCTAATCA   [395]
Pankaj               TTGACACCCCACGCATACAAGTGTAGATGCATAACACGTTCATCTAATCA   [395]
Bashful              TTGACACCCCACGCATACAAGTGTAGATACATAACACGTTCATCTAATCA   [393]
Moircha              TTGACACCCCACGCATACAAGTGTAGATGCATAACACGTTCATCTAATCA   [395]
Joya                 TTGACACCCCACGCATACAAGTGTAGATGCATAACACGTTCATCTAATCA   [395]
Bas Beroin           TTGACACCCCACGCATATAAGTGTAGATACATAACACGTTCATCTAATCA   [393]
Ranga Borah          TTGACACCCCACGCATACAAGTGTAGATGCATAACACGTTCATCTAATCA   [395]
Mulahail             TTGACACCCCACGCATACAAGTGTAGATGCATAACACGTTCATCTAATCA   [393]
Guaroi               TTGACACCCCACGCATACAAGTGTAGATACATAACACGTTCATCTAATCA   [393]
Mimutim              TTGACACCCCACGCATATAAGTGTAGATACATAACACGTTCATCTAATCA   [393]
Harinarayn           TTGACACCCCACGCATATAAGTGTAGATACATAACACGTTCATCTAATCA   [393]
Bherapawa            TTGACACCCCACGCATACAAGTGTAGATACATAACACGTTCATCTAATCA   [393]
O. rufipogon         TTGACACCCCACGCATATAAGTGTAGATACATAACACGTTCATCTAATCA   [397]

[                             410       420       430       440       450]
[                               .         .         .         .         .]
Papue                TCTTAATTAGACTTAGGTAAAACTACAATGAGGTTTATGTCCTACGGAAT   [443]
Lahi                 TCTTAATTAGACTTAGGTAAAACTACAATGAGGTTTATGTCCTACGGAAT   [443]
Joha                 TCTTAATTAGACTTAGGTAAAACTACAATGAGGTTTATGTCCTACGGAAT   [443]
Local Basmati        TCTTAATTAGACTTAGGTAAAACTACAATGAGGTTTATGTCCTACGGAAT   [443]
Sorpuma              TCTTAATTAGACTTAGGTAAAACTACAATGAGGTTTATGTCCTACGGAAT   [445]
Kawanglawang         TCTTAATTAGACTTAGGTAAAACTACAATGAGGTTTATGTCCTACGGAAT   [443]
Borjahinga           TCTTAATTAGACTTAGGTAAAACTACAATGAGGTTTATGTCCTACGGAAT   [445]
Til Bora             TCTTAATTAGACTTAGGTAAAACTACAATGAGGTTTATGTCCTACGGAAT   [443]
Hati Hali            TCTTAATTAGACTTAGGTAAAACTACAATGAGGTTTATGTCCTACGGAAT   [443]
Ranjit               TCTTAATTAGACTTAGGTAAAACTACAATGAGGTTTATGTCCTACGGAAT   [445]
Kakiberoin           TCTTAATTAGACTTAGGTAAAACTACAATGAGGTTTATGTCCTACGGAAT   [443]
Aubalam              TCTTAATTAGACTTAGGTAAAACTACAATGAGGTTTATGTCCTACGGAAT   [446]
Balam                TCTTAATTAGACTTAGGTAAAACTACAATGAGGTTTATGTCCTACGGAAT   [446]
Borua Beroin         TCTTAATTAGACTTAGGTAAAACTACAATGAGGTTTATGTCCTACGGAAT   [445]
Lallatoi             TCTTAATTAGACTTAGGTAAAACTACAATGAGGTTTATGTCCTACGGAAT   [445]
IR8                  TCTTAATTAGACTTAGGTAAAACTACAATGAGGTTTATGTCCTACGGAAT   [445]
Arfa                 TCTTAATTAGACTTAGGTAAAACTACAATGAGGTTTATGTCCTACGGAAT   [445]
Bahadur              TCTTAATTAGACTTAGGTAAAACTACAATGAGGTTTATGTCCTACGGAAT   [445]
Pankaj               TCTTAATTAGACTTAGGTAAAACTACAATGAGGTTTATGTCCTACGGAAT   [445]
Bashful              TCTTAATTAGACTTAGGTAAAACTACAATGAGGTTTATGTCCTACGGAAT   [443]
Moircha              TCTTAATTAGACTTAGGTAAAACTACAATGAGGTTTATGTCCTACGGAAT   [445]
Joya                 TCTTAATTAGACTTAGGTAAAACTACAATGAGGTTTATGTCCTACGGAAT   [445]
Bas Beroin           TCTTAATTAGACTTAGGTAAAACTACAATGAGGTTTATGTCCTACGGAAT   [443]
Ranga Borah          TCTTAATTAGACTTAGGTAAAACTACAATGAGGTTTATGTCCTACGGAAT   [445]
Mulahail             TCTTAATTAGACTTAGGTAAAACTACAATGAGGTTTATGTCCTACGGAAT   [443]
Guaroi               TCTTAATTAGACTTAGGTAAAACTACAATGAGGTTTATGTCCTACGGAAT   [443]
Mimutim              TCTTAATTAGACTTAGGTAAAACTACAATGAGGTTTATGTCCTACGGAAT   [443]
Harinarayn           TCTTAATTAGACTTAGGTAAAACTACAATGAGGTTTATGTCCTACGGAAT   [443]
Bherapawa            TCTTAATTAGACTTAGGTAAAACTACAATGAGGTTTATGTCCTACGGAAT   [443]
O. rufipogon         TCTTAATTAGACTTAGGTAAAACTACAATGAGGTTTATGTCCTACGGAAT   [447]

[                             460       470       480       490       500]
[                               .         .         .         .         .]
Papue                GACGACAAGCTAGCAGCACAGAGGCACAGATCATATCGTCTCCAGACTCA   [493]
Lahi                 GACGACAAGCTAGCAGCACAGAGGCACAGATCATATCGTCTCCAGACTCA   [493]
Joha                 GACGACAAGCTAGCAGCACAGAGGCACAGATCATATCGTCTCCAGACTCA   [493]
Local Basmati        GACGATAAGCTAGCAGCACAGAGGCACAGATCATATCGTCTCCAGACTCA   [493]
Sorpuma              GACGATAAGCTAGCAGCACAGAGGCACAGATCATATCGTCTCCAGACTCA   [495]
Kawanglawang         GACGACAAGCTAGCAGCACAGAGGCACAGATCATATCGTCTCCAGACTCA   [493]
Borjahinga           GACGATAAGCTAGCAGCACAGAGGCACAGATCATATCGTCTCCAGACTCA   [495]
Til Bora             GACGACAAGCTAGCAGCACAGAGGCACAGATCATATCGTCTCCAGACTCA   [493]
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Hati Hali           GACGATAAGCTAGCAGCACAGAGGCACAGATCATATCGTCTCCAGACTCA   [493]
Ranjit              GACGATAAGCTAGCAGCACAGAGGCACAGATCATATCGTCTCCAGACTCA   [495]
Kakiberoin          GACGACAAGCTAGCAGCACAGAGGCACAGATCATATCGTCTCCAGACTCA   [493]
Aubalam             GACGATAAGCTAGCAGCACAGAGGCACAGATCATATCGTCTCCAGACTCA   [496]
Balam               GACGATAAGCTAGCAGCACAGAGGCACAGATCATATCGTCTCCAGACTCA   [496]
Borua Beroin        GACGATAAGCTAGCAGCACAGAGGCACAGATCATATCGTCTCCAGACTCA   [495]
Lallatoi            GACGATAAGCTAGCAGCACAGAGGCACAGATCATATCGTCTCCAGACTCA   [495]
IR8                 GACGATAAGCTAGCAGCACAGAGGCACAGATCATATCGTCTCCAGACTCA   [495]
Arfa                GACGATAAGCTAGCAGCACAGAGGCACAGATCATATCGTCTCCAGACTCA   [495]
Bahadur             GACGATAAGCTAGCAGCACAGAGGCACAGATCATATCGTCTCCAGACTCA   [495]
Pankaj              GACGATAAGCTAGCAGCACAGAGGCACAGATCATATCGTCTCCAGACTCA   [495]
Bashful             GACGATAAGCTAGCAGCACAGAGGCACAGATCATATCGTCTCCAGACTCA   [493]
Moircha             GACGATAAGCTAGCAGCACAGAGGCACAGATCATATCGTCTCCAGACTCA   [495]
Joya                GACGATAAGCTAGCAGCACAGAGGCACAGATCATATCGTCTCCAGACTCA   [495]
Bas Beroin          GACGACAAGCTAGCAGCACAGAGGCACAGATCATATCGTCTCCAGACTCA   [493]
Ranga Borah         GACGATAAGCTAGCAGCACAGAGGCACAGATCATATCGTCTCCAGACTCA   [495]
Mulahail            GACGATAAGCTAGCAGCACAGAGGCACAGATCATATCGTCTCCAGACTCA   [493]
Guaroi              GACGATAAGCTAGCAGCACAGAGGCACAGATCATATCGTCTCCAGACTCA   [493]
Mimutim             GACGACAAGCTAGCAGCACAGAGGCACAGATCATATCGTCTCCAGACTCA   [493]
Harinarayn          GACGACAAGCTAGCAGCACAGAGGCACAGATCATATCGTCTCCAGACTCA   [493]
Bherapawa           GACGATAAGCTAGCAGCACAGAGGCACAGATCATATCGTCTCCAGACTCA   [493]
O. rufipogon        GACGACAAGCTAGCAGCACAGAGGCACAGATCATATCGTCTCCAGACTCA   [497]

[                            510       520       530       540       550]
[                              .         .         .         .         .]
Papue               AGTGCACGTTGATCGTTCGCTCACTGCTTCATCGATCATCCCTTTGTCGA   [543]
Lahi                AGTGCACGTTGATCGTTCGCTCACTGCTTCATCGATCATCCCTTTGTCGA   [543]
Joha                AGTGCACGTTGATCGTTCGCTCACTGCTTCATCGATCATCCCTTTGTCGA   [543]
Local Basmati       AGTGCACGTTGATCATTCGCTCACTGCTTCATCGATCATCCCTTTGTCGA   [543]
Sorpuma             AGTGCACGTTGATCATTCGCTCACTGCTTCATCGATCATCCCTTTGTCGA   [545]
Kawanglawang        AGTGCACGTTGATCGTTCGCTCACTGCTTCATCGATCATCCCTTTGTCGA   [543]
Borjahinga          AGTGCACGTTGATCATTCGCTCACTGCTTCATCGATCATCCCTTTGTCGA   [545]
Til Bora            AGTGCACGTTGATCGTTCGCTCACTGCTTCATCGATCATCCCTTTGTCGA   [543]
Hati Hali           AGTGCACGTTGATCATTCGCTCACTGCTTCATCGATCATCCCTTTGTCGA   [543]
Ranjit              AGTGCACGTTGATCATTCGCTCACTGCTTCATCGATCATCCCTTTGTCGA   [545]
Kakiberoin          AGTGCACGTTGATCGTTCGCTCACTGCTTCATCGATCATCCCTTTGTCGA   [543]
Aubalam             AGTGCACGTTGATCATTCGCTCACTGCTTCATCGATCATCCCTTTGTCGA   [546]
Balam               AGTGCACGTTGATCATTCGCTCACTGCTTCATCGATCATCCCTTTGTCGA   [546]
Borua Beroin        AGTGCACGTTGATCATTCGCTCACTGCTTCATCGATCATCCCTTTGTCGA   [545]
Lallatoi            AGTGCACGTTGATCATTCGCTCACTGCTTCATCGATCATCCCTTTGTCGA   [545]
IR8                 AGTGCACGTTGATCATTCGCTCACTGCTTCATCGATCATCCCTTTGTCGA   [545]
Arfa                AGTGCACGTTGATCATTCGCTCACTGCTTCATCGATCATCCCTTTGTCGA   [545]
Bahadur             AGTGCACGTTGATCATTCGCTCACTGCTTCATCGATCATCCCTTTGTCGA   [545]
Pankaj              AGTGCACGTTGATCATTCGCTCACTGCTTCATCGATCATCCCTTTGTCGA   [545]
Bashful             AGTGCACGTTGATCATTCGCTCACTGCTTCATCGATCATCCCTTTGTCGA   [543]
Moircha             AGTGCACGTTGATCATTCGCTCACTGCTTCATCGATCATCCCTTTGTCGA   [545]
Joya                AGTGCACGTTGATCATTCGCTCACTGCTTCATCGATCATCCCTTTGTCGA   [545]
Bas Beroin          AGTGCACGTTGATCGTTCGCTCACTGCTTCATCGATCATCCCTTTGTCGA   [543]
Ranga Borah         AGTGCACGTTGATCATTCGCTCACTGCTTCATCGATCATCCCTTTGTCGA   [545]
Mulahail            AGTGCACGTTGATCGTTCGCTCACTGCTTCATCGATCATCCCTTTGTCGA   [543]
Guaroi              AGTGCACGTTGATCATTCGCTCACTGCTTCATCGATCATCCCTTTGTCGA   [543]
Mimutim             AGTGCACGTTGATCGTTCGCTCACTGCTTCATCGATCATCCCTTTGTCGA   [543]
Harinarayn          AGTGCACGTTGATCGTTCGCTCACTGCTTCATCGATCATCCCTTTGTCGA   [543]
Bherapawa           AGTGCACGTTGATCATTCGCTCACTGCTTCATCGATCATCCCTTTGTCGA   [543]
O. rufipogon        AGTGCACGTTGATCGTTCGCTCACTGCTTCATCGATCATCCCTTTGTCGA   [547]

[                            560       570       580       590       600]
[                              .         .         .         .         .]
Papue               GGCGTTAGTTGGCAGGCACTAATAGCTACAGTAAAGTAAAGAGCAACGTG   [593]
Lahi                GGCGTTAGTTGGCAGGCACTAATAGCTACAGTAAAGTAAAGAGCAACGTG   [593]
Joha                GGCGTTAGTTGGCAGGCACTAATAGCTACAGTAAAGTAAAGAGCAACGTG   [593]
Local Basmati       GGCGTTAGTTGGCAGGCACTAATAGCTACAGTAAAGTAAAGAGCAACGTG   [593]
Sorpuma             GGCGTTAGTTGGCAGGCACTAATAGCTACAGTAAAGTAAAGAGCAACGTG   [595]
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Kawanglawang       GGCGTTAGTTGGCAGGCACTAATAGCTACAGTAAAGTAAAGAGCAACGTG   [593]
Borjahinga         GGCGTTAGTTGGCAGGCACTAATAGCTACAGTAAAGTAAAGAGCAACGTG   [595]
Til Bora           GGCGTTAGTTGGCAGGCACTAATAGCTACAGTAAAGTAAAGAGCAACGTG   [593]
Hati Hali          GGCGTTAGTTGGCAGGCACTAATAGCTACAGTAAAGTAAAGAGCAACGTG   [593]
Ranjit             GGCGTTAGTTGGCAGGCACTAATAGCTACAGTAAAGTAAAGAGCAACGTG   [595]
Kakiberoin         GGCGTTAGTTGGCAGGCACTAATAGCTACAGTAAAGTAAAGAGCAACGTG   [593]
Aubalam            GGCGTTAGTTGGCAGGCACTAATAGCTACAGTAAAGTAAAGAGCAACGTG   [596]
Balam              GGCGTTAGTTGGCAGGCACTAATAGCTACAGTAAAGTAAAGAGCAACGTG   [596]
Borua Beroin       GGCGTTAGTTGGCAGGCACTAATAGCTACAGTAAAGTAAAGAGCAACGTG   [595]
Lallatoi           GGCGTTAGTTGGCAGGCACTAATAGCTACAGTAAAGTAAAGAGCAACGTG   [595]
IR8                GGCGTTAGTTGGCAGGCACTAATAGCTACAGTAAAGTAAAGAGCAACGTG   [595]
Arfa               GGCGTTAGTTGGCAGGCACTAATAGCTACAGTAAAGTAAAGAGCAACGTG   [595]
Bahadur            GGCGTTAGTTGGCAGGCACTAATAGCTACAGTAAAGTAAAGAGCAACGTG   [595]
Pankaj             GGCGTTAGTTGGCAGGCACTAATAGCTACAGTAAAGTAAAGAGCAACGTG   [595]
Bashful            GGCGTTAGTTGGCAGGCACTAATAGCTACAGTAAAGTAAAGAGCAACGTG   [593]
Moircha            GGCGTTAGTTGGCAGGCACTAATAGCTACAGTAAAGTAAAGAGCAACGTG   [595]
Joya               GGCGTTAGTTGGCAGGCACTAATAGCTACAGTAAAGTAAAGAGCAACGTG   [595]
Bas Beroin         GGCGTTAGTTGGCAGGCACTAATAGCTACAGTAAAGTAAAGAGCAACGTG   [593]
Ranga Borah        GGCGTTAGTTGGCAGGCACTAATAGCTACAGTAAAGTAAAGAGCAACGTG   [595]
Mulahail           GGCGTTAGTTGGCAGGCACTAATAGCTACAGTAAAGTAAAGAGCAACGTG   [593]
Guaroi             GGCGTTAGTTGGCAGGCACTAATAGCTACAGTAAAGTAAAGAGCAACGTG   [593]
Mimutim            GGCGTTAGTTGGCAGGCACTAATAGCTACAGTAAAGTAAAGAGCAACGTG   [593]
Harinarayn         GGCGTTAGTTGGCAGGCACTAATAGCTACAGTAAAGTAAAGAGCAACGTG   [593]
Bherapawa          GGCGTTAGTTGGCAGGCACTAATAGCTACAGTAAAGTAAAGAGCAACGTG   [593]
O. rufipogon       GGCGTTAGTTGGCAGGCACTAATAGCTACAGTAAAGTAAAGAGCAACGTG   [597]

[                           610       620       630       640       650]
[                            .         .         .         .         .]
Papue              CCAACGTACGCACGCTAACGTGAGTCATGTAGCGTAATTCCAAGTTCTTT   [643]
Lahi               CCAACGTACGCACGCTAACGTGAGTCATGTAGCGTAATTCCAAGTTCTTT   [643]
Joha               CCAACGTACGCACGCTAACGTGAGTCATGTAGCGTAATTCCAAGTTCTTT   [643]
Local Basmati      CCAACGTACGCACGCTAACGTGAGTCATGTAGCGTAATTCCAAGTTCTTT   [643]
Sorpuma            CCAACGTACGCACGCTAACGTGAGTCATGTAGCGTAATTCCAAGTTCTTT   [645]
Kawanglawang       CCAACGTACGCACGCTAACGTGAGTCATGTAGCGTAATTCCAAGTTCTTT   [643]
Borjahinga         CCAACGTACGCACGCTAACGTGAGTCATGTAGCGTAATTCCAAGTTCTTT   [645]
Til Bora           CCAACGTACGCACGCTAACGTGAGTCATGTAGCGTAATTCCAAGTTCTTT   [643]
Hati Hali          CCAACGTACGCACGCTAACGTGAGTCATGTAGCGTAATTCCAAGTTCTTT   [643]
Ranjit             CCAACGTACGCACGCTAACGTGAGTCATGTAGCGTAATTCCAAGTTCTTT   [645]
Kakiberoin         CCAACGTACGCACGCTAACGTGAGTCATGTAGCGTAATTCCAAGTTCTTT   [643]
Aubalam            CCAACGTACGCACGCTAACGTGAGTCATGTAGCGTAATTCCAAGTTCTTT   [646]
Balam              CCAACGTACGCACGCTAACGTGAGTCATGTAGCGTAATTCCAAGTTCTTT   [646]
Borua Beroin       CCAACGTACGCACGCTAACGTGAGTCATGTAGCGTAATTCCAAGTTCTTT   [645]
Lallatoi           CCAACGTACGCACGCTAACGTGAGTCATGTAGCGTAATTCCAAGTTCTTT   [645]
IR8                CCAACGTACGCACGCTAACGTGAGTCATGTAGCGTAATTCCAAGTTCTTT   [645]
Arfa               CCAACGTACGCACGCTAACGTGAGTCATGTAGCGTAATTCCAAGTTCTTT   [645]
Bahadur            CCAACGTACGCACGCTAACGTGAGTCATGTAGCGTAATTCCAAGTTCTTT   [645]
Pankaj             CCAACGTACGCACGCTAACGTGAGTCATGTAGCGTAATTCCAAGTTCTTT   [645]
Bashful            CCAACGTACGCACGCTAACGTGAGTCATGTAGCGTAATTCCAAGTTCTTT   [643]
Moircha            CCAACGTACGCACGCTAACGTGAGTCATGTAGCGTAATTCCAAGTTCTTT   [645]
Joya               CCAACGTACGCACGCTAACGTGAGTCATGTAGCGTAATTCCAAGTTCTTT   [645]
Bas Beroin         CCAACGTACGCACGCTAACGTGAGTCATGTAGCGTAATTCCAAGTTCTTT   [643]
Ranga Borah        CCAACGTACGCACGCTAACGTGAGTCATGTAGCGTAATTCCAAGTTCTTT   [645]
Mulahail           CCAACGTACGCACGCTAACGTGAGTCATGTAGCGTAATTCCAAGTTCTTT   [643]
Guaroi             CCAACGTACGCACGCTAACGTGAGTCATGTAGCGTAATTCCAAGTTCTTT   [643]
Mimutim            CCAACGTACGCACGCTAACGTGAGTCATGTAGCGTAATTCCAAGTTCTTT   [643]
Harinarayn         CCAACGTACGCACGCTAACGTGAGTCATGTAGCGTAATTCCAAGTTCTTT   [643]
Bherapawa          CCAACGTACGCACGCTAACGTGAGTCATGTAGCGTAATTCCAAGTTCTTT   [643]
O. rufipogon       CCAACGTACGCACGCTAACGTGAGTCATGTAGCGTAATTCCAAGTTCTTT   [647]
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[                                 660       670       680       690       700]
[                                   .         .         .         .         .]
Papue               TTTTTTTGTCAGCACGTACAAGCAGCCGCTAGCCTCGCCCTGCATGAGAA   [693]
Lahi                TTTTTTTGTCAGCACGTACAAGCAGCCGCTAGCCTCGCCCTGCATGAGAA   [693]
Joha                TTTTTTTGTCAGCACGTACAAGCAGCCGCTAGCCTCGCCCTGCATGAGAA   [693]
Local Basmati       TTTTTTTGTCAGCACGTACAAGCAGCCGCTAGCCTCGCCCTGCATGAGAA   [693]
Sorpuma             TTTTTTTGTCAGCACGTACAAGCAGCCGCTAGCCTCGCCCTGCATGAGAA   [695]
Kawanglawang        TTTTTTTGTCAGCACGTACAAGCAGCCGCTAGCCTCGCCCTGCATGAGAA   [693]
Borjahinga          TTTTTTTGTCAGCACGTACAAGCAGCCGCTAGCCTCGCCCTGCATGAGAA   [695]
Til Bora            TTTTTTTGTCAGCACGTACAAGCAGCCGCTAGCCTCGCCCTGCATGAGAA   [693]
Hati Hali           TTTTTTTGTCAGCACGTACAAGCAGCCGCTAGCCTCGCCCTGCATGAGAA   [693]
Ranjit              TTTTTTTGTCAGCACGTACAAGCAGCCGCTAGCCTCGCCCTGCATGAGAA   [695]
Kakiberoin          TTTTTTTGTCAGCACGTACAAGCAGCCGCTAGCCTCGCCCTGCATGAGAA   [693]
Aubalam             TTTTTTTGTCAGCACGTACAAGCAGCCGCTAGCCTCGCCCTGCATGAGAA   [696]
Balam               TTTTTTTGTCAGCACGTACAAGCAGCCGCTAGCCTCGCCCTGCATGAGAA   [696]
Borua Beroin        TTTTTTTGTCAGCACGTACAAGCAGCCGCTAGCCTCGCCCTGCATGAGAA   [695]
Lallatoi            TTTTTTTGTCAGCACGTACAAGCAGCCGCTAGCCTCGCCCTGCATGAGAA   [695]
IR8                 TTTTTTTGTCAGCACGTACAAGCAGCCGCTAGCCTCGCCCTGCATGAGAA   [695]
Arfa                TTTTTTTGTCAGCACGTACAAGCAGCCGCTAGCCTCGCCCTGCATGAGAA   [695]
Bahadur             TTTTTTTGTCAGCACGTACAAGCAGCCGCTAGCCTCGCCCTGCATGAGAA   [695]
Pankaj              TTTTTTTGTCAGCACGTACAAGCAGCCGCTAGCCTCGCCCTGCATGAGAA   [695]
Bashful             TTTTTTTGTCAGCACGTACAAGCAGCCGCTAGCCTCGCCCTGCATGAGAA   [693]
Moircha             TTTTTTTGTCAGCACGTACAAGCAGCCGCTAGCCTCGCCCTGCATGAGAA   [695]
Joya                TTTTTTTGTCAGCACGTACAAGCAGCCGCTAGCCTCGCCCTGCATGAGAA   [695]
Bas Beroin          TTTTTTTGTCAGCACGTACAAGCAGCCGCTAGCCTCGCCCTGCATGAGAA   [693]
Ranga Borah         TTTTTTTGTCAGCACGTACAAGCAGCCGCTAGCCTCGCCCTGCATGAGAA   [695]
Mulahail            TTTTTTTGTCAGCACGTACAAGCAGCCGCTAGCCTCGCCCTGCATGAGAA   [693]
Guaroi              TTTTTTTGTCAGCACGTACAAGCAGCCGCTAGCCTCGCCCTGCATGAGAA   [693]
Mimutim             TTTTTTTGTCAGCACGTACAAGCAGCCGCTAGCCTCGCCCTGCATGAGAA   [693]
Harinarayn          TTTTTTTGTCAGCACGTACAAGCAGCCGCTAGCCTCGCCCTGCATGAGAA   [693]
Bherapawa           TTTTTTTGTCAGCACGTACAAGCAGCCGCTAGCCTCGCCCTGCATGAGAA   [693]
O. rufipogon        TTTTTTTGTCAGCACGTACAAGCAGCCGCTAGCCTCGCCCTGCATGAGAA   [697]

[                                 710       720       730       740       750]
[                                   .         .         .         .         .]
Papue               GCTCGCGGCGCGCCACC---AAACT-GGCAGGCACTCAGCTCGCTGCTGG   [739]
Lahi                GCTCGCGGCGCGCCACC---AAACT-GGCAGGCACTCAGCTCGCTGCTGG   [739]
Joha                GCTCGCGGCGCGCCACC---AAACT-GGCAGGCACTCAGCTCGCTGCTGG   [739]
Local Basmati       GCTCGCGGCGCGCCACC---AAACT-GGCAGGCACTCAGCTCGCTGCTGG   [739]
Sorpuma             GCTCGCGGCGCGCCACC---AAACT-GGCAGGCACTCAGCTCGCTGCTGG   [741]
Kawanglawang        GCTCGCGGCGCGCCACC---AAACT-GGCAGGCACTCAGCTCGCTGCTGG   [739]
Borjahinga          GCTCGCGGCGCGCCACC---AAACT-GGCAGGCACTCAGCTCGCTGCTGG   [741]
Til Bora            GCTCGCGGCGCGCCACC---AAACT-GGCAGGCACTCAGCTCGCTGCTGG   [739]
Hati Hali           GCTCGCGGCGCGCCACC---AAACT-GGCAGGCACTCAGCTCGCTGCTGG   [739]
Ranjit              GCTCGCGGCGCGCCACC---AAACT-GGCAGGCACTCAGCTCGCTGCTGG   [741]
Kakiberoin          GCTCGCGGCGCGCCACC---AAACT-GGCAGGCACTCAGCTCGCTGCTGG   [739]
Aubalam             GCTCGCGGCGCGCCACC---AAACT-GGCAGGCACTCAGCTCGCTGCTGG   [742]
Balam               GCTCGCGGCGCGCCACC---AAACT-GGCAGGCACTCAGCTCGCTGCTGG   [742]
Borua Beroin        GCTCGCGGCGCGCCACC---AAACT-GGCAGGCACTCAGCTCGCTGCTGG   [741]
Lallatoi            GCTCGCGGCGCGCCACC---AAACT-GGCAGGCACTCAGCTCGCTGCTGG   [741]
IR8                 GCTCGCGGCGCGCCACC---AAACT-GGCAGGCACTCAGCTCGCTGCTGG   [741]
Arfa                GCTCGCGGCGCGCCACC---AAACTGGGCAGGCACTCAGCTCGCTGCTGG   [742]
Bahadur             GCTCGCGGCGCGCCACC---AAACT-GGCAGGCACTCAGCTCGCTGCTGG   [741]
Pankaj              GCTCGCGGCGCGCCACC---AAACT-GGCAGGCACTCAGCTCGCTGCTGG   [741]
Bashful             GCTCGCGGCGCGCCACC---AAACT-GGCAGGCACTCAGCTCGCTGCTGG   [739]
Moircha             GCTCGCGGCGCGCCACC---AAACT-GGCAGGCACTCAGCTCGCTGCTGG   [741]
Joya                GCTCGCGGCGCGCCACC---AAACT-GGCAGGCACTCAGCTCGCTGCTGG   [741]
Bas Beroin          GCTCGCGGCGCGCCACC---AAACT-GGCAGGCACTCAGCTCGCTGCTGG   [739]
Ranga Borah         GCTCGCGGCGCGCCACC---AAACT-GGCAGGCACTCAGCTCGCTGCTGG   [741]
Mulahail            GCTCGCGGCGCGCCACC---AAACT-GGCAGGCACTCAGCTCGCTGCTGG   [739]
Guaroi              GCTCGCGGCGCGCCACC---AAACT-GGCAGGCACTCAGCTCGCTGCTGG   [739]
Mimutim             GCTCGCGGCGCGCCACC---AAACT-GGCAGGCACTCAGCTCGCTGCTGG   [739]
Harinarayn          GCTCGCGGCGCGCCACC---AAACTGGGCAGGCACTCAGCTCGCTGCTGG   [740]
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Bherapawa           GCTCGCGGCGCGCCACC---AAACT-GGCAGGCACTCAGCTCGCTGCTGG   [739]
O. rufipogon        GCTCGCGGCGCGCCACCCCAAAACT-GGCAGCCACTCAGCTCGCTGCTGG   [746]

[                           760       770       780       790       800]
[                             .         .         .         .         .]
Papue               TCCCGCACGTCGCCACACGATCGACG-TACGCACGCGAGCGAGATCCACC   [788]
Lahi                TCCCGCACGTCGCCACACGATCGACG-TACGCACGCGAGCGAGATCCACC   [788]
Joha                TCCCGCACGTCGCCACACGATCGACG-TACGCACGCGAGCGAGATCCACC   [788]
Local Basmati       TCCCGCACGTCGCCACACGATCGACG-TACGCACGCGAGCGAGATCCACC   [788]
Sorpuma             TCCCGCACGTCGCCACACGATCGACG-TACGCACGCGAGCGAGATCCACC   [790]
Kawanglawang        TCCCGCACGTCGCCACACGATCGACG-TACGCACGCGAGCGAGATCCACC   [788]
Borjahinga          TCCCGCACGTCGCCACACGATCGACGTTACGCACGCGAGCGAGATCCACC   [791]
Til Bora            TCCCGCACGTCGCCACACGATCGACG-TACGCACGCGAGCGAGATCCACC   [788]
Hati Hali           TCCCGCACGTCGCCACACGATCGACG-TACGCACGCGAGCGAGATCCACC   [788]
Ranjit              TCCCGCACGTCGCCACACGATCGACG-TACGCACGCGAGCGAGATCCACC   [790]
Kakiberoin          TCCCGCACGTCGCCACACGATCGACG-TACGCACGCGAGCGAGATCCACC   [788]
Aubalam             TCCCGCACGTCGCCACACGATCGACG-TACGCACGCGAGCGAGATCCACC   [791]
Balam               TCCCGCACGTCGCCACACGATCGACG-TACGCACGCGAGCGAGATCCACC   [791]
Borua Beroin        TCCCGCACGTCGCCACACGATCGACG-TACGCACGCGAGCGAGATCCACC   [790]
Lallatoi            TCCCGCACGTCGCCACACGATCGACG-TACGCACGCGAGCGAGATCCACC   [790]
IR8                 TCCCGCACGTCGCCACACGATCGACG-TACGCACGCGAGCGAGATCCACC   [790]
Arfa                TCCCGCACGTCGCCACACGATCGACG-TACGCACGCGAGCGAGATCCACC   [791]
Bahadur             TCCCGCACGTCGCCACACGATCGACG-TACGCACGCGAGCGAGATCCACC   [790]
Pankaj              TCCCGCACGTCGCCACACGATCGACG-TACGCACGCGAGCGAGATCCACC   [790]
Bashful             TCCCGCACGTCGCCACACGATCGACG-TACGCACGCGAGCGAGATCCACC   [788]
Moircha             TCCCGCACGTCGCCACACGATCGACG-TACGCACGCGAGCGAGATCCACC   [790]
Joya                TCCCGCACGTCGCCACACGATCGACG-TACGCACGCGAGCGAGATCCACC   [790]
Bas Beroin          TCCCGCACGTCGCCACACGATCGACG-TACGCACGCGAGCGAGATCCACC   [788]
Ranga Borah         TCCCGCACGTCGCCACACGATCGACG-TACGCACGCGAGCGAGATCCACC   [790]
Mulahail            TCCCGCACGTCGCCACACGATCGACG-TACGCACGCGAGCGAGATCCACC   [788]
Guaroi              TCCCGCACGTCGCCACACGATCGACG-TACGCACGCGAGCGAGATCCACC   [788]
Mimutim             TCCCGCACGTCGCCACACGATCGACG-TACGCACGCGAGCGAGATCCACC   [788]
Harinarayn          TCCCGCACGTCGCCACACGATCGACG-TACGCACGCGAGCGAGATCCACC   [789]
Bherapawa           TCCCGCACGTCGCCACACGATCGACG-TACGCACGCGAGCGAGATCCACC   [788]
O. rufipogon        TCCCGCACGTCGCCACACGTACGATC-GCCGCACGCGAGCGAGATCCACC   [795]

[                           810       820       830       840       850]
[                             .         .         .         .         .]
Papue               GATGGTTTACGCGTACGCCGACG---GCTCACACATCCCCCGGTGCCCAA   [835]
Lahi                GATGGTTTACGCGTACGCCGACG---GCTCACACATCCCCCGGTGCCCAA   [835]
Joha                GATGGTTTACGCGTACGCCGACG---GCTCACACATCCCCCGGTGCCCAA   [835]
Local Basmati       GATGGTTTACGCGTACGCCGACG---GCTCACACATCCCCCGGTGCCCAA   [835]
Sorpuma             GATGGTTTACGCGTACGCCGACG---GCTCACACATCCCCCGGTGCCCAA   [837]
Kawanglawang        GATGGTTTACGCGTACGCCGACG---GCTCACACATCCCCCGGTGCCCAA   [835]
Borjahinga          GATGGTTTACGCGTACGCCGACG---GCTCACACATCCCCCGGTGCCCAA   [838]
Til Bora            GATGGTTTACGCGTACGCCGACG---GCTCACACATCCCCCGGTGCCCAA   [835]
Hati Hali           GATGGTTTACGCGTACGCCGACG---GCTCACACATCCCCCGGTGCCCAA   [835]
Ranjit              GATGGTTTACGCGTACGCCGACG---GCTCACACATCCCCCGGTGCCCAA   [837]
Kakiberoin          GATGGTTTACGCGTACGCCGACG---GCTCACACATCCCCCGGTGCCCAA   [835]
Aubalam             GATGGTTTACGCGTACGCCGACG---GCTCACACATCCCCCGGTGCCCAA   [838]
Balam               GATGGTTTACGCGTACGCCGACG---GCTCACACATCCCCCGGTGCCCAA   [838]
Borua Beroin        GATGGTTTACGCGTACGCCGACG---GCTCACACATCCCCCGGTGCCCAA   [837]
Lallatoi            GATGGTTTACGCGTACGCCGACG---GCTCACACATCCCCCGGTGCCCAA   [837]
IR8                 GATGGTTTACGCGTACGCCGACG---GCTCACACATCCCCCGGTGCCCAA   [837]
Arfa                GATGGTTTACGCGTACGCCGACG---GCTCACACATCCCCCGGTGCCCAA   [838]
Bahadur             GATGGTTTACGCGTACGCCGACG---GCTCACACATCCCCCGGTGCCCAA   [837]
Pankaj              GATGGTTTACGCGTACGCCGACG---GCTCACACATCCCCCGGTGCCCAA   [837]
Bashful             GATGGTTTACGCGTACGCCGACG---GCTCACACATCCCCCGGTGCCCAA   [835]
Moircha             GATGGTTTACGCGTACGCCGACG---GCTCACACATCCCCCGGTGCCCAA   [837]
Joya                GATGGTTTACGCGTACGCCGACG---GCTCACACATCCCCCGGTGCCCAA   [837]
Bas Beroin          GATGGTTTACGCGTACGCCGACG---GCTCACACATCCCCCGGTGCCCAA   [835]
Ranga Borah         GATGGTTTACGCGTACGCCGACG---GCTCACACATCCCCCGGTGCCCAA   [837]
Mulahail            GATGGTTTACGCGTACGCCGACG---GCTCACACATCCCCCGGTGCCCAA   [835]
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Guaroi          GATGGTTTACGCGTACGCCGACG---GCTCACACATCCCCCGGTGCCCAA   [835]
Mimutim         GATGGTTTACGCGTACGCCGACG---GCTCACACATCCCCCGGTGCCCAA   [835]
Harinarayn      GATGGTTTACGCGTACGCCGACG---GCTCACACATCCCCCGGTGCCCAA   [836]
Bherapawa       GATGGTTTACGCGTACGCCGACG---GCTCACACATCCCCCGGTGCCCAA   [835]
O. rufipogon    GATGGTTTACTCGTACGCCGACGGCCGCTCACACATCC------------   [833]

[                        860       870       880       890       900]
[                          .         .         .         .         .]
Papue           CAGAAACCACACACCACCCGCACGAAAAAAACCGAACCGCACGTGCGCGC   [885]
Lahi            CAGAAACCACACACCACCCGCACGAAAAAAACCGAACCGCACGTGCGCGC   [885]
Joha            CAGAAACCACACACCACCCGCACGAAAAAAACCGAACCGCACGTGCGCGC   [885]
Local Basmati   CAGAAACCACACACCACCCGCACGAAAAAAACCGAACCGCACGTGCGCGC   [885]
Sorpuma         CAGAAACCACACACCACCCGCACGAAAAAAACCGAACCGCACGTGCGCGC   [887]
Kawanglawang    CAGAAACCACACACCACCCGCACGAAAAAAACCGAACCGCACGTGCGCGC   [885]
Borjahinga      CAGAAACCACACACCACCCGCACGAAAAAAACCGAACCGCACGTGCGCGC   [888]
Til Bora        CAGAAACCACACACCACCCGCACGAAAAAAACCGAACCGCACGTGCGCGC   [885]
Hati Hali       CAGAAACCACACACCACCCGCACGAAAAAAACCGAACCGCACGTGCGCGC   [885]
Ranjit          CAGAAACCACACACCACCCGCACGAAAAAAACCGAACCGCACGTGCGCGC   [887]
Kakiberoin      CAGAAACCACACACCACCCGCACGAAAAAAACCGAACCGCACGTGCGCGC   [885]
Aubalam         CAGAAACCACACACCACCCGCACGAAAAAAACCGAACCGCACGTGCGCGC   [888]
Balam           CAGAAACCACACACCACCCGCACGAAAAAAACCGAACCGCACGTGCGCGC   [888]
Borua Beroin    CAGAAACCACACACCACCCGCACGAAAAAAACCGAACCGCACGTGCGCGC   [887]
Lallatoi        CAGAAACCACACACCACCCGCACGAAAAAAACCGAACCGCACGTGCGCGC   [887]
IR8             CAGAAACCACACACCACCCGCACGAAAAAAACCGAACCGCACGTGCGCGC   [887]
Arfa            CAGAAACCACACACCACCCGCACGAAAAAAACCGAACCGCACGTGCGCGC   [888]
Bahadur         CAGAAACCACACACCACCCGCACGAAAAAAACCGAACCGCACGTGCGCGC   [887]
Pankaj          CAGAAACCACACACCACCCGCACGAAAAAAACCGAACCGCACGTGCGCGC   [887]
Bashful         CAGAAACCACACACCACCCGCACGAAAAAAACCGAACCGCACGTGCGCGC   [885]
Moircha         CAGAAACCACACACCACCCGCACGAAAAAAACCGAACCGCACGTGCGCGC   [887]
Joya            CAGAAACCACACACCACCCGCACGAAAAAAACCGAACCGCACGTGCGCGC   [887]
Bas Beroin      CAGAAACCACACACCACCCGCACGAAAAAAACCGAACCGCACGTGCGCGC   [885]
Ranga Borah     CAGAAACCACACACCACCCGCACGAAAAAAACCGAACCGCACGTGCGCGC   [887]
Mulahail        CAGAAACCACACACCACCCGCACGAAAAAAACCGAACCGCACGTGCGCGC   [885]
Guaroi          CAGAAACCACACACCACCCGCACGAAAAAAACCGAACCGCACGTGCGCGC   [885]
Mimutim         CAGAAACCACACACCACCCGCACGAAAAAAACCGAACCGCACGTGCGCGC   [885]
Harinarayn      CAGAAACCACACACCACCCGCACGAAAAAAACCGAACCGCACGTGCGCGC   [886]
Bherapawa       CAGAAACCACACACCACCCGCACGAAAAAAACCGAACCGCACGTGCGCGC   [885]
O. rufipogon    ----------------CCCGCACG-AAAAAACCGAACCGCGCGTGCATGC   [866]

[                        910       920       930       940       950]
[                          .         .         .         .         .]
Papue           GCGCTCCACGCACACCCCAAACAGACGGCACGGCGGGAGCGCGCGCGCGC   [935]
Lahi            GCGCTCCACGCACACCCCAAACAGACGGCACGGCGGGAGCGCGCGCGCGC   [935]
Joha            GCGCTCCACGCACACCCCAAACAGACGGCACGGCGGGAGCGCGCGCGCGC   [935]
Local Basmati   GCGCTCCACGCACACCCCAAACAGACGGCACGGCGGGAGCGCGCGCGCGC   [935]
Sorpuma         GCGCTCCACGCACACCCCAAACAGACGGCACGGCGGGAGCGCGCGCGCGC   [937]
Kawanglawang    GCGCTCCACGCACACCCCAAACAGACGGCACGGCGGGAGCGCGCGCGCGC   [935]
Borjahinga      GCGCTCCACGCACACCCCAAACAGACGGCACGGCGGGAGCGCGCGCGCGC   [938]
Til Bora        GCGCTCCACGCACACCCCAAACAGACGGCACGGCGGGAGCGCGCGCGCGC   [935]
Hati Hali       GCGCTCCACGCACACCCCAAACAGACGGCACGGCGGGAGCGCGCGCGCGC   [935]
Ranjit          GCGCTCCACGCACACCCCAAACAGACGGCACGGCGGGAGCGCGCGCGCGC   [937]
Kakiberoin      GCGCTCCACGCACACCCCAAACAGACGGCACGGCGGGAGCGCGCGCGCGC   [935]
Aubalam         GCGCTCCACGCACACCCCAAACAGACGGCACGGCGGGAGCGCGCGCGCGC   [938]
Balam           GCGCTCCACGCACACCCCAAACAGACGGCACGGCGGGAGCGCGCGCGCGC   [938]
Borua Beroin    GCGCTCCACGCACACCCCAAACAGACGGCACGGCGGGAGCGCGCGCGCGC   [937]
Lallatoi        GCGCTCCACGCACACCCCAAACAGACGGCACGGCGGGAGCGCGCGCGCGC   [937]
IR8             GCGCTCCACGCACACCCCAAACAGACGGCACGGCGGGAGCGCGCGCGCGC   [937]
Arfa            GCGCTCCACGCACACCCCAAACAGACGGCACGGCGGGAGCGCGCGCGCGC   [938]
Bahadur         GCGCTCCACGCACACCCCAAACAGACGGCACGGCGGGAGCGCGCGCGCGC   [937]
Pankaj          GCGCTCCACGCACACCCCAAACAGACGGCACGGCGGGAGCGCGCGCGCGC   [937]
Bashful         GCGCTCCACGCACACCCCAAACAGACGGCACGGCGGGAGCGCGCGCGCGC   [935]
Moircha         GCGCTCCACGCACACCCCAAACAGACGGCACGGCGGGAGCGCGCGCGCGC   [937]
Joya            GCGCTCCACGCACACCCCAAACAGACGGCACGGCGGGAGCGCGCGCGCGC   [937]
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Bas Beroin         GCGCTCCACGCACACCCCAAACAGACGGCACGGCGGGAGCGCGCGCGCGC   [935]
Ranga Borah        GCGCTCCACGCACACCCCAAACAGACGGCACGGCGGGAGCGCGCGCGCGC   [937]
Mulahail           GCGCTCCACGCACACCCCAAACAGACGGCACGGCGGGAGCGCGCGCGCGC   [935]
Guaroi             GCGCTCCACGCACACCCCAAACAGACGGCACGGCGGGAGCGCGCGCGCGC   [935]
Mimutim            GCGCTCCACGCACACCCCAAACAGACGGCACGGCGGGAGCGCGCGCGCGC   [935]
Harinarayn         GCGCTCCACGCACACCCCAAACAGACGGCACGGCGGGAGCGCGCGCGCGC   [936]
Bherapawa          GCGCTCCACGCACACCCCAAACAGACGGCACGGCGGGAGCGCGCGCGCGC   [935]
O. rufipogon       GCGCTCCACGCACACCCCAAACAGA---------------------ACGC   [895]

[                           960       970       980       990      1000]
[                             .         .         .         .         .]
Papue              ACGCGAGCCGAGGAGAAAACAAACGGGGGAAACAAGCTGGAAAAGCAAAA   [985]
Lahi               ACGCGAGCCGAGGAGAAAACAAACGGGGGAAACAAGCTGGAAAAGCAAAA   [985]
Joha               ACGCGAGCCGAGGAGAAAACAAACGGGGGAAACAAGCTGGAAAAGCAAAA   [985]
Local Basmati      ACGCGAGCCGAGGAGAAAACAAACGGGGGAAACAAGCTGGAAAAGCAAAA   [985]
Sorpuma            ACGCGAGCCGAGGAGAAAACAAACGGGGGAAACAAGCTGGAAAAGCAAAA   [987]
Kawanglawang       ACGCGAGCCGAGGAGAAAACAAACGGGGGAAACAAGCTGGAAAAGCAAAA   [985]
Borjahinga         ACGCGAGCCGAGGAGAAAACAAACGGGGGAAACAAGCTGGAAAAGCAAAA   [988]
Til Bora           ACGCGAGCCGAGGAGAAAACAAACGGGGGAAACAAGCTGGAAAAGCAAAA   [985]
Hati Hali          ACGCGAGCCGAGGAGAAAACAAACGGGGGAAACAAGCTGGAAAAGCAAAA   [985]
Ranjit             ACGCGAGCCGAGGAGAAAACAAACGGGGGAAACAAGCTGGAAAAGCAAAA   [987]
Kakiberoin         ACGCGAGCCGAGGAGAAAACAAACGGGGGAAACAAGCTGGAAAAGCAAAA   [985]
Aubalam            ACGCGAGCCGAGGAGAAAACAAACGGGGGAAACAAGCTGGAAAAGCAAAA   [988]
Balam              ACGCGAGCCGAGGAGAAAACAAACGGGGGAAACAAGCTGGAAAAGCAAAA   [988]
Borua Beroin       ACGCGAGCCGAGGAGAAAACAAACGGGGGAAACAAGCTGGAAAAGCAAAA   [987]
Lallatoi           ACGCGAGCCGAGGAGAAAACAAACGGGGGAAACAAGCTGGAAAAGCAAAA   [987]
IR8                ACGCGAGCCGAGGAGAAAACAAACGGGGGAAACAAGCTGGAAAAGCAAAA   [987]
Arfa               ACGCGAGCCGAGGAGAAAACAAACGGGGGAAACAAGCTGGAAAAGCAAAA   [988]
Bahadur            ACGCGAGCCGAGGAGAAAACAAACGGGGGAAACAAGCTGGAAAAGCAAAA   [987]
Pankaj             ACGCGAGCCGAGGAGAAAACAAACGGGGGAAACAAGCTGGAAAAGCAAAA   [987]
Bashful            ACGCGAGCCGAGGAGAAAACAAACGGGGGAAACAAGCTGGAAAAGCAAAA   [985]
Moircha            ACGCGAGCCGAGGAGAAAACAAACGGGGGAAACAAGCTGGAAAAGCAAAA   [987]
Joya               ACGCGAGCCGAGGAGAAAACAAACGGGGGAAACAAGCTGGAAAAGCAAAA   [987]
Bas Beroin         ACGCGAGCCGAGGAGAAAACAAACGGGGGAAACAAGCTGGAAAAGCAAAA   [985]
Ranga Borah        ACGCGAGCCGAGGAGAAAACAAACGGGGGAAACAAGCTGGAAAAGCAAAA   [987]
Mulahail           ACGCGAGCCGAGGAGAAAACAAACGGGGGAAACAAGCTGGAAAAGCAAAA   [985]
Guaroi             ACGCGAGCCGAGGAGAAAACAAACGGGGGAAACAAGCTGGAAAAGCAAAA   [985]
Mimutim            ACGCGAGCCGAGGAGAAAACAAACGGGGGAAACAAGCTGGAAAAGCAAAA   [985]
Harinarayn         ACGCGAGCCGAGGAGAAAACAAACGGGGGAAACAAGCTGGAAAAGCAAAA   [986]
Bherapawa          ACGCGAGCCGAGGAGAAAACAAACGGGGGAAACAAGCTGGAAAAGCAAAA   [985]
O. rufipogon       GTACGAGCCGAGGAGAAAACAAC-------------CTGGAAAGCAAAAG   [932]

[                          1010      1020      1030      1040      1050]
[                             .         .         .         .         .]
Papue              GGGGAAAAGAACGGAGC----GGAGGCTTCACCCACGGCCACCGCGACGC   [1031]
Lahi               GGGGAAAAGAACGGAGC----GGAGGCTTCACCCACGGCCACCGCGACGC   [1031]
Joha               GGGGAAAAGAACGGAGC----GGAGGCTTCACCCACGGCCACCGCGACGC   [1031]
Local Basmati      GGGGAAAAGAACGGAGC----GGAGGCTTCACCCACGGCCACCGCGACGC   [1031]
Sorpuma            GGGGAAAAGAACGGAGC----GGAGGCTTCACCCACGGCCACCGCGACGC   [1033]
Kawanglawang       GGGGAAAAGAACGGAGC----GGAGGCTTCACCCACGGCCACCGCGACGC   [1031]
Borjahinga         GGGGAAAAGAACGGAGC----GGAGGCTTCACCCACGGCCACCGCGACGC   [1034]
Til Bora           GGGGAAAAGAACGGAGC----GGAGGCTTCACCCACGGCCACCGCGACGC   [1031]
Hati Hali          GGGGAAAAGAACGGAGC----GGAGGCTTCACCCACGGCCACCGCGACGC   [1031]
Ranjit             GGGGAAAAGAACGGAGC----GGAGGCTTCACCCACGGCCACCGCGACGC   [1033]
Kakiberoin         GGGGAAAAGAACGGAGC----GGAGGCTTCACCCACGGCCACCGCGACGC   [1031]
Aubalam            GGGGAAAAGAACGGAGC----GGAGGCTTCACCCACGGCCACCGCGACGC   [1034]
Balam              GGGGAAAAGAACGGAGC----GGAGGCTTCACCCACGGCCACCGCGACGC   [1034]
Borua Beroin       GGGGAAAAGAACGGAGC----GGAGGCTTCACCCACGGCCACCGCGACGC   [1033]
Lallatoi           GGGGAAAAGAACGGAGC----GGAGGCTTCACCCACGGCCACCGCGACGC   [1033]
IR8                GGGGAAAAGAACGGAGC----GGAGGCTTCACCCACGGCCACCGCGACGC   [1033]
Arfa               GGGGAAAAGAACGGAGC----GGAGGCTTCACCCACGGCCACCGCGACGC   [1034]
Bahadur            GGGGAAAAGAACGGAGC----GGAGGCTTCACCCACGGCCACCGCGACGC   [1033]
Pankaj             GGGGAAAAGAACGGAGC----GGAGGCTTCACCCACGGCCACCGCGACGC   [1033]
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Bashful            GGGGAAAAGAACGGAGC----GGAGGCTTCACCCACGGCCACCGCGACGC   [1031]
Moircha            GGGGAAAAGAACGGAGC----GGAGGCTTCACCCACGGCCACCGCGACGC   [1033]
Joya               GGGGAAAAGAACGGAGC----GGAGGCTTCACCCACGGCCACCGCGACGC   [1033]
Bas Beroin         GGGGAAAAGAACGGAGC----GGAGGCTTCACCCACGGCCACCGCGACGC   [1031]
Ranga Borah        GGGGAAAAGAACGGAGC----GGAGGCTTCACCCACGGCCACCGCGACGC   [1033]
Mulahail           GGGGAAAAGAACGGAGC----GGAGGCTTCACCCACGGCCACCGCGACGC   [1031]
Guaroi             GGGGAAAAGAACGGAGC----GGAGGCTTCACCCACGGCCACCGCGACGC   [1031]
Mimutim            GGGGAAAAGAACGGAGC----GGAGGCTTCACCCACGGCCACCGCGACGC   [1031]
Harinarayn         GGGGAAAAGAACGGAGC----GGAGGCTTCACCCACGGCCACCGCGACGC   [1032]
Bherapawa          GGGGAAAAGAACGGAGC----GGAGGCTTCACCCACGGCCACCGCGACGC   [1031]
O. rufipogon       GGGGAAAAGAGCGGAGCGGAAGGAGGGTTCACCCACGGCCACCGCGACGC   [982]

[                           1060      1070      1080      1090      1100]
[                           .         .         .         .         .]
Papue              GCCACCA----GCGTGCGGTGCAATGCAACGTACGCCAAGCCGAAACGGC   [1077]
Lahi               GCCACCA----GCGTGCGGTGCAATGCAACGTACGCCAAGCCGAAACGGC   [1077]
Joha               GCCACCA----GCGTGCGGTGCAATGCAACGTACGCCAAGCCGAAACGGC   [1077]
Local Basmati      GCCACCA----GCGTGCGGTGCAATGCAACGTACGCCAAGCCGAAACGGC   [1077]
Sorpuma            GCCACCA----GCGTGCGGTGCAATGCAACGTACGCCAAGCCGAAACGGC   [1079]
Kawanglawang       GCCACCA----GCGTGCGGTGCAATGCAACGTACGCCAAGCCGAAACGGC   [1077]
Borjahinga         GCCACCA----GCGTGCGGTGCAATGCAACGTACGCCAAGCCGAAACGGC   [1080]
Til Bora           GCCACCA----GCGTGCGGTGCAATGCAACGTACGCCAAGCCGAAACGGC   [1077]
Hati Hali          GCCACCA----GCGTGCGGTGCAATGCAACGTACGCCAAGCCGAAACGGC   [1077]
Ranjit             GCCACCA----GCGTGCGGTGCAATGCAACGTACGCCAAGCCGAAACGGC   [1079]
Kakiberoin         GCCACCA----GCGTGCGGTGCAATGCAACGTACGCCAAGCCGAAACGGC   [1077]
Aubalam            GCCACCA----GCGTGCGGTGCAATGCAACGTACGCCAAGCCGAAACGGC   [1080]
Balam              GCCACCA----GCGTGCGGTGCAATGCAACGTACGCCAAGCCGAAACGGC   [1080]
Borua Beroin       GCCACCA----GCGTGCGGTGCAATGCAACGTACGCCAAGCCGAAACGGC   [1079]
Lallatoi           GCCACCA----GCGTGCGGTGCAATGCAACGTACGCCAAGCCGAAACGGC   [1079]
IR8                GCCACCA----GCGTGCGGTGCAATGCAACGTACGCCAAGCCGAAACGGC   [1079]
Arfa               GCCACCA----GCGTGCGGTGCAATGCAACGTACGCCAAGCCGAAACGGC   [1080]
Bahadur            GCCACCA----GCGTGCGGTGCAATGCAACGTACGCCAAGCCGAAACGGC   [1079]
Pankaj             GCCACCA----GCGTGCGGTGCAATGCAACGTACGCCAAGCCGAAACGGC   [1079]
Bashful            GCCACCA----GCGTGCGGTGCAATGCAACGTACGCCAAGCCGAAACGGC   [1077]
Moircha            GCCACCA----GCGTGCGGTGCAATGCAACGTACGCCAAGCCGAAACGGC   [1079]
Joya               GCCACCA----GCGTGCGGTGCAATGCAACGTACGCCAAGCCGAAACGGC   [1079]
Bas Beroin         GCCACCA----GCGTGCGGTGCAATGCAACGTACGCCAAGCCGAAACGGC   [1077]
Ranga Borah        GCCACCA----GCGTGCGGTGCAATGCAACGTACGCCAAGCCGAAACGGC   [1079]
Mulahail           GCCACCA----GCGTGCGGTGCAATGCAACGTACGCCAAGCCGAAACGGC   [1077]
Guaroi             GCCACCA----GCGTGCGGTGCAATGCAACGTACGCCAAGCCGAAACGGC   [1077]
Mimutim            GCCACCA----GCGTGCGGTGCAATGCAACGTACGCCAAGCCGAAACGGC   [1077]
Harinarayn         GCCACCA----GCGTGCGGTGCAATGCAACGTACGCCAAGCCGAAACGGC   [1078]
Bherapawa          GCCACCA----GCGTGCGGTGCAATGCAACGTACGCCAAGCCGAAACGGC   [1077]
O. rufipogon       GCCACCAGCGTGCGTGCGGTGCAATGCAACGTACGCCAAGCCGAAACGGC   [1032]

[                           1110      1120      1130      1140      1150]
[                           .         .         .         .         .]
Papue              AGGCAGCATCGCGCACGCACGCACACACAGGCCACAGCACACGCGAGCGA   [1127]
Lahi               AGGCAGCATCGCGCACGCACGCACACACAGGCCACAGCACACGCGAGCGA   [1127]
Joha               AGGCAGCATCGCGCACGCACGCACACACAGGCCACAGCACACGCGAGCGA   [1127]
Local Basmati      AGGCAGCATCGCGCACGCACGCACACACAGGCCACAGCACACGCGAGCGA   [1127]
Sorpuma            AGGCAGCATCGCGCACGCACGCACACACAGGCCACAGCACACGCGAGCGA   [1129]
Kawanglawang       AGGCAGCATCGCGCACGCACGCACACACAGGCCACAGCACACGCGAGCGA   [1127]
Borjahinga         AGGCAGCATCGCGCACGCACGCACACACAGGCCACAGCACACGCGAGCGA   [1130]
Til Bora           AGGCAGCATCGCGCACGCACGCACACACAGGCCACAGCACACGCGAGCGA   [1127]
Hati Hali          AGGCAGCATCGCGCACGCACGCACACACAGGCCACAGCACACGCGAGCGA   [1127]
Ranjit             AGGCAGCATCGCGCACGCACGCACACACAGGCCACAGCACACGCGAGCGA   [1129]
Kakiberoin         AGGCAGCATCGCGCACGCACGCACACACAGGCCACAGCACACGCGAGCGA   [1127]
Aubalam            AGGCAGCATCGCGCACGCACGCACACACAGGCCACAGCACACGCGAGCGA   [1130]
Balam              AGGCAGCATCGCGCACGCACGCACACACAGGCCACAGCACACGCGAGCGA   [1130]
Borua Beroin       AGGCAGCATCGCGCACGCACGCACACACAGGCCACAGCACACGCGAGCGA   [1129]
Lallatoi           AGGCAGCATCGCGCACGCACGCACACACAGGCCACAGCACACGCGAGCGA   [1129]
IR8                AGGCAGCATCGCGCACGCACGCACACACAGGCCACAGCACACGCGAGCGA   [1129]
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Arfa              AGGCAGCATCGCGCACGCACGCACACACAGGCCACAGCACACGCGAGCGA   [1130]
Bahadur           AGGCAGCATCGCGCACGCACGCACACACAGGCCACAGCACACGCGAGCGA   [1129]
Pankaj            AGGCAGCATCGCGCACGCACGCACACACAGGCCACAGCACACGCGAGCGA   [1129]
Bashful           AGGCAGCATCGCGCACGCACGCACACACAGGCCACAGCACACGCGAGCGA   [1127]
Moircha           AGGCAGCATCGCGCACGCACGCACACACAGGCCACAGCACACGCGAGCGA   [1129]
Joya              AGGCAGCATCGCGCACGCACGCACACACAGGCCACAGCACACGCGAGCGA   [1129]
Bas Beroin        AGGCAGCATCGCGCACGCACGCACACACAGGCCACAGCACACGCGAGCGA   [1127]
Ranga Borah       AGGCAGCATCGCGCACGCACGCACACACAGGCCACAGCACACGCGAGCGA   [1129]
Mulahail          AGGCAGCATCGCGCACGCACGCACACACAGGCCACAGCACACGCGAGCGA   [1127]
Guaroi            AGGCAGCATCGCGCACGCACGCACACACAGGCCACAGCACACGCGAGCGA   [1127]
Mimutim           AGGCAGCATCGCGCACGCACGCACACACAGGCCACAGCACACGCGAGCGA   [1127]
Harinarayn        AGGCAGCATCGCGCACGCACGCACACACAGGCCACAGCACACGCGAGCGA   [1128]
Bherapawa         AGGCAGCATCGCGCACGCACGCACACACAGGCCACAGCACACGCGAGCGA   [1127]
O. rufipogon      AGGCAGCACCGCGCGCGCACGCACGCAC----------------------   [1060]

[                          1160      1170      1180      1190      1200]
[                             .         .         .         .         .]
Papue             CGTACGCGAGTGCATGCAGATGCATGCGCGGGGCTCGCGCGAGACCGGCC   [1177]
Lahi              CGTACGCGAGTGCATGCAGATGCATGCGCGGGGCTCGCGCGAGACCGGCC   [1177]
Joha              CGTACGCGAGTGCATGCAGATGCATGCGCGGGGCTCGCGCGAGACCGGCC   [1177]
Local Basmati     CGTACGCGAGTGCATGCAGATGCATGCGCGGGGCTCGCGCGAGACCGGCC   [1177]
Sorpuma           CGTACGCGAGTGCATGCAGATGCATGCGCGGGGCTCGCGCGAGACCGGCC   [1179]
Kawanglawang      CGTACGCGAGTGCATGCAGATGCATGCGCGGGGCTCGCGCGAGACCGGCC   [1177]
Borjahinga        CGTACGCGAGTGCATGCAGATGCATGCGCGGGGCTCGCGCGAGACCGGCC   [1180]
Til Bora          CGTACGCGAGTGCATGCAGATGCATGCGCGGGGCTCGCGCGAGACCGGCC   [1177]
Hati Hali         CGTACGCGAGTGCATGCAGATGCATGCGCGGGGCTCGCGCGAGACCGGCC   [1177]
Ranjit            CGTACGCGAGTGCATGCAGATGCATGCGCGGGGCTCGCGCGAGACCGGCC   [1179]
Kakiberoin        CGTACGCGAGTGCATGCAGATGCATGCGCGGGGCTCGCGCGAGACCGGCC   [1177]
Aubalam           CGTACGCGAGTGCATGCAGATGCATGCGCGGGGCTCGCGCGAGACCGGCC   [1180]
Balam             CGTACGCGAGTGCATGCAGATGCATGCGCGGGGCTCGCGCGAGACCGGCC   [1180]
Borua Beroin      CGTACGCGAGTGCATGCAGATGCATGCGCGGGGCTCGCGCGAGACCGGCC   [1179]
Lallatoi          CGTACGCGAGTGCATGCAGATGCATGCGCGGGGCTCGCGCGAGACCGGCC   [1179]
IR8               CGTACGCGAGTGCATGCAGATGCATGCGCGGGGCTCGCGCGAGACCGGCC   [1179]
Arfa              CGTACGCGAGTGCATGCAGATGCATGCGCGGGGCTCGCGCGAGACCGGCC   [1180]
Bahadur           CGTACGCGAGTGCATGCAGATGCATGCGCGGGGCTCGCGCGAGACCGGCC   [1179]
Pankaj            CGTACGCGAGTGCATGCAGATGCATGCGCGGGGCTCGCGCGAGACCGGCC   [1179]
Bashful           CGTACGCGAGTGCATGCAGATGCATGCGCGGGGCTCGCGCGAGACCGGCC   [1177]
Moircha           CGTACGCGAGTGCATGCAGATGCATGCGCGGGGCTCGCGCGAGACCGGCC   [1179]
Joya              CGTACGCGAGTGCATGCAGATGCATGCGCGGGGCTCGCGCGAGACCGGCC   [1179]
Bas Beroin        CGTACGCGAGTGCATGCAGATGCATGCGCGGGGCTCGCGCGAGACCGGCC   [1177]
Ranga Borah       CGTACGCGAGTGCATGCAGATGCATGCGCGGGGCTCGCGCGAGACCGGCC   [1179]
Mulahail          CGTACGCGAGTGCATGCAGATGCATGCGCGGGGCTCGCGCGAGACCGGCC   [1177]
Guaroi            CGTACGCGAGTGCATGCAGATGCATGCGCGGGGCTCGCGCGAGACCGGCC   [1177]
Mimutim           CGTACGCGAGTGCATGCAGATGCATGCGCGGGGCTCGCGCGAGACCGGCC   [1177]
Harinarayn        CGTACGCGAGTGCATGCAGATGCATGCGCGGGGCTCGCGCGAGACCGGCC   [1178]
Bherapawa         CGTACGCGAGTGCATGCAGATGCATGCGCGGGGCTCGCGCGAGACCGGCC   [1177]
O. rufipogon      ---ACGCGAGAGCATGCAGATGCATGCGCGGGGCTCGCGCGAGACCGGCC   [1107]

[                          1210      1220      1230      1240      1250]
[                             .         .         .         .         .]
Papue             GATGGG-TTCGCTTCTC-TTCTCTCTCCCGTCCCGTTGC-----GTCGTC   [1220]
Lahi              GATGGG-TTCGCTTCTC-TTCTCTCTCCCGTCCCGTTGC-----GTCGTC   [1220]
Joha              GATGGG-TTCGCTTCTC-TTCTCTCTCCCGTCCCGTTGC-----GTCGTC   [1220]
Local Basmati     GATGGG-TTCGCTTCTC-TTCTCTCTCCCGTCCCGTTGC-----GTCGTC   [1220]
Sorpuma           GATGGG-TTCGCTTCTC-TTCTCTCTCCCGTCCCGTTGC-----GTCGTC   [1222]
Kawanglawang      GATGGG-TTCGCTTCTC-TTCTCTCTCCCGTCCCGTTGC-----GTCGTC   [1220]
Borjahinga        GATGGG-TTCGCTTCTC-TTCTCTCTCCCGTCCCGTTGC-----GTCGTC   [1223]
Til Bora          GATGGG-TTCGCTTCTC-TTCTCTCTCCCGTCCCGTTGC-----GTCGTC   [1220]
Hati Hali         GATGGG-TTCGCTTCTC-TTCTCTCTCCCGTCCCGTTGC-----GTCGTC   [1220]
Ranjit            GATGGG-TTCGCTTCTC-TTCTCTCTCCCGTCCCGTTGC-----GTCGTC   [1222]
Kakiberoin        GATGGG-TTCGCTTCTC-TTCTCTCTCCCGTCCCGTTGC-----GTCGTC   [1220]
Aubalam           GATGGG-TTCGCTTCTC-TTCTCTCTCCCGTCCCGTTGC-----GTCGTC   [1223]
Balam             GATGGG-TTCGCTTCTC-TTCTCTCTCCCGTCCCGTTGC-----GTCGTC   [1223]
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Borua Beroin        GATGGG-TTCGCTTCTC-TTCTCTCTCCCGTCCCGTTGC-----GTCGTC   [1222]
Lallatoi            GATGGG-TTCGCTTCTC-TTCTCTCTCCCGTCCCGTTGC-----GTCGTC   [1222]
IR8                 GATGGG-TTCGCTTCTC-TTCTCTCTCCCGTCCCGTTGC-----GTCGTC   [1222]
Arfa                GATGGG-TTCGCTTCTC-TTCTCTCTCCCGTCCCGTTGC-----GTCGTC   [1223]
Bahadur             GATGGG-TTCGCTTCTC-TTCTCTCTCCCGTCCCGTTGC-----GTCGTC   [1222]
Pankaj              GATGGG-TTCGCTTCTC-TTCTCTCTCCCGTCCCGTTGC-----GTCGTC   [1222]
Bashful             GATGGG-TTCGCTTCTC-TTCTCTCTCCCGTCCCGTTGC-----GTCGTC   [1220]
Moircha             GATGGG-TTCGCTTCTC-TTCTCTCTCCCGTCCCGTTGC-----GTCGTC   [1222]
Joya                GATGGG-TTCGCTTCTC-TTCTCTCTCCCGTCCCGTTGC-----GTCGTC   [1222]
Bas Beroin          GATGGG-TTCGCTTCTC-TTCTCTCTCCCGTCCCGTTGC-----GTCGTC   [1220]
Ranga Borah         GATGGG-TTCGCTTCTC-TTCTCTCTCCCGTCCCGTTGC-----GTCGTC   [1222]
Mulahail            GATGGG-TTCGCTTCTC-TTCTCTCTCCCGTCCCGTTGC-----GTCGTC   [1220]
Guaroi              GATGGG-TTCGCTTCTC-TTCTCTCTCCCGTCCCGTTGC-----GTCGTC   [1220]
Mimutim             GATGGG-TTCGCTTCTC-TTCTCTCTCCCGTCCCGTTGC-----GTCGTC   [1220]
Harinarayn          GATGGG-TTCGCTTCTC-TTCTCTCTCCCGTCCCGTTGC-----GTCGTC   [1221]
Bherapawa           GATGGG-TTCGCTTCTC-TTCTCTCTCCCGTCCCGTTGC-----GTCGTC   [1220]
O. rufipogon        GATGGGGTTCGCTTCTCCTTCTCTCTCCCGTCCCGTTGCTTGCCGTCGTC   [1157]

[                            1260      1270      1280      1290      1300]
[                               .         .         .         .         .]
Papue               ATAGAC-AAAAGTCGGTTTTGCTTTTGGTTTTTT-GGCTCTGAGGCACTG   [1268]
Lahi                ATAGAC-AAAAGTCGGTTTTGCTTTTGGTTTTTT-GGCTCTGAGGCACTG   [1268]
Joha                ATAGAC-AAAAGTCGGTTTTGCTTTTGGTTTTTT-GGCTCTGAGGCACTG   [1268]
Local Basmati       ATGGAC-AAAAGTCGGTTTTGCTTTTGGTTTTTT-GGTTCTGAGGCACTG   [1268]
Sorpuma             ATGGAC-AAAAGTCGGTTTTGCTTTTGGTTTTTT-GGTTCTGAGGCACTG   [1270]
Kawanglawang        ATAGAC-AAAAGTCGGTTTTGCTTTTGGTTTTTT-GGCTCTGAGGCACTG   [1268]
Borjahinga          ATGGAC-AAAAGTCGGTTTTGCTTTTGGTTTTTT-GGTTCTGAGGCACTG   [1271]
Til Bora            ATAGAC-AAAAGTCGGTTTTGCTTTTGGTTTTTT-GGCTCTGAGGCACTG   [1268]
Hati Hali           ATGGAC-AAAAGTCGGTTTTGCTTTTAGTTTTTT-GGTTCTGAGGCACTG   [1268]
Ranjit              ATGGAC-AAAAGTCGGTTTTGCTTTTGGTTTTTT-GGTTCTGAGGCACTG   [1270]
Kakiberoin          ATGGAC-AAAAGTCGGTTTTGCTTTTGGTTTTTT-GGTTCTGAGGCACTG   [1268]
Aubalam             ATGGAC-AAAAGTCGGTTTTGCTTTTGGTTTTTT-GGTTCTGAGGCACTG   [1271]
Balam               ATGGAC-AAAAGTCGGTTTTGCTTTTGGTTTTTT-GGTTCTGAGGCACTG   [1271]
Borua Beroin        ATAGAC-AAAAGTCGGTTTTGCTTTTGGTTTTTT-GGCTCTGAGGCACTG   [1270]
Lallatoi            ATGGAC-AAAAGTCGGTTTTGCTTTTGGTTTTTT-GGTTCTGAGGCACTG   [1270]
IR8                 ATGGAC-AAAAGTCGGTTTTGCTTTTGGTTTTTT-GGTTCTGAGGCACTG   [1270]
Arfa                ATGGAC-AAAAGTCGGTTTTGCTTTTGGTTTTTT-GGTTCTGAGGCACTG   [1271]
Bahadur             ATGGAC-AAAAGTCGGTTTTGCTTTTGGTTTTTT-GGTTCTGAGGCACTG   [1270]
Pankaj              ATGGAC-AAAAGTCGGTTTTGCTTTTGGTTTTTT-GGTTCTGAGGCACTG   [1270]
Bashful             ATGGAC-AAAAGTCGGTTTTGCTTTTGGTTTTTT-GGTTCTGAGGCACTG   [1268]
Moircha             ATGGAC-AAAAGTCGGTTTTGCTTTTGGTTTTTT-GGTTCTGAGGCACTG   [1270]
Joya                ATGGAC-AAAAGTCGGTTTTGCTTTTGGTTTTTT-GGTTCTGAGGCACTG   [1270]
Bas Beroin          ATAGAC-AAAAGTCGGTTTTGCTTTTGGTTTTTT-GGCTCTGAGGCACTG   [1268]
Ranga Borah         ATGGAC-AAAAGTCGGTTTTGCTTTTGGTTTTTT-GGTTCTGAGGCACTG   [1270]
Mulahail            ATAGAC-AAAAGTCGGTTTTGCTTTTAGTTTTTT-GGTTCTGAGGCACTG   [1268]
Guaroi              ATGGAC-AAAAGTCGGTTTTGCTTTTAGTTTTTT-GGTTCTGAGGCACTG   [1268]
Mimutim             ATAGAC-AAAAGTCGGTTTTGCTTTTGGTTTTTT-GGCTCTGAGGCACTG   [1268]
Harinarayn          ATGGAC-AAAAGTCGGTTTTGCTTTTAGTTTTTT-GGTTCTGAGGCACTG   [1269]
Bherapawa           ATGGAC-AAAAGTCGGTTTTGCTTTTAGTTTTTT-GGTTCTGAGGCACTG   [1268]
O. rufipogon        ATGGACAAAAAGTCGGTTTTGCTTTTGGTTTTTTGGGTTCCGAGGCACTG   [1207]

[                            1310      1320      1330      1340      1350]
[                               .         .         .         .         .]
Papue               ACGTGCGGGCCAGCGTACGCCTGCGTGCCCCGCATGTCATCGTCGACACC   [1318]
Lahi                ACGTGCGGGCCAGCGTACGCCTGCGTGCCCCGCATGTCATCGTCGACACC   [1318]
Joha                ACGTGCGGGCCAGCGTACGCCTGCGTGCCCCGCATGTCATCGTCGACACC   [1318]
Local Basmati       ACGTGCGGGCCAGCGTACGCCTGCGTGCCCCGCATGTCATCGTCGACACC   [1318]
Sorpuma             ACGTGCGGGCCAGCGTACGCCTGCGTGCCCCGCATGTCATCGTCGACACC   [1320]
Kawanglawang        ACGTGCGGGCCAGCGTACGCCTGCGTGCCCCGCATGTCATCGTCGACACC   [1318]
Borjahinga          ACGTGCGGGCCAGCGTACGCCTGCGTGCCCCGCATGTCATCGTCGACACC   [1321]
Til Bora            ACGTGCGGGCCAGCGTACGCCTGCGTGCCCCGCATGTCATCGTCGACACC   [1318]
Hati Hali           ACGTGCGGGCCAGCGTACGCCTGCGTGCCCCGCATGTCATCGTCGACACC   [1318]
Ranjit              ACGTGCGGGCCAGCGTACGCCTGCGTGCCCCGCATGTCATCGTCGACACC   [1320]
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Kakiberoin        ACGTGCGGGCCAGCGTACGCCTGCGTGCCCCGCATGTCATCGTCGACACC   [1318]
Aubalam           ACGTGCGGGCCAGCGTACGCCTGCGTGCCCCGCATGTCATCGTCGACACC   [1321]
Balam             ACGTGCGGGCCAGCGTACGCCTGCGTGCCCCGCATGTCATCGTCGACACC   [1321]
Borua Beroin      ACGTGCGGGCCAGCGTACGCCTGCGTGCCCCGCATGTCATCGTCGACACC   [1320]
Lallatoi          ACGTGCGGGCCAGCGTACGCCTGCGTGCCCCGCATGTCATCGTCGACACC   [1320]
IR8               ACGTGCGGGCCAGCGTACGCCTGCGTGCCCCGCATGTCATCGTCGACACC   [1320]
Arfa              ACGTGCGGGCCAGCGTACGCCTGCGTGCCCCGCATGTCATCGTCGACACC   [1321]
Bahadur           ACGTGCGGGCCAGCGTACGCCTGCGTGCCCCGCATGTCATCGTCGACACC   [1320]
Pankaj            ACGTGCGGGCCAGCGTACGCCTGCGTGCCCCGCATGTCATCGTCGACACC   [1320]
Bashful           ACGTGCGGGCCAGCGTACGCCTGCGTGCCCCGCATGTCATCGTCGACACC   [1318]
Moircha           ACGTGCGGGCCAGCGTACGCCTGCGTGCCCCGCATGTCATCGTCGACACC   [1320]
Joya              ACGTGCGGGCCAGCGTACGCCTGCGTGCCCCGCATGTCATCGTCGACACC   [1320]
Bas Beroin        ACGTGCGGGCCAGCGTACGCCTGCGTGCCCCGCATGTCATCGTCGACACC   [1318]
Ranga Borah       ACGTGCGGGCCAGCGTACGCCTGCGTGCCCCGCATGTCATCGTCGACACC   [1320]
Mulahail          ACGTGCGGGCCAGCGTACGCCTGCGTGCCCCGCATGTCATCGTCGACACC   [1318]
Guaroi            ACGTGCGGGCCAGCGTACGCCTGCGTGCCCCGCATGTCATCGTCGACACC   [1318]
Mimutim           ACGTGCGGGCCAGCGTACGCCTGCGTGCCCCGCATGTCATCGTCGACACC   [1318]
Harinarayn        ACGTGCGGGCCAGCGTACGCCTGCGTGCCCCGCATGTCATCGTCGACACC   [1319]
Bherapawa         ACGTGCGGGCCAGCGTACGCCTGCGTGCCCCGCATGTCATCGTCGACACC   [1318]
O. rufipogon      ACGTGCGGGCCAGCGTACGCCTGCGTGCCCCGCATGTCATCGTCGACACC   [1257]

[                          1360      1370      1380      1390      1400]
[                             .         .         .         .         .]
Papue             GGCCGGGGACCGGGTAAAATGTGTTGCGGGAGGGAGAGGGGGAGAGAGAG   [1368]
Lahi              GGCCGGGGACCGGGTAAAATGTGTTGCGGGAGGGAGAGGGGGAGAGAGAG   [1368]
Joha              GGCCGGGGACCGGGTAAAATGTGTTGCGGGAGGGAGAGGGGGAGAGAGAG   [1368]
Local Basmati     GGCCGGGGACCGGGTAAAATGTGTTGCGGGAGGGAGAGGGGGAGAGAGAG   [1368]
Sorpuma           GGCCGGGGACCGGGTAAAATGTGTTGCGGGAGGGAGAGGGGGAGAGAGAG   [1370]
Kawanglawang      GGCCGGGGACCGGGTAAAATGTGTTGCGGGAGGGAGAGGGGGAGAGAGAG   [1368]
Borjahinga        GGCCGGGGACCGGGTAAAATGTGTTGCGGGAGGGAGAGGGGGAGAGAGAG   [1371]
Til Bora          GGCCGGGGACCGGGTAAAATGTGTTGCGGGAGGGAGAGGGGGAGAGAGAG   [1368]
Hati Hali         GGCCGGGGACCGGGTAAAATGTGTTGCGGGAGGGAGAGGGGGAGAGAGAG   [1368]
Ranjit            GGCCGGGGACCGGGTAAAATGTGTTGCGGGAGGGAGAGGGGGAGAGAGAG   [1370]
Kakiberoin        GGCCGGGGACCGGGTAAAATGTGTTGCGGGAGGGAGAGGGGGAGAGAGAG   [1368]
Aubalam           GGCCGGGGACCGGGTAAAATGTGTTGCGGGAGGAGAAGGGGGAGAGAGAG   [1371]
Balam             GGCCGGGGACCGGGTAAAATGTGTTGCGGGAGGGAGAGGGGGAGAGAGAG   [1371]
Borua Beroin      GGCCGGGGACCGGGTAAAATGTGTTGCGGGAGGGAGAGGGGGAGAGAGAG   [1370]
Lallatoi          GGCCGGGGACCGGGTAAAATGTGTTGCGGGAGGGAGAGGGGGAGAGAGAG   [1370]
IR8               GGCCGGGGACCGGGTAAAATGTGTTGCGGGAGGGAGAGGGGGAGAGAGAG   [1370]
Arfa              GGCCGGGGACCGGGTAAAATGTGTTGCGGGAGGGAGAGGGGGAGAGAGAG   [1371]
Bahadur           GGCCGGGGACCGGGTAAAATGTGTTGCGGGAGGGAGAGGGGGAGAGAGAG   [1370]
Pankaj            GGCCGGGGACCGGGTAAAATGTGTTGCGGGAGGGAGAGGGGGAGAGAGAG   [1370]
Bashful           GGCCGGGGACCGGGTAAAATGTGTTGCGGGAGGGAGAGGGGGAGAGAGAG   [1368]
Moircha           GGCCGGGGACCGGGTAAAATGTGTTGCGGGAGGGAGAGGGGGAGAGAGAG   [1370]
Joya              GGCCGGGGACCGGGTAAAATGTGTTGCGGGAGGGAGAGGGGGAGAGAGAG   [1370]
Bas Beroin        GGCCGGGGACCGGGTAAAATGTGTTGCGGGAGGGAGAGGGGGAGAGAGAG   [1368]
Ranga Borah       GGCCGGGGACCGGGTAAAATGTGTTGCGGGAGGGAGAGGGGGAGAGAGAG   [1370]
Mulahail          GGCCGGGGACCGGGTAAAATGTGTTGCGGGAGGGAGAGGGGGAGAGAGAG   [1368]
Guaroi            GGCCGGGGACCGGGTAAAATGTGTTGCGGGAGGGAGAGGGGGAGAGAGAG   [1368]
Mimutim           GGCCGGGGACCGGGTAAAATGTGTTGCGGGAGGGAGAGGGGGAGAGAGAG   [1368]
Harinarayn        GGCCGGGGACCGGGTAAAATGTGTTGCGGGAGGGAGAGGGGGAGAGAGAG   [1369]
Bherapawa         GGCCGGGGACCGGGTAAAATGTGTTGCGGGAGGGAGAGGGGGAGAGAGAG   [1368]
O. rufipogon      GGCCGGGGACCGGGTAAAATGTGTTGC----------GGGGGAGAGAGAG   [1297]

[                          1410      1420      1430      1440      1450]
[                             .         .         .         .         .]
Papue             ATCGCGCGGGCTTCACGCAACGGCGCTACAAATAGCCACCCACACCACCA   [1418]
Lahi              ATCGCGCGGGCTTCACGCAACGGCGCTACAAATAGCCACCCACACCACCA   [1418]
Joha              ATCGCGCGGGCTTCACGCAACGGCGCTACAAATAGCCACCCACACCACCA   [1418]
Local Basmati     ATCGCGCGGGCTTCACGCAACGGCGCTACAAATAGCCACCCACACCACCA   [1418]
Sorpuma           ATCGCGCGGGCTTCACGCAACGGCGCTACAAATAGCCACCCACACCACCA   [1420]
Kawanglawang      ATCGCGCGGGCTTCACGCAACGGCGCTACAAATAGCCACCCACACCACCA   [1418]
Borjahinga        ATCGCGCGGGCTTCACGCAACGGCGCTACAAATAGCCACCCACACCACCA   [1421]
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Til Bora          ATCGCGCGGGCTTCACGCAACGGCGCTACAAATAGCCACCCACACCACCA   [1418]
Hati Hali         ATCGCGCGGGCTTCACGCAACGGCGCTACAAATAGCCACCCACACCACCA   [1418]
Ranjit            ATCGCGCGGGCTTCACGCAACGGCGCTACAAATAGCCACCCACACCACCA   [1420]
Kakiberoin        ATCGCGCGGGCTTCACGCAACGGCGCTACAAATAGCCACCCACACCACCA   [1418]
Aubalam           ATCGCGCGGGCTTCACGCAACGGCGCTACAAATAGCCACCCACACCACCA   [1421]
Balam             ATCGCGCGGGCTTCACGCAACGGCGCTACAAATAGCCACCCACACCACCA   [1421]
Borua Beroin      ATCGCGCGGGCTTCACGCAACGGCGCTACAAATAGCCACCCACACCACCA   [1420]
Lallatoi          ATCGCGCGGGCTTCACGCAACGGCGCTACAAATAGCCACCCACACCACCA   [1420]
IR8               ATCGCGCGGGCTTCACGCAACGGCGCTACAAATAGCCACCCACACCACCA   [1420]
Arfa              ATCGCGCGGGCTTCACGCAACGGCGCTACAAATAGCCACCCACACCACCA   [1421]
Bahadur           ATCGCGCGGGCTTCACGCAACGGCGCTACAAATAGCCACCCACACCACCA   [1420]
Pankaj            ATCGCGCGGGCTTCACGCAACGGCGCTACAAATAGCCACCCACACCACCA   [1420]
Bashful           ATCGCGCGGGCTTCACGCAACGGCGCTACAAATAGCCACCCACACCACCA   [1418]
Moircha           ATCGCGCGGGCTTCACGCAACGGCGCTACAAATAGCCACCCACACCACCA   [1420]
Joya              ATCGCGCGGGCTTCACGCAACGGCGCTACAAATAGCCACCCACACCACCA   [1420]
Bas Beroin        ATCGCGCGGGCTTCACGCAACGGCGCTACAAATAGCCACCCACACCACCA   [1418]
Ranga Borah       ATCGCGCGGGCTTCACGCAACGGCGCTACAAATAGCCACCCACACCACCA   [1420]
Mulahail          ATCGCGCGGGCTTCACGCAACGGCGCTACAAATAGCCACCCACACCACCA   [1418]
Guaroi            ATCGCGCGGGCTTCACGCAACGGCGCTACAAATAGCCACCCACACCACCA   [1418]
Mimutim           ATCGCGCGGGCTTCACGCAACGGCGCTACAAATAGCCACCCACACCACCA   [1418]
Harinarayn        ATCGCGCGGGCTTCACGCAACGGCGCTACAAATAGCCACCCACACCACCA   [1419]
Bherapawa         ATCGCGCGGGCTTCACGCAACGGCGCTACAAATAGCCACCCACACCACCA   [1418]
O. rufipogon      ATCGCGCGGGCTTCACGCAACGGCGCTACAAATAGCCACCCACACCACCA   [1347]

[                          1460      1470      1480      1490      1500]
[                             .         .         .         .         .]
Papue             CCCCCTCTCTCACCATTCCTTCAGTTCTTTGTCTATCTCAAGACACAAAT   [1468]
Lahi              CCCCCTCTCTCACCATTCCTTCAGTTCTTTGTCTATCTCAAGACACAAAT   [1468]
Joha              CCCCCTCTCTCACCATTCCTTCAGTTCTTTGTCTATCTCAAGACACAAAT   [1468]
Local Basmati     CCCCCTCTCTCACCATTCCTTCAGTTCTTTGTCTATCTCAAGACACAAAT   [1468]
Sorpuma           CCCCCTCTCTCACCATTCCTTCAGTTCTTTGTCTATCTCAAGACACAAAT   [1470]
Kawanglawang      CCCCCTCTCTCACCATTCCTTCAGTTCTTTGTCTATCTCAAGACACAAAT   [1468]
Borjahinga        CCCCCTCTCTCACCATTCCTTCAGTTCTTTGTCTATCTCAAGACACAAAT   [1471]
Til Bora          CCCCCTCTCTCACCATTCCTTCAGTTCTTTGTCTATCTCAAGACACAAAT   [1468]
Hati Hali         CCCCCTCTCTCACCATTCCTTCAGTTCTTTGTCTATCTCAAGACACAAAT   [1468]
Ranjit            CCCCCTCTCTCACCATTCCTTCAGTTCTTTGTCTATCTCAAGACACAAAT   [1470]
Kakiberoin        CCCCCTCTCTCACCATTCCTTCAGTTCTTTGTCTATCTCAAGACACAAAT   [1468]
Aubalam           CCCCCTCTCTCACCATTCCTTCAGTTCTTTGTCTATCTCAAGACACAAAT   [1471]
Balam             CCCCCTCTCTCACCATTCCTTCAGTTCTTTGTCTATCTCAAGACACAAAT   [1471]
Borua Beroin      CCCCCTCTCTCACCATTCCTTCAGTTCTTTGTCTATCTCAAGACACAAAT   [1470]
Lallatoi          CCCCCTCTCTCACCATTCCTTCAGTTCTTTGTCTATCTCAAGACACAAAT   [1470]
IR8               CCCCCTCTCTCACCATTCCTTCAGTTCTTTGTCTATCTCAAGACACAAAT   [1470]
Arfa              CCCCCTCTCTCACCATTCCTTCAGTTCTTTGTCTATCTCAAGACACAAAT   [1471]
Bahadur           CCCCCTCTCTCACCATTCCTTCAGTTCTTTGTCTATCTCAAGACACAAAT   [1470]
Pankaj            CCCCCTCTCTCACCATTCCTTCAGTTCTTTGTCTATCTCAAGACACAAAT   [1470]
Bashful           CCCCCTCTCTCACCATTCCTTCAGTTCTTTGTCTATCTCAAGACACAAAT   [1468]
Moircha           CCCCCTCTCTCACCATTCCTTCAGTTCTTTGTCTATCTCAAGACACAAAT   [1470]
Joya              CCCCCTCTCTCACCATTCCTTCAGTTCTTTGTCTATCTCAAGACACAAAT   [1470]
Bas Beroin        CCCCCTCTCTCACCATTCCTTCAGTTCTTTGTCTATCTCAAGACACAAAT   [1468]
Ranga Borah       CCCCCTCTCTCACCATTCCTTCAGTTCTTTGTCTATCTCAAGACACAAAT   [1470]
Mulahail          CCCCCTCTCTCACCATTCCTTCAGTTCTTTGTCTATCTCAAGACACAAAT   [1468]
Guaroi            CCCCCTCTCTCACCATTCCTTCAGTTCTTTGTCTATCTCAAGACACAAAT   [1468]
Mimutim           CCCCCTCTCTCACCATTCCTTCAGTTCTTTGTCTATCTCAAGACACAAAT   [1468]
Harinarayn        CCCCCTCTCTCACCATTCCTTCAGTTCTTTGTCTATCTCAAGACACAAAT   [1469]
Bherapawa         CCCCCTCTCTCACCATTCCTTCAGTTCTTTGTCTATCTCAAGACACAAAT   [1468]
O. rufipogon      CCCCCTCTCTCACCATTCCTTCAGTTCTTTGTCTATCTCAAGACACAAAT   [1397]

[                          1510      1520      1530      1540      1550]
[                             .         .         .         .         .]
Papue             AAAAGCAGTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCTG   [1518]
Lahi              AAATGCAGTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCT------G   [1512]
Joha              AAATGCAGTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCT----G   [1514]
Local Basmati     AACTGCAGTCTCTCTCTCTCTCTCTCTCTCT------------------G   [1500]
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Sorpuma          AACTGCAGTCTCTCTCTCTCTCTCTCTCT--------------------G   [1500]
Kawanglawang     AAATGCAGTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCT------G   [1512]
Borjahinga       AACTGCAGTCTCTCTCTCTCTCTCTCTCTCT------------------G   [1503]
Til Bora         AAATGCAGTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCT------G   [1512]
Hati Hali        AAATGCAGTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCT----G   [1514]
Ranjit           AACTGCAGTCTCTCTCTCTCTCTCTCTCTCT------------------G   [1502]
Kakiberoin       AACTGCAGTCTCTCTCTCTCTCTCTCTCTCT------------------G   [1500]
Aubalam          AACTGCAGTCTCTCTCTCTCTCTCTCTCTCT------------------G   [1503]
Balam            AACTGCAGTCTCTCTCTCTCTCTCTCTCTCT------------------G   [1503]
Borua Beroin     AAATGCAGTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCT------G   [1514]
Lallatoi         AAATGCAGTCTCTCTCTCTCTCTCTCTCTCT------------------G   [1502]
IR8              AACTGCAGTCTCTCTCTCTCTCTCTCTCTCT------------------G   [1502]
Arfa             AACTGCAGTCTCTCTCTCTCTCTCTCTCTCT------------------G   [1503]
Bahadur          AACTGCAGTCTCTCTCTCTCTCTCTCTCTCT------------------G   [1502]
Pankaj           AACTGCAGTCTCTCTCTCTCTCTCTCTCTCTCT----------------G   [1504]
Bashful          AACTGCAGTCTCTCTCTCTCTCTCTCTCT--------------------G   [1498]
Moircha          AACTGCAGTCTCTCTCTCTCTCTCTCTCTCT------------------G   [1502]
Joya             AACTGCAGTCTCTCTCTCTCTCTCTCTCTCT------------------G   [1502]
Bas Beroin       AAATGCAGTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCT------G   [1512]
Ranga Borah      AACTGCAGTCTCTCTCTCTCTCTCTCTCTCT------------------G   [1502]
Mulahail         AAATGCAGTCTCTCTCTCTCTCTCTCTCT--------------------G   [1498]
Guaroi           AAATGCAGTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCT------G   [1512]
Mimutim          AAATGCAGTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCT----G   [1514]
Harinarayn       AAATGCAGTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCT------G   [1513]
Bherapawa        AAATGCAGTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCTCT------G   [1512]
O. rufipogon     AACTGCAGTCTCTGTCTCTCTCTCTCTCT--------------------G   [1427]

[                         1560      1570      1580      1590      1600]
[                            .         .         .         .         .]
Papue            CTTCACTTCTCTGCTTGTGTTGTTCTGTTGTTCATCAGGAAGAACATCTG   [1568]
Lahi             CTTCACTTCTCTGCTTGTGTTGTTCTGTTGTTCATCAGGAAGAACATCTG   [1562]
Joha             CTTCACTTCTCTGCTTGTGTTGTTCTGTTGTTCATCAGGAAGAACATCTG   [1564]
Local Basmati    CTTCACTTCTCTGCTTGTGTTGTTCTGTTGTTCATCAGGAAGAACATCTG   [1550]
Sorpuma          CTTCACTTCTCTGCTTGTGTTGTTCTGTTGTTCATCAGGAAGAACATCTG   [1550]
Kawanglawang     CTTCACTTCTCTGCTTGTGTTGTTCTGTTGTTCATCAGGAAGAACATCTG   [1562]
Borjahinga       CTTCACTTCTCTGCTTGTGTTGTTCTGTTGTTCATCAGGAAGAACATCTG   [1553]
Til Bora         CTTCACTTCTCTGCTTGTGTTGTTCTGTTGTTCATCAGGAAGAACATCTG   [1562]
Hati Hali        CTTCACTTCTCTGCTTGTGTTGTTCTGTTGTTCATCAGGAAGAACATCTG   [1564]
Ranjit           CTTCACTTCTCTGCTTGTGTTGTTCTGTTGTTCATCAGGAAGAACATCTG   [1552]
Kakiberoin       CTTCACTTCTCTGCTTGTGTTGTTCTGTTGTTCATCAGGAAGAACATCTG   [1550]
Aubalam          CTTCACTTCTCTGCTTGTGTTGTTCTGTTGTTCATCAGGAAGAACATCTG   [1553]
Balam            CTTCACTTCTCTGCTTGTGTTGTTCTGTTGTTCATCAGGAAGAACATCTG   [1553]
Borua Beroin     CTTCACTTCTCTGCTTGTGTTGTTCTGTTGTTCATCAGGAAGAACATCTG   [1564]
Lallatoi         CTTCACTTCTCTGCTTGTGTTGTTCTGTTGTTCATCAGGAAGAACATCTG   [1552]
IR8              CTTCACTTCTCTGCTTGTGTTGTTCTGTTGTTCATCAGGAAGAACATCTG   [1552]
Arfa             CTTCACTTCTCTGCTTGTGTTGTTCTGTTGTTCATCAGGAAGAACATCTG   [1553]
Bahadur          CTTCACTTCTCTGCTTGTGTTGTTCTGTTGTTCATCAGGAAGAACATCTG   [1552]
Pankaj           CTTCACTTCTCTGCTTGTGTTGTTCTGTTGTTCATCAGGAAGAACATCTG   [1554]
Bashful          CTTCACTTCTCTGCTTGTGTTGTTCTGTTGTTCATCAGGAAGAACATCTG   [1548]
Moircha          CTTCACTTCTCTGCTTGTGTTGTTCTGTTGTTCATCAGGAAGAACATCTG   [1552]
Joya             CTTCACTTCTCTGCTTGTGTTGTTCTGTTGTTCATCAGGAAGAACATCTG   [1552]
Bas Beroin       CTTCACTTCTCTGCTTGTGTTGTTCTGTTGTTCATCAGGAAGAACATCTG   [1562]
Ranga Borah      CTTCACTTCTCTGCTTGTGTTGTTCTGTTGTTCATCAGGAAGAACATCTG   [1552]
Mulahail         CTTCACTTCTCTGCTTGTGTTGTTCTGTTGTTCATCAGGAAGAACATCTG   [1548]
Guaroi           CTTCACTTCTCTGCTTGTGTTGTTCTGTTGTTCATCAGGAAGAACATCTG   [1562]
Mimutim          CTTCACTTCTCTGCTTGTGTTGTTCTGTTGTTCATCAGGAAGAACATCTG   [1564]
Harinarayn       CTTCACTTCTCTGCTTGTGTTGTTCTGTTGTTCATCAGGAAGAACATCTG   [1563]
Bherapawa        CTTCACTTCTCTGCTTGTGTTGTTCTGTTGTTCATCAGGAAGAACATCTG   [1562]
O. rufipogon     CTTCACTTCTCTGCTTGTGTTCTTCTGTTGTTCATCAGGAAGAACATCTG   [1477]
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[                             1610      1620      1630      1640      1650]
[                                .         .         .         .         .]
Papue               CAAGGTATACA----TATATGTTTATAATTCTTTGT-TTCCCCTCTTATT   [1613]
Lahi                CAAGGTATACA----TATATGTTTATAATTCTTTGT-TTCCCCTCTTATT   [1607]
Joha                CAAGGTATACA----TATATGTTTATAATTCTTTGT-TTCCCCTCTTATT   [1609]
Local Basmati       CAAGGTATACA----TATATGTTTATAATTCTTTGT-TTCCCCTCTTATT   [1595]
Sorpuma             CAAGGTATACA----TATATGTTTATAATTCTTTGT-TTCCCCTCTTATT   [1595]
Kawanglawang        CAAGTTATACA----TATATGTTTATAATTCTTTGT-TTCCCCTCTTATT   [1607]
Borjahinga          CAAGGTATACA----TATATGTTTATAATTCTTTGT-TTCCCCTCTTATT   [1598]
Til Bora            CAAGTTATACA----TATATGTTTATAATTCTTTGT-TTCCCCTCTTATT   [1607]
Hati Hali           CAAGGTATACA----TATATGTTTATAATTCTTTGT-TTCCCCTCTTATT   [1609]
Ranjit              CAAGGTATACA----TATATGTTTATAATTCTTTGT-TTCCCCTCTTATT   [1597]
Kakiberoin          CAAGGTATACA----TATATGTTTATAATTCTTTGT-TTCCCCTCTTATT   [1595]
Aubalam             CAAGGTATACA----TATATGTTTATAATTCTTTGT-TTCCCCTCTTATT   [1598]
Balam               CAAGGTATACA----TATATGTTTATAATTCTTTGT-TTCCCCTCTTATT   [1598]
Borua Beroin        CAAGTTATACA----TATATGTTTATAATTCTTTGT-TTCCCCTCTTATT   [1609]
Lallatoi            CAAGGTATACA----TATATGTTTATAATTCTTTGT-TTCCCCTCTTATT   [1597]
IR8                 CAAGGTATACA----TATATGTTTATAATTCTTTGT-TTCCCCTCTTATT   [1597]
Arfa                CAAGGTATACA----TATATGTTTATAATTCTTTGT-TTCCCCTCTTATT   [1598]
Bahadur             CAAGGTATACA----TATATGTTTATAATTCTTTGT-TTCCCCTCTTATT   [1597]
Pankaj              CAAGGTATACA----TATATGTTTATAATTCTTTGT-TTCCCCTCTTATT   [1599]
Bashful             CAAGGTATACA----TATATGTTTATAATTCTTTGT-TTCCCCTCTTATT   [1593]
Moircha             CAAGGTATACA----TATATGTTTATAATTCTTTGT-TTCCCCTCTTATT   [1597]
Joya                CAAGGTATACA----TATATGTTTATAATTCTTTGT-TTCCCCTCTTATT   [1597]
Bas Beroin          CAAGTTATACA----TATATGTTTATAATTCTTTGT-TTCCCCTCTTATT   [1607]
Ranga Borah         CAAGGTATACA----TATATGTTTATAATTCTTTGT-TTCCCCTCTTATT   [1597]
Mulahail            CAAGGTATACA----TATATGTTTATAATTCTTTGT-TTCCCCTCTTATT   [1593]
Guaroi              CAAGGTATACA----TATATGTTTATAATTCTTTGT-TTCCCCTCTTATT   [1607]
Mimutim             CAAGGTATACA----TATATGTTTATAATTCTTTGT-TTCCCCTCTTATT   [1609]
Harinarayn          CAAGGTATACA----TATATGTTTATAATTCTTTGT-TTCCCCTCTTATT   [1608]
Bherapawa           CAAGGTATACA----TATATGTTTATAATTCTTTGT-TTCCCCTCTTATT   [1607]
O. rufipogon        CAAGGTATACATGTATATATGTTTATAATTCTTTGTTTTCCCCCCTTCTT   [1527]

[                             1660      1670      1680      1690      1700]
[                                .         .         .         .         .]
Papue               CAGATCGATCACATGCATCTTTCATTGCTCGTTTTTCCTTACAAGTAGTC   [1663]
Lahi                CAGATCGATCACATGCATCTTTCATTGCTCGTTTTTCCTTACAAGTAGTC   [1657]
Joha                CAGATCGATCACATGCATCTTTCATTGCTCGTTTTTCCTTACAAGTAGTC   [1659]
Local Basmati       CAGATCGATCACATGCATCTTTCATTGCTCGTTTTTCCTTACAAATAGTC   [1645]
Sorpuma             CAGATCGATCACATGCATCTTTCATTGCTCGTTTTTCCTTACAA--AGTC   [1643]
Kawanglawang        CAGATCGATCACATGCATCTTTCATTGCTCGTTTTTCCTTACAAGTAGTC   [1657]
Borjahinga          CAGATCGATCACATGCATCTTTCATTGCTCGTTTTTCCTTACAAATAGTC   [1648]
Til Bora            CAGATCGATCACATGCATCTTTCATTGCTCGTTTTTCCTTACAAGTAGTC   [1657]
Hati Hali           CAGATCGATCACATGCATCTTTCATTGCTCGTTTTTCCTTACAAATAGTC   [1659]
Ranjit              CAGATCGATCACATGCATCTTTCATTGCTCGTTTTTCCTTACAAATAGTC   [1647]
Kakiberoin          CAGATCGATCACATGCATCTTTCATTGCTCGTTTTTCCTTACAAATAGTC   [1645]
Aubalam             CAGATCGATCACATGCATCTTTCATTGCTCGTTTTTCCTTACAAATAGTC   [1648]
Balam               CAGATCGATCACATGCATCTTTCATTGCTCGTTTTTCCTTACAAATAGTC   [1648]
Borua Beroin        CAGATCGATCACATGCATCTTTCATTGCTCGTTTTTCCTTACAAGTAGTC   [1659]
Lallatoi            CAGATCGATCACATGCATCTTTCATTGCTCGTTTTTCCTTACAAATAGTC   [1647]
IR8                 CAGATCGATCACATGCATCTTTCATTGCTCGTTTTTCCTTACAAATAGTC   [1647]
Arfa                CAGATCGATCACATGCATCTTTCATTGCTCGTTTTTCCTTACAAATAGTC   [1648]
Bahadur             CAGATCGATCACATGCATCTTTCATTGCTCGTTTTTCCTTACAAATAGTC   [1647]
Pankaj              CAGATCGATCACATGCATCTTTCATTGCTCGTTTTTCCTTACAAATAGTC   [1649]
Bashful             CAGATCGATCACATGCATCTTTCATTGCTCGTTTTTCCTTACAA--AGTC   [1641]
Moircha             CAGATCGATCACATGCATCTTTCATTGCTCGTTTTTCCTTACAAATAGTC   [1647]
Joya                CAGATCGATCACATGCATCTTTCATTGCTCGTTTTTCCTTACAAATAGTC   [1647]
Bas Beroin          CAGATCGATCACATGCATCTTTCATTGCTCGTTTTTCCTTACAAGTAGTC   [1657]
Ranga Borah         CAGATCGATCACATGCATCTTTCATTGCTCGTTTTTCCTTACAAATAGTC   [1647]
Mulahail            CAGATCGATCACATGCATCTTTCATTGCTCGTTTTTCCTTACAA--AGTC   [1641]
Guaroi              CAGATCGATCACATGCATCTTTCATTGCTCGTTTTTCCTTACAAATAGTC   [1657]
Mimutim             CAGATCGATCACATGCATCTTTCATTGCTCGTTTTTCCTTACAAGTAGTC   [1659]
Harinarayn          CAGATCGATCACATGCATCTTTCATTGCTCGTTTTTCCTTACAAATAGTC   [1658]
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Bherapawa          CAGATCGATCACATGCATCTTTCATTGCTCGTTTTTCCTTACAAATAGTC   [1657]
O. rufipogon       CAGATCGATCACATGCATCTTTCATTGCTCGTTTTTCCTTACAAGTAGTC   [1577]

[                           1710      1720      1730      1740      1750]
[                           .         .         .         .         .]
Papue              TCATACATGCTAATTTCTGTAAGGTGTTGGGCTGGAA----ATTAATTAA   [1709]
Lahi               TCATACATGCTAATTTCTGTAAGGTGTTGGGCTGGAA----ATTAATTAA   [1703]
Joha               TCATACATGCTAATTTCTGTAAGGTGTTGGGCTGGAA----ATTAATTAA   [1705]
Local Basmati      TCATACATGCTAATTTCTGTAAGGTGTTGGGCTGGAAATTAATTAATTAA   [1695]
Sorpuma            TCATACATGCTAATTTCTGTAAGGTGTTGGGCTGGAA----ATTAATTAA   [1689]
Kawanglawang       TCATACATGCTAATTTCTGTAAGGTGTTGGGCTGGAA----ATTAATTAA   [1703]
Borjahinga         TCATACATGCTAATTTCTGTAAGGTGTTGGGCTGGAAATTAATTAATTAA   [1698]
Til Bora           TCATACATGCTAATTTCTGTAAGGTGTTGGGCTGGAA----ATTAATTAA   [1703]
Hati Hali          TCATACATGCTAATTTCTGTAAGGTGTTGGGCTGGAA----ATTAATTAA   [1705]
Ranjit             TCATACATGCTAATTTCTGTAAGGTGTTGGGCTGGAAATTAATTAATTAA   [1697]
Kakiberoin         TCATACATGCTAATTTCTGTAAGGTGTTGGGCTGGAAATTAATTAATTAA   [1695]
Aubalam            TCATACATGCTAATTTCTGTAAGGTGTTGGGCTGGAAATTAATTAATTAA   [1698]
Balam              TCATACATGCTAATTTCTGTAAGGTGTTGGGCTGGAAATTAATTAATTAA   [1698]
Borua Beroin       TCATACATGCTAATTTCTGTAAGGTGTTGGGCTGGAA----ATTAATTAA   [1705]
Lallatoi           TCATACATGCTAATTTCTGTAAGGTGTTGGGCTGGAAATTAATTAATTAA   [1697]
IR8                TCATACATGCTAATTTCTGTAAGGTGTTGGGCTGGAAATTAATTAATTAA   [1697]
Arfa               TCATACATGCTAATTTCTGTAAGGTGTTGGGCTGGAAATTAATTAATTAA   [1698]
Bahadur            TCATACATGCTAATTTCTGTAAGGTGTTGGGCTGGAAATTAATTAATTAA   [1697]
Pankaj             TCATACATGCTAATTTCTGTAAGGTGTTGGGCTGGAAATTAATTAATTAA   [1699]
Bashful            TCATACATGCTAATTTCTGTAAGGTGTTGGGCTGGAA----ATTAATTAA   [1687]
Moircha            TCATACATGCTAATTTCTGTAAGGTGTTGGGCTGGAAATTAATTAATTAA   [1697]
Joya               TCATACATGCTAATTTCTGTAAGGTGTTGGGCTGGAAATTAATTAATTAA   [1697]
Bas Beroin         TCATACATGCTAATTTCTGTAAGGTGTTGGGCTGGAA----ATTAATTAA   [1703]
Ranga Borah        TCATACATGCTAATTTCTGTAAGGTGTTGGGCTGGAAATTAATTAATTAA   [1697]
Mulahail           TCATACATGCTAATTTCTGTAAGGTGTTGGGCTGGAA----ATTAATTAA   [1687]
Guaroi             TCATACATGCTAATTTCTGTAAGGTGTTGGGCTGGAA----ATTAATTAA   [1703]
Mimutim            TCATACATGCTAATTTCTGTAAGGTGTTGGGCTGGAA----ATTAATTAA   [1705]
Harinarayn         TCATACATGCTAATTTCTGTAAGGTGTTGGGCTGGAA----ATTAATTAA   [1704]
Bherapawa          TCATACATGCTAATTTCTGTAAGGTGTTGGGCTGGAA----ATTAATTAA   [1703]
O. rufipogon       TCGTACATGCTAATTTCTGTAAGGTGTTGGGCTGCAA----ATTAATTAA   [1623]

[                           1760      1770      1780      1790      1800]
[                           .         .         .         .         .]
Papue              TTAATTAATTGACTTGCCAAGA-TCC--------ATATATATGTCCTGAT   [1750]
Lahi               TTAATTAATTGACTTGCCAAGA-TCC--------ATATATATGTCCTGAT   [1744]
Joha               TTAATTAATTGACTTGCCAAGA-TCC--------ATATATATGTCCTGAT   [1746]
Local Basmati      TTAATTAATTGACTTGCCAAGA-TCC--------ATATATATGTCCTGAT   [1736]
Sorpuma            TTAATTAATTGACTTGCCAAGA-TCC--------ATATATATGTCCTGAT   [1730]
Kawanglawang       TTAATTAATTGACTTGCCAAGA-TCC--------ATATATATGTCCTGAT   [1744]
Borjahinga         TTAATTAATTGACTTGCCAAGA-TCC--------ATATATATGTCCTGAT   [1739]
Til Bora           TTAATTAATTGACTTGCCAAGA-TCC--------ATATATATGTCCTGAT   [1744]
Hati Hali          TTAATTAATTGACTTGCCAAGA-TCC--------ATATATATGTCCTGAT   [1746]
Ranjit             TTAATTAATTGACTTGCCAAGA-TCC--------ATATATATGTCCTGAT   [1738]
Kakiberoin         TTAATTAATTGACTTGCCAAGA-TCC--------ATATATATGTCCTGAT   [1736]
Aubalam            TTAATTAATTGACTTGCCAAGA-TCC--------ATATATATGTCCTGAT   [1739]
Balam              TTAATTAATTGACTTGCCAAGA-TCC--------ATATATATGTCCTGAT   [1739]
Borua Beroin       TTAATTAATTGACTTGCCAAGA-TCC--------ATATATATGTCCTGAT   [1746]
Lallatoi           TTAATTAATTGACTTGCCAAGA-TCC--------ATATATATGTCCTGAT   [1738]
IR8                TTAATTAATTGACTTGCCAAGA-TCC--------ATATATATGTCCTGAT   [1738]
Arfa               TTAATTAATTGACTTGCCAAGA-TCC--------ATATATATGTCCTGAT   [1739]
Bahadur            TTAATTAATTGACTTGCCAAGA-TCC--------ATATATATGTCCTGAT   [1738]
Pankaj             TTAATTAATTGACTTGCCAAGA-TCC--------ATATATATGTCCTGAT   [1740]
Bashful            TTAATTAATTGACTTGCCAAGA-TCC--------ATATATATGTCCTGAT   [1728]
Moircha            TTAATTAATTGACTTGCCAAGA-TCC--------ATATATATGTCCTGAT   [1738]
Joya               TTAATTAATTGACTTGCCAAGA-TCC--------ATATATATGTCCTGAT   [1738]
Bas Beroin         TTAATTAATTGACTTGCCAAGA-TCC--------ATATATATGTCCTGAT   [1744]
Ranga Borah        TTAATTAATTGACTTGCCAAGA-TCC--------ATATATATGTCCTGAT   [1738]
Mulahail           TTAATTAATTGACTTGCCAAGA-TCC--------ATATATATGTCCTGAT   [1728]
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Guaroi          TTAATTAATTGACTTGCCAAGA-TCC--------ATATATATGTCCTGAT   [1744]
Mimutim         TTAATTAATTGACTTGCCAAGA-TCC--------ATATATATGTCCTGAT   [1746]
Harinarayn      TTAATTAATTGACTTGCCAAGA-TCC--------ATATATATGTCCTGAT   [1745]
Bherapawa       TTAATTAATTGACTTGCCAAGA-TCC--------ATATATATGTCCTGAT   [1744]
O. rufipogon    TTAATTAATTGACTTGCCAAGATTCAATATATATATATATATGTCCTGAT   [1673]

[                        1810      1820      1830      1840      1850]
[                        .         .         .         .         .]
Papue           ATTAAATCTTCGTTCGTTATGTTTGGTTAGGCTGATCAATGTTATTCTAG   [1800]
Lahi            ATTAAATCTTCGTTCGTTATGTTTGGTTAGGCTGATCAATGTTATTCTAG   [1794]
Joha            ATTAAATCTTCGTTCGTTATGTTTGGTTAGGCTGATCAATGTTATTCTAG   [1796]
Local Basmati   ATTAAATCTTCGTTCGTTATGTTTGGTTAGGCTGATCGATGTTATTCTAG   [1786]
Sorpuma         ATTAAATCTTCGTTCGTTATGTTTGGTTAGGCTGATCAATGTTATTCTAG   [1780]
Kawanglawang    ATTAAATCTTCGTTCGTTATGTTTGGTTAGGCTGATCAATGTTATTCTAG   [1794]
Borjahinga      ATTAAATCTTCGTTCGTTATGTTTGGTTAGGCTGATCGATGTTATTCTAG   [1789]
Til Bora        ATTAAATCTTCGTTCGTTATGTTTGGTTAGGCTGATCAATGTTATTCTAG   [1794]
Hati Hali       ATTAAATCTTCGTTCGTTATGTTTGGTTAGGCTGATCGATGTTATTCTAG   [1796]
Ranjit          ATTAAATCTTCGTTCGTTATGTTTGGTTAGGCTGATCGATGTTATTCTAG   [1788]
Kakiberoin      ATTAAATCTTCGTTCGTTATGTTTGGTTAGGCTGATCGATGTTATTCTAG   [1786]
Aubalam         ATTAAATCTTCGTTCGTTATGTTTGGTTAGGCTGATCGATGTTATTCTAG   [1789]
Balam           ATTAAATCTTCGTTCGTTATGTTTGGTTAGGCTGATCGATGTTATTCTAG   [1789]
Borua Beroin    ATTAAATCTTCGTTCGTTATGTTTGGTTAGGCTGATCAATGTTATTCTAG   [1796]
Lallatoi        ATTAAATCTTCGTTCGTTATGTTTGGTTAGGCTGATCGATGTTATTCTAG   [1788]
IR8             ATTAAATCTTCGTTCGTTATGTTTGGTTAGGCTGATCGATGTTATTCTAG   [1788]
Arfa            ATTAAATCTTCGTTCGTTATGTTTGGTTAGGCTGATCGATGTTATTCTAG   [1789]
Bahadur         ATTAAATCTTCGTTCGTTATGTTTGGTTAGGCTGATCGATGTTATTCTAG   [1788]
Pankaj          ATTAAATCTTCGTTCGTTATGTTTGGTTAGGCTGATCGATGTTATTCTAG   [1790]
Bashful         ATTAAATCTTCGTTCGTTATGTTTGGTTAGGCTGATCAATGTTATTCTAG   [1778]
Moircha         ATTAAATCTTCGTTCGTTATGTTTGGTTAGGCTGATCGATGTTATTCTAG   [1788]
Joya            ATTAAATCTTCGTTCGTTATGTTTGGTTAGGCTGATCGATGTTATTCTAG   [1788]
Bas Beroin      ATTAAATCTTCGTTCGTTATGTTTGGTTAGGCTGATCAATGTTATTCTAG   [1794]
Ranga Borah     ATTAAATCTTCGTTCGTTATGTTTGGTTAGGCTGATCGATGTTATTCTAG   [1788]
Mulahail        ATTAAATCTTCGTTCGTTATGTTTGGTTAGGCTGATCAATGTTATTCTAG   [1778]
Guaroi          ATTAAATCTTCGTTCGTTATGTTTGGTTAGGCTGATCGATGTTATTCTAG   [1794]
Mimutim         ATTAAATCTTCGTTCGTTATGTTTGGTTAGGCTGATCAATGTTATTCTAG   [1796]
Harinarayn      ATTAAATCTTCGTTCGTTATGTTTGGTTAGGCTGATCGATGTTATTCTAG   [1795]
Bherapawa       ATTAAATCTTCGTTCGTTATGTTTGGTTAGGCTGATCGATGTTATTCTAG   [1794]
O. rufipogon    ATTAAATCTTCGTTCCTTATGTTTGGTTAGGCTGATCGATGTTATTCTAG   [1723]

[                        1860      1870      1880      1890      1900]
[                        .         .         .         .         .]
Papue           AGTCTAGAGAAACACACCCAGGGGTTTTCCAACTAGCTCCACA-AGATGG   [1849]
Lahi            AGTCTAGAGAAACACACCCAGGGGTTTTCCAACTAGCTCCACA-AGATGG   [1843]
Joha            AGTCTAGAGAAACACACCCAGGGGTTTTCCAACTAGCTCCACA-AGATGG   [1845]
Local Basmati   AGTCTAGAGAAACATACCCAGGGGTTTTCCAGCTAGCTCCACA-AGATGG   [1835]
Sorpuma         AGTCTAGAGAAACACACCCAGGGGTTTTCCAGCTAGCTCCACA-AGATGG   [1829]
Kawanglawang    AGTCTAGAGAAACACACCCAGGGGTTTTCCAACTAGCTCCACA-AGATGG   [1843]
Borjahinga      AGTCTAGAGAAACATACCCAGGGGTTTTCCAGCTAGCTCCACA-AGATGG   [1838]
Til Bora        AGTCTAGAGAAACACACCCAGGGGTTTTCCAACTAGCTCCACA-AGATGG   [1843]
Hati Hali       AGTCTAGAGAAACACACCCAGGGGTTTTCCAGCTAGCTCCACA-AGATGG   [1845]
Ranjit          AGTCTAGAGAAACATACCCAGGGGTTTTCCAGCTAGCTCCACA-AGATGG   [1837]
Kakiberoin      AGTCTAGAGAAACATACCCAGGGGTTTTCCAGCTAGCTCCACA-AGATGG   [1835]
Aubalam         AGTCTAGAGAAACATACCCAGGGGTTTTCCAGCTAGCTCCACA-AGATGG   [1838]
Balam           AGTCTAGAGAAACATACCCAGGGGTTTTCCAGCTAGCTCCACA-AGATGG   [1838]
Borua Beroin    AGTCTAGAGAAACACACCCAGGGGTTTTCCAACTAGCTCCACA-AGATGG   [1845]
Lallatoi        AGTCTAGAGAAACATACCCAGGGGTTTTCCAGCTAGCTCCACA-AGATGG   [1837]
IR8             AGTCTAGAGAAACATACCCAGGGGTTTTCCAGCTAGCTCCACA-AGATGG   [1837]
Arfa            AGTCTAGAGAAACATACCCAGGGGTTTTCCAGCTAGCTCCACA-AGATGG   [1838]
Bahadur         AGTCTAGAGAAACATACCCAGGGGTTTTCCAGCTAGCTCCACA-AGATGG   [1837]
Pankaj          AGTCTAGAGAAACATACCCAGGGGTTTTCCAGCTAGCTCCACA-AGATGG   [1839]
Bashful         AGTCTAGAGAAACACACCCAGGGGTTTTCCAGCTAGCTCCACA-AGATGG   [1827]
Moircha         AGTCTAGAGAAACATACCCAGGGGTTTTCCAGCTAGCTCCACA-AGATGG   [1837]
Joya            AGTCTAGAGAAACATACCCAGGGGTTTTCCAGCTAGCTCCACA-AGATGG   [1837]
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Bas Beroin          AGTCTAGAGAAACACACCCAGGGGTTTTCCAACTAGCTCCACA-AGATGG   [1843]
Ranga Borah         AGTCTAGAGAAACATACCCAGGGGTTTTCCAGCTAGCTCCACA-AGATGG   [1837]
Mulahail            AGTCTAGAGAAACACACCCAGGGGTTTTCCAGCTAGCTCCACA-AGATGG   [1827]
Guaroi              AGTCTAGAGAAACACACCCAGGGGTTTTCCAGCTAGCTCCACA-AGATGG   [1843]
Mimutim             AGTCTAGAGAAACACACCCAGGGGTTTTCCAACTAGCTCCACA-AGATGG   [1845]
Harinarayn          AGTCTAGAGAAACACACCCAGGGGTTTTCCAGCTAGCTCCACA-AGATGG   [1844]
Bherapawa           AGTCTAGAGAAACACACCCAGGGGTTTTCCAGCTAGCTCCACA-AGATGG   [1843]
O. rufipogon        AGTCTAGAGAAACACACCCAGGGGTTTTCCAGCTAGCTCCACAGAGATGG   [1773]

[                            1910      1920      1930      1940      1950]
[                               .         .         .         .         .]
Papue               TGGGCTAGCTGACCTAGATTTGAAGTCTCACTCCTTATAATTATTTTATA   [1899]
Lahi                TGGGCTAGCTGACCTAGATTTGAAGTCTCACTCCTTATAATTATTTTATA   [1893]
Joha                TGGGCTAGCTGACCTAGATTTGAAGTCTCACTCCTTATAATTATTTTATA   [1895]
Local Basmati       TGGGCTAGCTGACCTAGATTT-AAGTCTCACTCTTTCTAATTATTTGATA   [1884]
Sorpuma             TGGGCTAGCTGACCTAGATTTGAAGTCTCACTCTTTCTAATTATTTGATA   [1879]
Kawanglawang        TGGGCTAGCTGACCTAGATTTGAAGTCTCACTCCTTATAATTATTTTATA   [1893]
Borjahinga          TGGGCTAGCTGACCTAGATTT-AAGTCTCACTCTTTCTAATTATTTGATA   [1887]
Til Bora            TGGGCTAGCTGACCTAGATTTGAAGTCTCACTCCTTATAATTATTTTATA   [1893]
Hati Hali           TGGGCTAGCTGACCTAGATTT-AAGTCTCACTCTTTCTAATTATTTGATA   [1894]
Ranjit              TGGGCTAGCTGACCTAGATTT-AAGTCTCACTCTTTCTAATTATTTGATA   [1886]
Kakiberoin          TGGGCTAGCTGACCTAGATTT-AAGTCTCACTCTTTCTAATTATTTGATA   [1884]
Aubalam             TGGGCTAGCTGACCTAGATTT-AAGTCTCACTCTTTCTAATTATTTGATA   [1887]
Balam               TGGGCTAGCTGACCTAGATTT-AAGTCTCACTCTTTCTAATTATTTGATA   [1887]
Borua Beroin        TGGGCTAGCTGACCTAGATTTGAAGTCTCACTCCTTATAATTATTTTATA   [1895]
Lallatoi            TGGGCTAGCTGACCTAGATTT-AAGTCTCACTCCTTCTAATTATTTGATA   [1886]
IR8                 TGGGCTAGCTGACCTAGATTT-AAGTCTCACTCTTTCTAATTATTTGATA   [1886]
Arfa                TGGGCTAGCTGACCTAGATTT-AAGTCTCACTCTTTCTAATTATTTGATA   [1887]
Bahadur             TGGGCTAGCTGACCTAGATTT-AAGTCTCACTCTTTCTAATTATTTGATA   [1886]
Pankaj              TGGGCTAGCTGACCTAGATTT-AAGTCTCACTCTTTCTAATTATTTGATA   [1888]
Bashful             TGGGCTAGCTGACCTAGATTTGAAGTCTCACTCTTTCTAATTATTTGATA   [1877]
Moircha             TGGGCTAGCTGACCTAGATTT-AAGTCTCACTCTTTCTAATTATTTGATA   [1886]
Joya                TGGGCTAGCTGACCTAGATTT-AAGTCTCACTCTTTCTAATTATTTGATA   [1886]
Bas Beroin          TGGGCTAGCTGACCTAGATTTGAAGTCTCACTCCTTATAATTATTTTATA   [1893]
Ranga Borah         TGGGCTAGCTGACCTAGATTT-AAGTCTCACTCTTTCTAATTATTTGATA   [1886]
Mulahail            TGGGCTAGCTGACCTAGATTTGAAGTCTCACTCTTTCTAATTATTTGATA   [1877]
Guaroi              TGGGCTAGCTGACCTAGATTT-AAGTCTCACTCTTTCTAATTATTTGATA   [1892]
Mimutim             TGGGCTAGCTGACCTAGATTTGAAGTCTCACTCCTTATAATTATTTTATA   [1895]
Harinarayn          TGGGCTAGCTGACCTAGATTT-AAGTCTCACTCTTTCTAATTATTTGATA   [1893]
Bherapawa           TGGGCTAGCTGACCTAGATTT-AAGTCTCACTCTTTCTAATTATTTGATA   [1892]
O. rufipogon        TGGGCTAACTGACCTGGATTCGAGACCTCACTCCTTTTAATTATTTGATA   [1823]

[                            1960      1970      1980      1990      2000]
[                               .         .         .         .         .]
Papue               TTAGATCATTTTCTAATATTCGTGTCTTTTTTTATTCTAGAGTCTAGATC   [1949]
Lahi                TTAGATCATTTTCTAATATTCGTGTCTTTTTTTATTCTAGAGTCTAGATC   [1943]
Joha                TTAGATCATTTTCTAATATTCGTGTCTTTTTTTATTCTAGAGTCTAGATC   [1945]
Local Basmati       TTAGATCATTTTCTAATATTTGCGTCTTTTTTTATTCTAGAGTCTAGATC   [1934]
Sorpuma             TTAGATCATTTTCTAATATTTGCGTCTTTTTTTATTCTAGAGTCTAGATC   [1929]
Kawanglawang        TTAGATCATTTTCTAATATTCGTGTCTTTTTTTATTCTAGAGTCTAGATC   [1943]
Borjahinga          TTAGATCATTTTCTAATATTTGCGTCTTTTTTTATTCTAGAGTCTAGATC   [1937]
Til Bora            TTAGATCATTTTCTAATATTCGTGTCTTTTTTTATTCTAGAGTCTAGATC   [1943]
Hati Hali           TTAGATCATTTTCTAATATTTGCGTCTTTTTTTATTCTAGAGTCTAGATC   [1944]
Ranjit              TTAGATCATTTTCTAATATTTGCGTCTTTTTTTATTCTAGAGTCTAGATC   [1936]
Kakiberoin          TTAGATCATTTTCTAATATTTGCGTCTTTTTTTATTCTAGAGTCTAGATC   [1934]
Aubalam             TTAGATCATTTTCTAATATTTGCGTCTTTTTTTATTCTAGAGTCTAGATC   [1937]
Balam               TTAGATCATTTTCTAATATTTGCGTCTTTTTTTATTCTAGAGTCTAGATC   [1937]
Borua Beroin        TTAGATCATTTTCTAATATTCGTGTCTTTTTTTATTCTAGAGTCTAGATC   [1945]
Lallatoi            TTAGATCATTTTCTAATATTTGCGTCTTTTTTTATTCTAGAGTCTAGATC   [1936]
IR8                 TTAGATCATTTTCTAATATTTGCGTCTTTTTTTATTCTAGAGTCTAGATC   [1936]
Arfa                TTAGATCATTTTCTAATATTTGCGTCTTTTTTTATTCTAGAGTCTAGATC   [1937]
Bahadur             TTAGATCATTTTCTAATATTTGCGTCTTTTTTTATTCTAGAGTCTAGATC   [1936]
Pankaj              TTAGATCATTTTCTAATATTTGCGTCTTTTTTTATTCTAGAGTCTAGATC   [1938]
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Bashful             TTAGATCATTTTCTAATATTTGCGTCTTTTTTTATTCTAGAGTCTAGATC   [1927]
Moircha             TTAGATCATTTTCTAATATTTGCGTCTTTTTTTATTCTAGAGTCTAGATC   [1936]
Joya                TTAGATCATTTTCTAATATTTGCGTCTTTTTTTATTCTAGAGTCTAGATC   [1936]
Bas Beroin          TTAGATCATTTTCTAATATTCGTGTCTTTTTTTATTCTAGAGTCTAGATC   [1943]
Ranga Borah         TTAGATCATTTTCTAATATTTGCGTCTTTTTTTATTCTAGAGTCTAGATC   [1936]
Mulahail            TTAGATCATTTTCTAATATTTGCGTCTTTTTTTATTCTAGAGTCTAGATC   [1927]
Guaroi              TTAGATCATTTTCTAATATTTGCGTCTTTTTTTATTCTAGAGTCTAGATC   [1942]
Mimutim             TTAGATCATTTTCTAATATTCGTGTCTTTTTTTATTCTAGAGTCTAGATC   [1945]
Harinarayn          TTAGATCATTTTCTAATATTTGCGTCTTTTTTTATTCTAGAGTCTAGATC   [1943]
Bherapawa           TTAGATCATTTTCTAATATTTGCGTCTTTTTTTATTCTAGAGTCTAGATC   [1942]
O. rufipogon        TTAGATCATTTCCTAATATTCGCGTCTTTTTTTATTTTAGAGTCTAGATC   [1873]

[                            2010      2020      2030      2040      2050]
[                            .         .         .         .         .]
Papue               TTGTGTTCAACTCTCGTTAAATCATGTCTCTCGCCAC-TGGAGAAACAGA   [1998]
Lahi                TTGTGTTCAACTCTCGTTAAATCATGTCTCTCGCCAC-TGGAGAAACAGA   [1992]
Joha                TTGTGTTCAACTCTCGTTAAATCATGTCTCTCGCCAC-TGGAGAAACAGA   [1994]
Local Basmati       TTGTGTTCAACTCTCGTTAAATCATGTCTCTCGCCAC-TGGAGAAACAGA   [1983]
Sorpuma             TTGTGTTCAACTCTCGTTAAATCATGTCTCTCGCCAC-TGGAGAAACAGA   [1978]
Kawanglawang        TTGTGTTCAACTCTCGTTAAATCATGTCTCTCGCCAC-TGGAGAAACAGA   [1992]
Borjahinga          TTGTGTTCAACTCTCGTTAAATCATGTCTCTCGCCAC-TGGAGAAACAGA   [1986]
Til Bora            TTGTGTTCAACTCTCGTTAAATCATGTCTCTCGCCAC-TGGAGAAACAGA   [1992]
Hati Hali           TTGTGTTCAACTCTCGTTAAATCATGTCTCTCGCCAC-TGGAGAAACAGA   [1993]
Ranjit              TTGTGTTCAACTCTCGTTAAATCATGTCTCTCGCCAC-TGGAGAAACAGA   [1985]
Kakiberoin          TTGTGTTCAACTCTCGTTAAATCATGTCTCTCGCCAC-TGGAGAAACAGA   [1983]
Aubalam             TTGTGTTCAACTCTCGTTAAATCATGTCTCTCGCCAC-TGGAGAAACAGA   [1986]
Balam               TTGTGTTCAACTCTCGTTAAATCATGTCTCTCGCCAC-TGGAGAAACAGA   [1986]
Borua Beroin        TTGTGTTCAACTCTCGTTAAATCATGTCTCTCGCCAC-TGGAGAAACAGA   [1994]
Lallatoi            TTGTGTTCAACTCTCGTTAAATCATGTCTCTCGCCACCTGGAGAAACAGA   [1986]
IR8                 TTGTGTTCAACTCTCGTTAAATCATGTCTCTCGCCAC-TGGAGAAACAGA   [1985]
Arfa                TTGTGTTCAACTCTCGTTAAATCATGTCTCTCGCCAC-TGGAGAAACAGA   [1986]
Bahadur             TTGTGTTCAACTCTCGTTAAATCATGTCTCTCGCCAC-TGGAGAAACAGA   [1985]
Pankaj              TTGTGTTCAACTCTCGTTAAATCATGTCTCTCGCCAC-TGGAGAAACAGA   [1987]
Bashful             TTGTGTTCAACTCTCGTTAAATCATGTCTCTCGCCAC-TGGAGAAACAGA   [1976]
Moircha             TTGTGTTCAACTCTCGTTAAATCATGTCTCTCGCCAC-TGGAGAAACAGA   [1985]
Joya                TTGTGTTCAACTCTCGTTAAATCATGTCTCTCGCCAC-TGGAGAAACAGA   [1985]
Bas Beroin          TTGTGTTCAACTCTCGTTAAATCATGTCTCTCGCCAC-TGGAGAAACAGA   [1992]
Ranga Borah         TTGTGTTCAACTCTCGTTAAATCATGTCTCTCGCCAC-TGGAGAAACAGA   [1985]
Mulahail            TTGTGTTCAACTCTCGTTAAATCATGTCTCTCGCCAC-TGGAGAAACAGA   [1976]
Guaroi              TTGTGTTCAACTCTCGTTAAATCATGTCTCTCGCCAC-TGGAGAAACAGA   [1991]
Mimutim             TTGTGTTCAACTCTCGTTAAATCATGTCTCTCGCCAC-TGGAGAAACAGA   [1994]
Harinarayn          TTGTGTTCAACTCTCGTTAAATCATGTCTCTCGCCAC-TGGAGAAACAGA   [1992]
Bherapawa           TTGTGTTCAACTCTCGTTAAATCATGTCTCTCGCCAC-TGGAGAAACAGA   [1991]
O. rufipogon        TTGTGTTCAACTCTCGTTAAATCATGTCTCTTGCCAC-TGGAGAAACGGA   [1922]

[                            2060      2070      2080      2090      2100]
[                            .         .         .         .         .]
Papue               TCAGGAGGGTTTATTTTGGGTATAGGTCAAAGCTAAGATTGAAATTCACA   [2048]
Lahi                TCAGGAGGGTTTATTTTGGGTATAGGTCAAAGCTAAGATTGAAATTCACA   [2042]
Joha                TCAGGAGGGTTTATTTTGGGTATAGGTCAAAGCTAAGATTGAAATTCACA   [2044]
Local Basmati       TCAGGAGGGTTTATTTTGGGTATAGGTCAAAGCTAAGATTGAAATTCACA   [2033]
Sorpuma             TCAGGAGGGTTTATTTTGGGTATAGGTCAAAGCTAAGATTGAAATTCACA   [2028]
Kawanglawang        TCAGGAGGGTTTATTTTGGGTATAGGTCAAAGCTAAGATTGAAATTCACA   [2042]
Borjahinga          TCAGGAGGGTTTATTTTGGGTATAGGTCAAAGCTAAGATTGAAATTCACA   [2036]
Til Bora            TCAGGAGGGTTTATTTTGGGTATAGGTCAAAGCTAAGA-TGAAATTCACA   [2041]
Hati Hali           TCAGGAGGGTTTATTTTGGGTATAGGTCAAAGCTAAGATTGAAATTCACA   [2043]
Ranjit              TCAGGAGGGTTTATTTTGGGTATAGGTCAAAGCTAAGATTGAAATTCACA   [2035]
Kakiberoin          TCAGGAGGGTTTATTTTGGGTATAGGTCAAAGCTAAGATTGAAATTCACA   [2033]
Aubalam             TCAGGAGGGTTTATTTTGGGTATAGGTCAAAGCTAAGA-TGAAATTCACA   [2035]
Balam               TCAGGAGGGTTTATTTTGGGTATAGGTCAAAGCTAAGATTGAAATTCACA   [2036]
Borua Beroin        TCAGGAGGGTTTATTTTGGGTATAGGTCAAAGCTAAGA-TGAAATTCACA   [2043]
Lallatoi            TCAGGAGGGTTTATTTTGGGTATAGGTCAAAGCTAAGATTGAAATTCACA   [2036]
IR8                 TCAGGAGGGTTTATTTTGGGTATAGGTCAAAGCTAAGATTGAAATTCACA   [2035]
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Arfa              TCAGGAGGGTTTATTTTGGGTATAGGTCAAAGCTAAGATTGAAATTCACA   [2036]
Bahadur           TCAGGAGGGTTTATTTTGGGTATAGGTCAAAGCTAAGATTGAAATTCACA   [2035]
Pankaj            TCAGGAGGGTTTATTTTGGGTATAGGTCAAAGCTAAGATTGAAATTCACA   [2037]
Bashful           TCAGGAGGGTTTATTTTGGGTATAGGTCAAAGCTAAGATTGAAATTCACA   [2026]
Moircha           TCAGGAGGGTTTATTTTGGGTATAGGTCAAAGCTAAGA-TGAAATTCACA   [2034]
Joya              TCAGGAGGGTTTATTTTGGGTATAGGTCAAAGCTAAGA-TGAAATTCACA   [2034]
Bas Beroin        TCAGGAGGGTTTATTTTGGGTATAGGTCAAAGCTAAGATTGAAATTCACA   [2042]
Ranga Borah       TCAGGAGGGTTTATTTTGGGTATAGGTCAAAGCTAAGATTGAAATTCACA   [2035]
Mulahail          TCAGGAGGGTTTATTTTGGGTATAGGTCAAAGCTAAGA-TGAAATTCACA   [2025]
Guaroi            TCAGGAGGGTTTATTTTGGGTATAGGTCAAAGCTAAGA-TGAAATTCACA   [2040]
Mimutim           TCAGGAGGGTTTATTTTGGGTATAGGTCAAAGCTAAGA-TGAAATTCACA   [2043]
Harinarayn        TCAGGAGGGTTTATTTTGGGTATAGGTCAAAGCTAAGATTGAAATTCACA   [2042]
Bherapawa         TCAGGAGGGTTTATTTTGGGTATAGGTCAAAGCTAAGATTGAAATTCACA   [2041]
O. rufipogon      TCAGGAGGGTTTATTTTGGGTATAGGTCAAAGCTAAGGTTGAAATCCACA   [1972]

[                          2110      2120      2130      2140      2150]
[                             .         .         .         .         .]
Papue             AATAGTAAAATCAGAATCCAACCAATTTTAGTAGCCGAGTTGGTCAAAGG   [2098]
Lahi              AATAGTAAAATCAGAATCCAACCAATTTTAGTAGCCGAGTTGGTCAAAGG   [2092]
Joha              AATAGTAAAATCAGAATCCAACCAATTTTAGTAGCCGAGTTGGTCAAAGG   [2094]
Local Basmati     AATAGTAAAATCAGAATCCAACCAATTTTAGTAGCCGAGTTGGTCAAAGG   [2083]
Sorpuma           AATAGTAAAATCAGAATCCAACCAATTTTAGTAGCCGAGTTGGTCAAAGG   [2078]
Kawanglawang      AATAGTAAAATCAGAATCCAACCAATTTTAGTAGCCGAGTTGGTCAAAGG   [2092]
Borjahinga        AATAGTAAAATCAGAATCCAACCAATTTTAGTAGCCGAGTTGGTCAAAGG   [2086]
Til Bora          AATAGTAAAATCAGAATCCAACCAATTTTAGTAGCCGAGTTGGTCAAAGG   [2091]
Hati Hali         AATAGTAAAATCAGAATCCAACCAATTTTAGTAGCCGAGTTGGTCAAAGG   [2093]
Ranjit            AATAGTAAAATCAGAATCCAACCAATTTTAGTAGCCGAGTTGGTCAAAGG   [2085]
Kakiberoin        AATAGTAAAATCAGAATCCAACCAATTTTAGTAGCCGAGTTGGTCAAAGG   [2083]
Aubalam           AATAGTAAAATCAGAATCCAACCAATTTTAGTAGCCGAGTTGGTCAAAGG   [2085]
Balam             AATAGTAAAATCAGAATCCAACCAATTTTAGTAGCCGAGTTGGTCAAAGG   [2086]
Borua Beroin      AATAGTAAAATCAGAATCCAACCAATTTTAGTAGCCGAGTTGGTCAAAGG   [2093]
Lallatoi          AATAGTAAAATCAGAATCCAACCAATTTTAGTAGCCGAGTTGGTCAAAGG   [2086]
IR8               AATAGTAAAATCAGAATCCAACCAATTTTAGTAGCCGAGTTGGTCAAAGG   [2085]
Arfa              AATAGTAAAATCAGAATCCAACCAATTTTAGTAGCCGAGTTGGTCAAAGG   [2086]
Bahadur           AATAGTAAAATCAGAATCCAACCAATTTTAGTAGCCGAGTTGGTCAAAGG   [2085]
Pankaj            AATAGTAAAATCAGAATCCAACCAATTTTAGTAGCCGAGTTGGTCAAAGG   [2087]
Bashful           AATAGTAAAATCAGAATCCAACCAATTTTAGTAGCCGAGTTGGTCAAAGG   [2076]
Moircha           AATAGTAAAATCAGAATCCAACCAATTTTAGTAGCCGAGTTGGTCAAAGG   [2084]
Joya              AATAGTAAAATCAGAATCCAACCAATTTTAGTAGCCGAGTTGGTCAAAGG   [2084]
Bas Beroin        AATAGTAAAATCAGAATCCAACCAATTTTAGTAGCCGAGTTGGTCAAAGG   [2092]
Ranga Borah       AATAGTAAAATCAGAATCCAACCAATTTTAGTAGCCGAGTTGGTCAAAGG   [2085]
Mulahail          AATAGTAAAATCAGAATCCAACCAATTTTAGTAGCCGAGTTGGTCAAAGG   [2075]
Guaroi            AATAGTAAAATCAGAATCCAACCAATTTTAGTAGCCGAGTTGGTCAAAGG   [2090]
Mimutim           AATAGTAAAATCAGAATCCAACCAATTTTAGTAGCCGAGTTGGTCAAAGG   [2093]
Harinarayn        AATAGTAAAATCAGAATCCAACCAATTTTAGTAGCCGAGTTGGTCAAAGG   [2092]
Bherapawa         AATAGTAAAATCAGAATCCAACCAATTTTAGTAGCCGAGTTGGTCAAAGG   [2091]
O. rufipogon      AATAGTAAAATCAGAATCCAACCAATTTTAGTAGCCGAGTTGGTCAAAGG   [2022]

[                          2160      2170      2180      2190      2200]
[                             .         .         .         .         .]
Papue             AAAATGTATATAGCTAGATTTATTGTTTTGGCAAAAAAAAATCTGAATAT   [2148]
Lahi              AAAATGTATATAGCTAGATTTATTGTTTTGGCAAAAAAAAATCTGAATAT   [2142]
Joha              AAAATGTATATAGCTAGATTTATTGTTTTGGCAAAAAAAAATCTGAATAT   [2144]
Local Basmati     AAAATGTATATAGCTAGATTTATTGTTTTGGCAAAAAAAAATCTGAATAT   [2133]
Sorpuma           AAAATGTATATAGCTAGATTTATTGTTTTGGCAAAAAAAA-TCTGAATAT   [2127]
Kawanglawang      AAAATGTATATAGCTAGATTTATTGTTTTGGCAAAAAAAAATCTGAATAT   [2142]
Borjahinga        AAAATGTATATAGCTAGATTTATTGTTTTGGCAAAAAAAAATCTGAATAT   [2136]
Til Bora          AAAATGTATATAGCTAGATTTATTGTTTTGGCAAAAAAAAATCTGAATAT   [2141]
Hati Hali         AAAATGTATATAGCTAGATTTATTGTTTTGGCAAAAAAAA-TCTGAATAT   [2142]
Ranjit            AAAATGTATATAGCTAGATTTATTGTTTTGGCAAAAAAAAATCTGAATAT   [2135]
Kakiberoin        AAAATGTATATAGCTAGATTTATTGTTTTGGCAAAAAAAAATCTGAATAT   [2133]
Aubalam           AAAATGTATATAGCTAGATTTATTGTTTTGGCAAAAAAAAATCTGAATAT   [2135]
Balam             AAAATGTATATAGCTAGATTTATTGTTTTGGCAAAAAAAAATCTGAATAT   [2136]
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Borua Beroin AAAATGTATATAGCTAGATTTATTGTTTTGGCAAAAAAAAAATCTGAATAT [2143]
Lallatoi AAAATGTATATAGCTAGATTTATTGTTTTGGCAAAAAAAAAATCTGAATAT [2136]
IR8 AAAATGTATATAGCTAGATTTATTGTTTTGGCAAAAAAAAAATCTGAATAT [2135]
Arfa AAAATGTATATAGCTAGATTTATTGTTTTGGCAAAAAAAAAATCTGAATAT [2136]
Bahadur AAAATGTATATAGCTAGATTTATTGTTTTGGCAAAAAAAAAATCTGAATAT [2135]
Pankaj AAAATGTATATAGCTAGATTTATTGTTTTGGCAAAAAAAAAATCTGAATAT [2137]
Bashful AAAATGTATATAGCTAGATTTATTGTTTTGGCAAAAAAAA-TCTGAATAT [2125]
Moircha AAAATGTATATAGCTAGATTTATTGTTTTGGCAAAAAAAAAATCTGAATAT [2134]
Joya AAAATGTATATAGCTAGATTTATTGTTTTGGCAAAAAAAAAATCTGAATAT [2134]
Bas Beroin AAAATGTATATAGCTAGATTTATTGTTTTGGCAAAAAAAAAATCTGAATAT [2142]
Ranga Borah AAAATGTATATAGCTAGATTTATTGTTTTGGCAAAAAAAAAATCTGAATAT [2135]
Mulahail AAAATGTATATAGCTAGATTTATTGTTTTGGCAAAAAAAAAATCTGAATAT [2125]
Guaroi AAAATGTATATAGCTAGATTTATTGTTTTGGCAAAAAAAA-TCTGAATAT [2139]
Mimutim AAAATGTATATAGCTAGATTTATTGTTTTGGCAAAAAAAAAATCTGAATAT [2143]
Harinarayn AAAATGTATATAGCTAGATTTATTGTTTTGGCAAAAAAAAAATCTGAATAT [2142]
Bherapawa AAAATGTATATAGCTAGATTTATTGTTTTGGCAAAAAAAA-TCTGAATAT [2140]
O. rufipogon AAAATGTATATATCTAGATTTGTTGTTTTGGCAAAAAAAAAATTTGAATAT [2072]

[2210 2220 2230 2240 2250]
[. . . . .]
Papue GCAAAATACTTGTATATCTTTGTATTAAGAAGATGAAAATAAGTAGCAGA [2198]
Lahi GCAAAATACTTGTATATCTTTGTATTAAGAAGATGAAAATAAGTAGCAGA [2192]
Joha GCAAAATACTTGTATATCTTTGTATTAAGAAGATGAAAATAAGTAGCAGA [2194]
Local Basmati GCAAAATACTTGTATATCTTTGTATTAAGAAGATGAAAATAAGTAGCAGA [2183]
Sorpuma GCAAAATACTTGTATATCTTTGTATTAAGAAGATGAAAATAAGTAGCAGA [2177]
Kawanglawang GCAAAATACTTGTATATCTTTGTATTAAGAAGATGAAAATAAGTAGCAGA [2192]
Borjahinga GCAAAATACTTGTATATCTTTGTATTAAGAAGATGAAAATAAGTAGCAGA [2186]
Til Bora GCAAAATACTTGTATATCTTTGTATTAAGAAGATGAAAATAAGTAGCAGA [2191]
Hati Hali GCAAAATACTTGTATATCTTTGTATTAAGAAGATGAAAATAAGTAGCAGA [2192]
Ranjit GCAAAATACTTGTATATCTTTGTATTAAGAAGATGAAAATAAGTAGCAGA [2185]
Kakiberoin GCAAAATACTTGTATATCTTTGTATTAAGAAGATGAAAATAAGTAGCAGA [2183]
Aubalam GCAAAATACTTGTATATCTTTGTATTAAGAAGATGAAAATAAGTAGCAGA [2185]
Balam GCAAAATACTTGTATATCTTTGTATTAAGAAGATGAAAATAAGTAGCAGA [2186]
Borua Beroin GCAAAATACTTGTATATCTTTGTATTAAGAAGATGAAAATAAGTAGCAGA [2193]
Lallatoi GCAAAATACTTGTATATCTTTGTATTAAGAAGATGAAAATAAGTAGCAGA [2186]
IR8 GCAAAATACTTGTATATCTTTGTATTAAGAAGATGAAAATAAGTAGCAGA [2185]
Arfa GCAAAATACTTGTATATCTTTGTATTAAGAAGATGAAAATAAGTAGCAGA [2186]
Bahadur GCAAAATACTTGTATATCTTTGTATTAAGAAGATGAAAATAAGTAGCAGA [2185]
Pankaj GCAAAATACTTGTATATCTTTGTATTAAGAAGATGAAAATAAGTAGCAGA [2187]
Bashful GCAAAATACTTGTATATCTTTGTATTAAGAAGATGAAAATAAGTAGCAGA [2175]
Moircha GCAAAATACTTGTATATCTTTGTATTAAGAAGATGAAAATAAGTAGCAGA [2184]
Joya GCAAAATACTTGTATATCTTTGTATTAAGAAGATGAAAATAAGTAGCAGA [2184]
Bas Beroin GCAAAATACTTGTATATCTTTGTATTAAGAAGATGAAAATAAGTAGCAGA [2192]
Ranga Borah GCAAAATACTTGTATATCTTTGTATTAAGAAGATGAAAATAAGTAGCAGA [2185]
Mulahail GCAAAATACTTGTATATCTTTGTATTAAGAAGATGAAAATAAGTAGCAGA [2175]
Guaroi GCAAAATACTTGTATATCTTTGTATTAAGAAGATGAAAATAAGTAGCAGA [2189]
Mimutim GCAAAATACTTGTATATCTTTGTATTAAGAAGATGAAAATAAGTAGCAGA [2193]
Harinarayn GCAAAATACTTGTATATCTTTGTATTAAGAAGATGAAAATAAGTAGCAGA [2192]
Bherapawa GCAAAATACTTGTATATCTTTGTATTAAGAAGATGAAAATAAGTAGCAGA [2190]
O. rufipogon GCAAAATACTTGTATATCTTTTTATTAAGAAGATGAAAATAAGTAGCAGA [2122]

[2260 2270 2280 2290 2300]
[. . . . .]
Papue AAATTAAAAAATGGATTATATTTCCTGGG---CTAAAAGAATTGTTGATT [2245]
Lahi AAATTAAAAAATGGATTATATTTCCTGGG---CTAAAAGAATTGTTGATT [2239]
Joha AAATTAAAAAATGGATTATATTTCCTGGG---CTAAAAGAATTGTTGATT [2241]
Local Basmati AAATTAAAAAATGGATTATATTTCCTGGG---CTAAAAGAATTGTTGATT [2230]
Sorpuma AAATTAAAAAATGGATTATATTTCCTGGG---CTAAAAGAATTGTTGATT [2224]
Kawanglawang AAATTAAAAAATGGATTATATTTCCTGGG---CTAAAAGAATTGTTGATT [2239]
Borjahinga AAATTAAAAAATGGATTATATTTCCTGGG---CTAAAAGAATTGTTGATT [2233]
Til Bora AAATTAAAAAATGGATTATATTTCCTGGG---CTAAAAGAATTGTTGATT [2238]
Hati Hali AAATTAAAAAATGGATTATATTTCCTGGG---CTAAAAGAATTGTTGATT [2239]
Ranjit AAATTAAAAAATGGATTATATTTCCTGGG---CTAAAAGAATTGTTGATT [2232]

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Kakiberoin          AAATTAAAAAATGGATTATATTTCCTGGG---CTAAAAGAATTGTTGATT   [2230]
Aubalam             AAATTAAAAAATGGATTATATTTCCTGGG---CTAAAAGAATTGTTGATT   [2232]
Balam               AAATTAAAAAATGGATTATATTTCCTGGG---CTAAAAGAATTGTTGATT   [2233]
Borua Beroin        AAATTAAAAAATGGATTATATTTCCTGGG---CTAAAAGAATTGTTGATT   [2240]
Lallatoi            AAATTAAAAAATGGATTATATTTCCTGGG---CTAAAAGAATTGTTGATT   [2233]
IR8                 AAATTAAAAAATGGATTATATTTCCTGGG---CTAAAAGAATTGTTGATT   [2232]
Arfa                AAATTAAAAAATGGATTATATTTCCTGGG---CTAAAAGAATTGTTGATT   [2233]
Bahadur             AAATTAAAAAATGGATTATATTTCCTGGG---CTAAAAGAATTGTTGATT   [2232]
Pankaj              AAATTAAAAAATGGATTATATTTCCTGGG---CTAAAAGAATTGTTGATT   [2234]
Bashful             AAATTAAAAAATGGATTATATTTCCTGGG---CTAAAAGAATTGTTGATT   [2222]
Moircha             AAATTAAAAAATGGATTATATTTCCTGGG---CTAAAAGAATTGTTGATT   [2231]
Joya                AAATTAAAAAATGGATTATATTTCCTGGG---CTAAAAGAATTGTTGATT   [2231]
Bas Beroin          AAATTAAAAAATGGATTATATTTCCTGGG---CTAAAAGAATTGTTGATT   [2239]
Ranga Borah         AAATTAAAAAATGGATTATATTTCCTGGG---CTAAAAGAATTGTTGATT   [2232]
Mulahail            AAATTAAAAAATGGATTATATTTCCTGGG---CTAAAAGAATTGTTGATT   [2222]
Guaroi              AAATTAAAAAATGGATTATATTTCCTGGG---CTAAAAGAATTGTTGATT   [2236]
Mimutim             AAATTAAAAAATGGATTATATTTCCTGGG---CTAAAAGAATTGTTGATT   [2240]
Harinarayn          AAATTAAAAAATGGATTATATTTCCTGGG---CTAAAAGAATTGTTGATT   [2239]
Bherapawa           AAATTAAAAAATGGATTATATTTCCTGGG---CTAAAAGAATTGTTGATT   [2237]
O. rufipogon        AAATTTAAAAATGGATTATATTTCCCGGGGGGCTAAAAGAATTGTTGATT   [2172]

[                            2310      2320      2330      2340      2350]
[                               .         .         .         .         .]
Papue               TGGCACAATTAAATTCAGTGTCAAGGTTTTGTGCAAGAATTCAGTGTGAA   [2295]
Lahi                TGGCACAATTAAATTCAGTGTCAAGGTTTTGTGCAAGAATTCAGTGTGAA   [2289]
Joha                TGGCACAATTAAATTCAGTGTCAAGGTTTTGTGCAAGAATTCAGTGTGAA   [2291]
Local Basmati       TGGCACAATTAAATTCAGTGTCAAGGCTTTGTGCAAGAATTCAGTGTGAA   [2280]
Sorpuma             TGGCACAATTAAATTCAGTGTCAAGGCTTTGTGCAAGAATTCAGTGTGAA   [2274]
Kawanglawang        TGGCACAATTAAATTCAGTGTCAAGGTTTTGTGCAAGAATTCAGTGTGAA   [2289]
Borjahinga          TGGCACAATTAAATTCAGTGTCAAGGTTTTGTGCAAGAATTCAGTGTGAA   [2283]
Til Bora            TGGCACAATTAAATTCAGTGTCAAGGTTTTGTGCAAGAATTCAGTGTGAA   [2288]
Hati Hali           TGGCACAATTAAATTCAGTGTCAAGGCTTTGTGCAAGAATTCAGTGTGAA   [2289]
Ranjit              TGGCACAATTAAATTCAGTGTCAAGGCTTTGTGCAAGAATTCAGTGTGAA   [2282]
Kakiberoin          TGGCACAATTAAATTCAGTGTCAAGGCTTTGTGCAAGAATTCAGTGTGAA   [2280]
Aubalam             TGGCACAATTAAATTCAGTGTCAAGGCTTTGTGCAAGAATTCAGTGTGAA   [2282]
Balam               TGGCACAATTAAATTCAGTGTCAAGGCTTTGTGCAAGAATTCAGTGTGAA   [2283]
Borua Beroin        TGGCACAATTAAATTCAGTGTCAAGGTTTTGTGCAAGAATTCAGTGTGAA   [2290]
Lallatoi            TGGCACAATTAAATTCAGTGTCAAGGCTTTGTGCAAGAATTCAGTGTGAA   [2283]
IR8                 TGGCACAATTAAATTCAGTGTCAAGGCTTTGTGCAAGAATTCAGTGTGAA   [2282]
Arfa                TGGCACAATTAAATTCAGTGTCAAGGCTTTGTGCAAGAATTCAGTGTGAA   [2283]
Bahadur             TGGCACAATTAAATTCAGTGTCAAGGCTTTGTGCAAGAATTCAGTGTGAA   [2282]
Pankaj              TGGCACAATTAAATTCAGTGTCAAGGCTTTGTGCAAGAATTCAGTGTGAA   [2284]
Bashful             TGGCACAATTAAATTCAGTGTCAAGGCTTTGTGCAAGAATTCAGTGTGAA   [2272]
Moircha             TGGCACAATTAAATTCAGTGTCAAGGCTTTGTGCAAGAATTCAGTGTGAA   [2281]
Joya                TGGCACAATTAAATTCAGTGTCAAGGCTTTGTGCAAGAATTCAGTGTGAA   [2281]
Bas Beroin          TGGCACAATTAAATTCAGTGTCAAGGTTTTGTGCAAGAATTCAGTGTGAA   [2289]
Ranga Borah         TGGCACAATTAAATTCAGTGTCAAGGCTTTGTGCAAGAATTCAGTGTGAA   [2282]
Mulahail            TGGCACAATTAAATTCAGTGTCAAGGCTTTGTGCAAGAATTCAGTGTGAA   [2272]
Guaroi              TGGCACAATTAAATTCAGTGTCAAGGCTTTGTGCAAGAATTCAGTGTGAA   [2286]
Mimutim             TGGCACAATTAAATTCAGTGTCAAGGTTTTGTGCAAGAATTCAGTGTGAA   [2290]
Harinarayn          TGGCACAATTAAATTCAGTGTCAAGGTTTTGTGCAAGAATTCAGTGTGAA   [2289]
Bherapawa           TGGCACAATTAAATTCAGTGTCAAGGCTTTGTGCAAGAATTCAGTGTGAA   [2287]
O. rufipogon        TGGCGCAATTGAATTCAGTGTCAAGGCTTTGTGCAAGAATTCCCTTTGAA   [2222]

[                            2360      2370      2380      2390      2400]
[                               .         .         .         .         .]
Papue               GGAATAGATTCTCTTCAAAACAATTTAATCATTCATCTGATCTGCTCAAA   [2345]
Lahi                GGAATAGATTCTCTTCAAAACAATTTAATCATTCATCTGATCTGCTCAAA   [2339]
Joha                GGAATAGATTCTCTTCAAAACAATTTAATCATTCATCTGATCTGCTCAAA   [2341]
Local Basmati       GGAATAGATTCTCTTCAAAACAATTTAATCATTCATCTGATCTGCTCAAA   [2330]
Sorpuma             GGAATAGATTCTCTTCAAAACAATTTAATCATTCATCTGATCTGCTCAAA   [2324]
Kawanglawang        GGAATAGATTCTCTTCAAAACAATTTAATCATTCATCTGATCTGCTCAAA   [2339]
Borjahinga          GGAATAGATTCTCTTCAAAACAATTTAATCATTCATCTGATCTGCTCAAA   [2333]
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Til Bora            GGAATAGATTCTCTTCAAAACAATTTAATCATTCATCTGATCTGCTCAAA   [2338]
Hati Hali           GGAATAGATTCTCTTCAAAACAATTTAATCATTCATCTGATCTGCTCAAA   [2339]
Ranjit              GGAATAGATTCTCTTCAAAACAATTTAATCATTCATCTGATCTGCTCAAA   [2332]
Kakiberoin          GGAATAGATTCTCTTCAAAACAATTTAATCATTCATCTGATCTGCTCAAA   [2330]
Aubalam             GGAATAGATTCTCTTCAAAACAATTTAATCATTCATCTGATCTGCTCAAA   [2332]
Balam               GGAATAGATTCTCTTCAAAACAATTTAATCATTCATCTGATCTGCTCAAA   [2333]
Borua Beroin        GGAATAGATTCTCTTCAAAACAATTTAATCATTCATCTGATCTGCTCAAA   [2340]
Lallatoi            GGAATAGATTCTCTTCAAAACAATTTAATCATTCATCTGATCTGCTCAAA   [2333]
IR8                 GGAATAGATTCTCTTCAAAACAATTTAATCATTCATCTGATCTGCTCAAA   [2332]
Arfa                GGAATAGATTCTCTTCAAAACAATTTAATCATTCATCTGATCTGCTCAAA   [2333]
Bahadur             GGAATAGATTCTCTTCAAAACAATTTAATCATTCATCTGATCTGCTCAAA   [2332]
Pankaj              GGAATAGATTCTCTTCAAAACAATTTAATCATTCATCTGATCTGCTCAAA   [2334]
Bashful             GGAATAGATTCTCTTCAAAACAATTTAATCATTCATCTGATCTGCTCAAA   [2322]
Moircha             GGAATAGATTCTCTTCAAAACAATTTAATCATTCATCTGATCTGCTCAAA   [2331]
Joya                GGAATAGATTCTCTTCAAAACAATTTAATCATTCATCTGATCTGCTCAAA   [2331]
Bas Beroin          GGAATAGATTCTCTTCAAAACAATTTAATCATTCATCTGATCTGCTCAAA   [2339]
Ranga Borah         GGAATAGATTCTCTTCAAAACAATTTAATCATTCATCTGATCTGCTCAAA   [2332]
Mulahail            GGAATAGATTCTCTTCAAAACAATTTAATCATTCATCTGATCTGCTCAAA   [2322]
Guaroi              GGAATAGATTCTCTTCAAAACAATTTAATCATTCATCTGATCTGCTCAAA   [2336]
Mimutim             GGAATAGATTCTCTTCAAAACAATTTAATCATTCATCTGATCTGCTCAAA   [2340]
Harinarayn          GGAATAGATTCTCTTCAAAACAATTTAATCATTCATCTGATCTGCTCAAA   [2339]
Bherapawa           GGAATAGATTCTCTTCAAAACAATTTAATCATTCATCTGATCTGCTCAAA   [2337]
O. rufipogon        GGAATAGATTCTCTTCAAAAAAATTCAATCATTCA----TTTAGATCAAA   [2268]

[                            2410      2420      2430      2440      2450]
[                               .         .         .         .         .]
Papue               GCTCTGTGCATCTCCGGGTGCAACGGCCAGGATATTTATTGTGCAGTAAA   [2395]
Lahi                GCTCTGTGCATCTCCGGGTGCAACGGCCAGGATATTTATTGTCCAGTAAA   [2389]
Joha                GCTCTGTGCATCTCCGGGTGCAACGGCCAGGATATTTATTGTCCAGTAAA   [2391]
Local Basmati       GCTCTGTGCATCTCCGGGTGCAACGGCCAGGATATTTATTGTGCAGTAAA   [2380]
Sorpuma             GCTCTGTGCATCTCCGGGTGCAACGGCCAGGATATTTATTGTGCAGTAAA   [2374]
Kawanglawang        GCTCTGTGCATCTCCGGGTGCAACGGCCAGGATATTTATTGTGCAGTAAA   [2389]
Borjahinga          GCTCTGTGCATCTCCGGGTGCAACGGCCAGGATATTTATTGTGCAGTAAA   [2383]
Til Bora            GCTCTGTGCATCTCCGGGTGCAACGGCCAGGATATTTATTGTGCAGTAAA   [2388]
Hati Hali           GCTCTGTGCATCTCCGGGTGCAACGGCCAGGATATTTATTGTGCAGTAAA   [2389]
Ranjit              GCTCTGTGCATCTCCGGGTGCAACGGCCAGGATATTTATTGTGCAGTAAA   [2382]
Kakiberoin          GCTCTGTGCATCTCCGGGTGCAACGGCCAGGATATTTATTGTCCAGTAAA   [2380]
Aubalam             GCTCTGTGCATCTCCGGGTGCAACGGCCAGGATATTTATTGTGCAGTAAA   [2382]
Balam               GCTCTGTGCATCTCCGGGTGCAACGGCCAGGATATTTATTGTGCAGTAAA   [2383]
Borua Beroin        GCTCTGTGCATCTCCGGGTGCAACGGCCAGGATATTTATTGTGCAGTAAA   [2390]
Lallatoi            GCTCTGTGCATCTCCGGGTGCAACGGCCAGGATATTTATTGTGCAGTAAA   [2383]
IR8                 GCTCTGTGCATCTCCGGGTGCAACGGCCAGGATATTTATTGTGCAGTAAA   [2382]
Arfa                GCTCTGTGCATCTCCGGGTGCAACGGCCAGGATATTTATTGTGCAGTAAA   [2383]
Bahadur             GCTCTGTGCATCTCCGGGTGCAACGGCCAGGATATTTATTGTGCAGTAAA   [2382]
Pankaj              GCTCTGTGCATCTCCGGGTGCAACGGCCAGGATATTTATTGTGCAGTAAA   [2384]
Bashful             GCTCTGTGCATCTCCGGGTGCAACGGCCAGGATATTTATTGTGCAGTAAA   [2372]
Moircha             GCTCTGTGCATCTCCGGGTGCAACGGCCAGGATATTTATTGTGCAGTAAA   [2381]
Joya                GCTCTGTGCATCTCCGGGTGCAACGGCCAGGATATTTATTGTGCAGTAAA   [2381]
Bas Beroin          GCTCTGTGCATCTCCGGGTGCAACGGCCAGGATATTTATTGTGCAGTAAA   [2389]
Ranga Borah         GCTCTGTGCATCTCCGGGTGCAACGGCCAGGATATTTATTGTGCAGTAAA   [2382]
Mulahail            GCTCTGTGCATCTCCGGGTGCAACGGCCAGGATATTTATTGTGCAGTAAA   [2372]
Guaroi              GCTCTGTGCATCTCCGGGTGCAACGGCCAGGATATTTATTGTGCAGTAAA   [2386]
Mimutim             GCTCTGTGCATCTCCGGGTGCAACGGCCAGGATATTTATTGTGCAGTAAA   [2390]
Harinarayn          GCTCTGTGCATCTCCGGGTGCAACGGCCAGGATATTTATTGTGCAGTAAA   [2389]
Bherapawa           GCTCTGTGCATCTCCGGGTGCAACGGCCAGGATATTTATTGTGCAGTAAA   [2387]
O. rufipogon        GCTTTGTGCATCTCCGGGTGCAACGGGGAGGATATTTATTTTGCAGTAAA   [2318]

[                            2460      2470      2480      2490      2500]
[                               .         .         .         .         .]
Papue               AAAA-TGTCATATCCCCTAGCCACCCAAGAAACTGCTCCTTAAGTCCTTA   [2444]
Lahi                AAAA-TGTCATATCCCCTAGCCACCCAAGAAACTGCTCCTTAAGTCCTTA   [2438]
Joha                AAAA-TGTCATATCCCCTAGCCACCCAAGAAACTGCTCCTTAAGTCCTTA   [2440]
Local Basmati       AAAA-TGTCATATCCCCTAGCCACCCAAGAAACTGCTCCTTAAGTCCTTA   [2429]
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Sorpuma            AAAA-TGTCATATCCCCTAGCCACCCAAGAAACTGCTCCTTAAGTCCTTA   [2423]
Kawanglawang       AAAA-TGTCATATCCCCTAGCCACCCAAGAAACTGCTCCTTAAGTCCTTA   [2438]
Borjahinga         AAAA-TGTCATATCCCCTAGCCACCCAAGAAACTGCTCCTTAAGTCCTTA   [2432]
Til Bora           AAAA-TGTCATATCCCCTAGCCACCCAAGAAACTGCTCCTTAAGTCCTTA   [2437]
Hati Hali          AAAA-TGTCATATCCCCTAGCCACCCAAGAAACTGCTCCTTAAGTCCTTA   [2438]
Ranjit             AAAA-TGTCATATCCCCTAGCCACCCAAGAAACTGCTCCTTAAGTCCTTA   [2431]
Kakiberoin         AAAA-TGTCATATCCCCTAGCCACCCAAGAAACTGCTCCTTAAGTCCTTA   [2429]
Aubalam            AAAA-TGTCATATCCCCTAGCCACCCAAGAAACTGCTCCTTAAGTCCTTA   [2431]
Balam              AAAA-TGTCATATCCCCTAGCCACCCAAGAAACTGCTCCTTAAGTCCTTA   [2432]
Borua Beroin       AAAA-TGTCATATCCCCTAGCCACCCAAGAAACTGCTCCTTAAGTCCTTA   [2439]
Lallatoi           AAAA-TGTCATATCCCCTAGCCACCCAAGAAACTGCTCCTTAAGTCCTTA   [2432]
IR8                AAAA-TGTCATATCCCCTAGCCACCCAAGAAACTGCTCCTTAAGTCCTTA   [2431]
Arfa               AAAA-TGTCATATCCCCTAGCCACCCAAGAAACTGCTCCTTAAGTCCTTA   [2432]
Bahadur            AAAA-TGTCATATCCCCTAGCCACCCAAGAAACTGCTCCTTAAGTCCTTA   [2431]
Pankaj             AAAA-TGTCATATCCCCTAGCCACCCAAGAAACTGCTCCTTAAGTCCTTA   [2433]
Bashful            AAAA-TGTCATATCCCCTAGCCACCCAAGAAACTGCTCCTTAAGTCCTTA   [2421]
Moircha            AAAA-TGTCATATCCCCTAGCCACCCAAGAAACTGCTCCTTAAGTCCTTA   [2430]
Joya               AAAA-TGTCATATCCCCTAGCCACCCAAGAAACTGCTCCTTAAGTCCTTA   [2430]
Bas Beroin         AAAA-TGTCATATCCCCTAGCCACCCAAGAAACTGCTCCTTAAGTCCTTA   [2438]
Ranga Borah        AAAA-TGTCATATCCCCTAGCCACCCAAGAAACTGCTCCTTAAGTCCTTA   [2431]
Mulahail           AAAA-TGTCATATCCCCTAGCCACCCAAGAAACTGCTCCTTAAGTCCTTA   [2421]
Guaroi             AAAA-TGTCATATCCCCTAGCCACCCAAGAAACTGCTCCTTAAGTCCTTA   [2435]
Mimutim            AAAA-TGTCATATCCCCTAGCCACCCAAGAAACTGCTCCTTAAGTCCTTA   [2439]
Harinarayn         AAAA-TGTCATATCCCCTAGCCACCCAAGAAACTGCTCCTTAAGTCCTTA   [2438]
Bherapawa          AAAA-TGTCATATCCCCTAGCCACCCAAGAAACTGCTCCTTAAGTCCTTA   [2436]
O. rufipogon       AAAAAAGTCATATCCCCTAGCCACCCAAGAAACTGCTCCTTAAGTCCTTA   [2368]

[                           2510      2520      2530      2540      2550]
[                              .         .         .         .         .]
Papue              TAAGCACATATGGCATTGTAATATATATGTTTGAGTTTTAGCGACAATTT   [2494]
Lahi               TAAGCACATATGGCATTGTAATATATATGTTTGAGTTTTAGCGACAATTT   [2488]
Joha               TAAGCACATATGGCATTGTAATATATATGTTTGAGTTTTAGCGACAATTT   [2490]
Local Basmati      TAAGCACATATGGCATTGTAATATATATGTTTGAGTTTTAGCGACAATTT   [2479]
Sorpuma            TAAGCACATATGGCATTGTAATATATATGTTTGAGTTTTAGCGACAATTT   [2473]
Kawanglawang       TAAGCACATATGGCATTGTAATATATATGTTTGAGTTTTAGCGACAATTT   [2488]
Borjahinga         TAAGCACATATGGCATTGTAATATATATGTTTGAGTTTTAGCGACAATTT   [2482]
Til Bora           TAAGCACATATGGCATTGTAATATATATGTTTGAGTTTTAGCGACAATTT   [2487]
Hati Hali          TAAGCACATATGGCATTGTAATATATATGTTTGAGTTTTAGCGACAATTT   [2488]
Ranjit             TAAGCACATATGGCATTGTAATATATATGTTTGAGTTTTAGCGACAATTT   [2481]
Kakiberoin         TAAGCACATATGGCATTGTAATATATATGTTTGAGTTTTAGCGACAATTT   [2479]
Aubalam            TAAGCACATATGGCATTGTAATATATATGTTTGAGTTTTAGCGACAATTT   [2481]
Balam              TAAGCACATATGGCATTGTAATATATATGTTTGAGTTTTAGCGACAATTT   [2482]
Borua Beroin       TAAGCACATATGGCATTGTAATATATATGTTTGAGTTTTAGCGACAATTT   [2489]
Lallatoi           TAAGCACATATGGCATTGTAATATATATGTTTGAGTTTTAGCGACAATTT   [2482]
IR8                TAAGCACATATGGCATTGTAATATATATGTTTGAGTTTTAGCGACAATTT   [2481]
Arfa               TAAGCACATATGGCATTGTAATATATATGTTTGAGTTTTAGCGACAATTT   [2482]
Bahadur            TAAGCACATATGGCATTGTAATATATATGTTTGAGTTTTAGCGACAATTT   [2481]
Pankaj             TAAGCACATATGGCATTGTAATATATATGTTTGAGTTTTAGCGACAATTT   [2483]
Bashful            TAAGCACATATGGCATTGTAATATATATGTTTGAGTTTTAGCGACAATTT   [2471]
Moircha            TAAGCACATATGGCATTGTAATATATATGTTTGAGTTTTAGCGACAATTT   [2480]
Joya               TAAGCACATATGGCATTGTAATATATATGTTTGAGTTTTAGCGACAATTT   [2480]
Bas Beroin         TAAGCACATATGGCATTGTAATATATATGTTTGAGTTTTAGCGACAATTT   [2488]
Ranga Borah        TAAGCACATATGGCATTGTAATATATATGTTTGAGTTTTAGCGACAATTT   [2481]
Mulahail           TAAGCACATATGGCATTGTAATATATATGTTTGAGTTTTAGCGACAATTT   [2471]
Guaroi             TAAGCACATATGGCATTGTAATATATATGTTTGAGTTTTAGCGACAATTT   [2485]
Mimutim            TAAGCACATATGGCATTGTAATATATATGTTTGAGTTTTAGCGACAATTT   [2489]
Harinarayn         TAAGCACATATGGCATTGTAATATATATGTTTGAGTTTTAGCGACAATTT   [2488]
Bherapawa          TAAGCACATATGGCATTGTAATATATATGTTTGAGTTTTAGCGACAATTT   [2486]
O. rufipogon       TAAGCACATATGGCATTGTAATATATATGTTTGAGTTTTAGCGACA-TTT   [2417]
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[                              2560      2570      2580      2590      2600]
[                              .         .         .         .         .]
Papue             TTTT-----AAAAACT-TTTGGTCCTTTTTATGAACGTTTTAAGTTTCAC   [2538]
Lahi              TTTT-----AAAAACT-TTTGGTCCTTTTTATGAACGTTTTAAGTTTCAC   [2532]
Joha              TTTT-----AAAAACT-TTTGGTCCTTTTTATGAACGTTTTAAGTTTCAC   [2534]
Local Basmati     TTTT-----AAAAACT-TTTGGTCCTTTTTATGAACGTTTTAAGTTTCAC   [2523]
Sorpuma           TTTT-----AAAAACT-TTTGGTCCTTTTTATGAACGTTTTAAGTTTCAC   [2517]
Kawanglawang      TTTT-----AAAAACT-TTTGGTCCTTTTTATGAACGTTTTAAGTTTCAC   [2532]
Borjahinga        TTTT-----AAAAACT-TTTGGTCCTTTTTATGAACGTTTTAAGTTTCAC   [2526]
Til Bora          TTTT-----AAAAACT-TTTGGTCCTTTTTATGAACGTTTTAAGTTTCAC   [2531]
Hati Hali         TTTT-----AAAAACT-TTTGGTCCTTTTTATGAACGTTTTAAGTTTCAC   [2532]
Ranjit            TTTT-----AAAAACT-TTTGGTCCTTTTTATGAACGTTTTAAGTTTCAC   [2525]
Kakiberoin        TTTT-----AAAAACT-TTTGGTCCTTTTTATGAACGTTTTAAGTTTCAC   [2523]
Aubalam           TTTT-----AAAAACT-TTTGGTCCTTTTTATGAACGTTTTAAGTTTCAC   [2525]
Balam             TTTT-----AAAAACT-TTTGGTCCTTTTTATGAACGTTTTAAGTTTCAC   [2526]
Borua Beroin      TTTT-----AAAAACT-TTTGGTCCTTTTTATGAACGTTTTAAGTTTCAC   [2533]
Lallatoi          TTTT-----AAAAACT-TTTGGTCCTTTTTATGAACGTTTTAAGTTTCAC   [2526]
IR8               TTTT-----AAAAACT-TTTGGTCCTTTTTATGAACGTTTTAAGTTTCAC   [2525]
Arfa              TTTT-----AAAAACT-TTTGGTCCTTTTTATGAACGTTTTAAGTTTCAC   [2526]
Bahadur           TTTT-----AAAAACT-TTTGGTCCTTTTTATGAACGTTTTAAGTTTCAC   [2525]
Pankaj            TTTT-----AAAAACT-TTTGGTCCTTTTTATGAACGTTTTAAGTTTCAC   [2527]
Bashful           TTTT-----AAAAACT-TTTGGTCCTTTTTATGAACGTTTTAAGTTTCAC   [2515]
Moircha           TTTT-----AAAAACT-TTTGGTCCTTTTTATGAACGTTTTAAGTTTCAC   [2524]
Joya              TTTT-----AAAAACT-TTTGGTCCTTTTTATGAACGTTTTAAGTTTCAC   [2524]
Bas Beroin        TTTT-----AAAAACT-TTTGGTCCTTTTTATGAACGTTTTAAGTTTCAC   [2532]
Ranga Borah       TTTT-----AAAAACT-TTTGGTCCTTTTTATGAACGTTTTAAGTTTCAC   [2525]
Mulahail          TTTT-----AAAAACT-TTTGGTCCTTTTTATGAACGTTTTAAGTTTCAC   [2515]
Guaroi            TTTT-----AAAAACT-TTTGGTCCTTTTTATGAACGTTTTAAGTTTCAC   [2529]
Mimutim           TTTT-----AAAAACT-TTTGGTCCTTTTTATGAACGTTTTAAGTTTCAC   [2533]
Harinarayn        TTTT-----AAAAACT-TTTGGTCCTTTTTATGAACGTTTTAAGTTTCAC   [2532]
Bherapawa         TTTT-----AAAAACT-TTTGGTCCTTTTTATGAACGTTTTAAGTTTCAC   [2530]
O. rufipogon      TTTTTTAAAAAAAAAACTTTGGTCTTATTTTGAACGTTTTAAGTTTCA-   [2466]

[                              2610      2620      2630      2640      2650]
[                              .         .         .         .         .]
Papue             TG-TCTTTTTTTTT-CGAATTTTAAATGTAGCTTCAAATTCTAATCCCCA   [2586]
Lahi              TG-TCTTTTTTTTT-CGAATTTTAAATGTAGCTTCAAATTCTAATCCCCA   [2580]
Joha              TG-TCTTTTTTTTT-CGAATTTTAAATGTAGCTTCAAATTCTAATCCCCA   [2582]
Local Basmati     TG-TCTTTTTTTTT-CGAATTTTAAATGTAGCTTCAAATTCTAATCCCCA   [2571]
Sorpuma           TG-TCTTTTTTTTTTCGAATTTTAAATGTAGCTTCAAATTCTAATCCCCA   [2566]
Kawanglawang      TG-TCTTTTTTTTT-CGAATTTTAAATGTAGCTTCAAATTCTAATCCCCA   [2580]
Borjahinga        TG-TCTTTTTTTTT-CGAATTTTAAATGTAGCTTCAAATTCTAATCCCCA   [2574]
Til Bora          TG-TCTTTTTTTTT-CGAATTTTAAATGTAGCTTCAAATTCTAATCCCCA   [2579]
Hati Hali         TG-TCTTTTTTTTT-CGAATTTTAAATGTAGCTTCAAATTCTAATCCCCA   [2580]
Ranjit            TG-TCTTTTTTTTT-CGAATTTTAAATGTAGCTTCAAATTCTAATCCCCA   [2573]
Kakiberoin        TG-TCTTTTTTTTT-CGAATTTTAAATGTAGCTTCAAATTCTAATCCCCA   [2571]
Aubalam           TG-TCTTTTTTTTT-CGAATTTTAAATGTAGCTTCAAATTCTAATCCCCA   [2573]
Balam             TG-TCTTTTTTTTT-CGAATTTTAAATGTAGCTTCAAATTCTAATCCCCA   [2574]
Borua Beroin      TG-TCTTTTTTTTT-CGAATTTTAAATGTAGCTTCAAATTCTAATCCCCA   [2581]
Lallatoi          TG-TCTTTTTTTTT-CGAATTTTAAATGTAGCTTCAAATTCTAATCCCCA   [2574]
IR8               TG-TCTTTTTTTTT-CGAATTTTAAATGTAGCTTCAAATTCTAATCCCCA   [2573]
Arfa              TG-TCTTTTTTTTT-CGAATTTTAAATGTAGCTTCAAATTCTAATCCCCA   [2574]
Bahadur           TG-TCTTTTTTTTT-CGAATTTTAAATGTAGCTTCAAATTCTAATCCCCA   [2573]
Pankaj            TG-TCTTTTTTTTT-CGAATTTTAAATGTAGCTTCAAATTCTAATCCCCA   [2575]
Bashful           TG-TCTTTTTTTTTTCGAATTTTAAATGTAGCTTCAAATTCTAATCCCCA   [2564]
Moircha           TG-TCTTTTTTTTT-CGAATTTTAAATGTAGCTTCAAATTCTAATCCCCA   [2572]
Joya              TG-TCTTTTTTTTT-CGAATTTTAAATGTAGCTTCAAATTCTAATCCCCA   [2572]
Bas Beroin        TG-TCTTTTTTTTT-CGAATTTTAAATGTAGCTTCAAATTCTAATCCCCA   [2580]
Ranga Borah       TG-TCTTTTTTTTT-CGAATTTTAAATGTAGCTTCAAATTCTAATCCCCA   [2573]
Mulahail          TG-TCTTTTTTTTT-CGAATTTTAAATGTAGCTTCAAATTCTAATCCCCA   [2563]
Guaroi            TG-TCTTTTTTTTT-CGAATTTTAAATGTAGCTTCAAATTCTAATCCCCA   [2577]
Mimutim           TG-TCTTTTTTTTT-CGAATTTTAAATGTAGCTTCAAATTCTAATCCCCA   [2581]
Harinarayn        TG-TCTTTTTTTTT-CGAATTTTAAATGTAGCTTCAAATTCTAATCCCCA   [2580]
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Bherapawa          TG-TCTTTTTTTTT-CGAATTTTAAATGTAGCTTCAAATTCTAATCCCCA   [2578]
O. rufipogon       TGTTGTTTTTTTTTTTCGAATTTTAAATGTAGCTTCAAATCCTAATCCCCA   [2516]

[                            2660      2670      2680      2690      2700]
[                               .         .         .         .         .]
Papue              ATCCAAATTGTAATAAACTTCAATTCTCCTAATTAACATCTTAATTCATT   [2636]
Lahi               ATCCAAATTGTAATAAACTTCAATTCTCCTAATTAACATCTTAATTCATT   [2630]
Joha               ATCCAAATTGTAATAAACTTCAATTCTCCTAATTAACATCTTAATTCATT   [2632]
Local Basmati      ATCCAAATTGTAATAAACTTCAATTCTCCTAATTAACATCTTAATTCATT   [2621]
Sorpuma            ATCCAAATTGTAATAAACTTCAATTCTCCTAATTAACATCTTAATTCATT   [2616]
Kawanglawang       ATCCAAATTGTAATAAACTTCAATTCTCCTAATTAACATCTTAATTCATT   [2630]
Borjahinga         ATCCAAATTGTAATAAACTTCAATTCTCCTAATTAACATCTTAATTCATT   [2624]
Til Bora           ATCCAAATTGTAATAAACTTCAATTCTCCTAATTAACATCTTAATTCATT   [2629]
Hati Hali          ATCCAAATTGTAATAAACTTCAATTCTCCTAATTAACATCTTAATTCATT   [2630]
Ranjit             ATCCAAATTGTAATAAACTTCAATTCTCCTAATTAACATCTTAATTCATT   [2623]
Kakiberoin         ATCCAAATTGTAATAAACTTCAATTCTCCTAATTAACATCTTAATTCATT   [2621]
Aubalam            ATCCAAATTGTAATAAACTTCAATTCTCCTAATTAACATCTTAATTCATT   [2623]
Balam              ATCCAAATTGTAATAAACTTCAATTCTCCTAATTAACATCTTAATTCATT   [2624]
Borua Beroin       ATCCAAATTGTAATAAACTTCAATTCTCCTAATTAACATCTTAATTCATT   [2631]
Lallatoi           ATCCAAATTGTAATAAACTTCAATTCTCCTAATTAACATCTTAATTCATT   [2624]
IR8                ATCCAAATTGTAATAAACTTCAATTCTCCTAATTAACATCTTAATTCATT   [2623]
Arfa               ATCCAAATTGTAATAAACTTCAATTCTCCTAATTAACATCTTAATTCATT   [2624]
Bahadur            ATCCAAATTGTAATAAACTTCAATTCTCCTAATTAACATCTTAATTCATT   [2623]
Pankaj             ATCCAAATTGTAATAAACTTCAATTCTCCTAATTAACATCTTAATTCATT   [2625]
Bashful            ATCCAAATTGTAATAAACTTCAATTCTCCTAATTAACATCTTAATTCATT   [2614]
Moircha            ATCCAAATTGTAATAAACTTCAATTCTCCTAATTAACATCTTAATTCATT   [2622]
Joya               ATCCAAATTGTAATAAACTTCAATTCTCCTAATTAACATCTTAATTCATT   [2622]
Bas Beroin         ATCCAAATTGTAATAAACTTCAATTCTCCTAATTAACATCTTAATTCATT   [2630]
Ranga Borah        ATCCAAATTGTAATAAACTTCAATTCTCCTAATTAACATCTTAATTCATT   [2623]
Mulahail           ATCCAAATTGTAATAAACTTCAATTCTCCTAATTAACATCTTAATTCATT   [2613]
Guaroi             ATCCAAATTGTAATAAACTTCAATTCTCCTAATTAACATCTTAATTCATT   [2627]
Mimutim            ATCCAAATTGTAATAAACTTCAATTCTCCTAATTAACATCTTAATTCATT   [2631]
Harinarayn         ATCCAAATTGTAATAAACTTCAATTCTCCTAATTAACATCTTAATTCATT   [2630]
Bherapawa          ATCCAAATTGTAATAAACTTCAATTCTCCTAATTAACATCTTAATTCATT   [2628]
O. rufipogon       ATCCAGATTGTAATAAACTTCAATTCTCCTAATTAAGACCTTAATTCATT   [2566]

[                            2710      2720      2730      2740      2750]
[                               .         .         .         .         .]
Papue              TATT-GAAAACC-AGTTCAAATTCTTTTAGGCTCACCAAACCTTAAACAA   [2684]
Lahi               TATT-GAAAACC-AGTTCAAATTCTTTTAGGCTCACCAAACCTTAAACAA   [2678]
Joha               TATT-GAAAACC-AGTTCAAATTCTTTTAGGCTCACCAAACCTTAAACAA   [2680]
Local Basmati      TATTTGAAAACC-AGTTCAAATTCTTTTAGGCTCACCAAACCTTAAACAA   [2670]
Sorpuma            TATTTGAATACCCAGTTCAAATTCTTTTAGGCTCACCAAACCTTAAACAA   [2666]
Kawanglawang       TATT-GAAAACC-AGTTCAAATTCTTTTAGGCTCACCAAACCTTAAACAA   [2678]
Borjahinga         TATTTGACAACC-AGTTCAAATTCTTTTAGGCTCACCAAACCTTAAACAA   [2673]
Til Bora           TATTTGAAAACC-AGTTCAAATTCTTTTAGGCTCACCAAACCTTAAACAA   [2678]
Hati Hali          TATTTGAAAACCCAGTTCAAATTCTTTTAGGCTCACCAAACCTTAAACAA   [2680]
Ranjit             TATTTGAAAACC-AGTTCAAATTCTTTTAGGCTCACCAAACCTTAAACAA   [2672]
Kakiberoin         TATTTGAAAACC-AGTTCAAATTCTTTTAGGCTCACCAAACCTTAAACAA   [2670]
Aubalam            TATT-GAAAACC-AGTTCAAATTCTTTTAGGCTCACCAAACCTTAAACAA   [2671]
Balam              TATT-GAAAACC-AGTTCAAATTCTTTTAGGCTCACCAAACCTTAAACAA   [2672]
Borua Beroin       TATTTGAAAACC-AGTTCAAATTCTTTTAGGCTCACCAAACCTTAAACAA   [2680]
Lallatoi           TATT-GAAAACC-AGTTCAAATTCTTTTAGGCTCACCAAACCTTAAACAA   [2672]
IR8                TATT-GAAAACC-AGTTCAAATTCTTTTAGGCTCACCAAACCTTAAACAA   [2671]
Arfa               TATT-GAAAACC-AGTTCAAATTCTTTTAGGCTCACCAAACCTTAAACAA   [2672]
Bahadur            TATTTGAAAACC-AGTTCAAATTCTTTTAGGCTCACCAAACCTTAAACAA   [2672]
Pankaj             TATT-GAAAACCCAGTTCAAATTCTTTTAGGCTCACCAAACCTTAAACAA   [2674]
Bashful            TATTTGAAAACC-AGTTCAAATTCTTTTAGGCTCACCAAACCTTAAACAA   [2663]
Moircha            TATTTGAAAACC-AGTTCAAATTCTTTTAGGCTCACCAAACCTTAAACAA   [2671]
Joya               TATT-GAAAACC-AGTTCAAATTCTTTTAGGCTCACCAAACCTTAAACAA   [2670]
Bas Beroin         TATTTGAAAACC-AGTTCAAATTCTTTTAGGCTCACCAAACCTTAAACAA   [2679]
Ranga Borah        TATTTGAAAACC-AGTTCAAATTCTTTTAGGCTCACCAAACCTTAAACAA   [2672]
Mulahail           TATTTGAAAACC-AGTTCAAATTCTTTTAGGCTCACCAAACCTTAAACAA   [2662]
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Guaroi              TATTTGAAAACC-AGTTCAAATTCTTTTAGGCTCACCAAACCTTAAACAA   [2676]
Mimutim             TATTTGAAAACC-AGTTCAAATTCTTTTAGGCTCACCAAACCTTAAACAA   [2680]
Harinarayn          TATTTGAAAACC-AGTTCAAATTCTTTTAGGCTCACCAAACCTTAAACAA   [2679]
Bherapawa           TATTTGAAAACC-AGTTCAAATTCTTTTAGGCTCACCAAACCTTAAACAA   [2677]
O. rufipogon        TATTTCAAAACC-AGTTCAAATTCTTTTAGGCTCACCAAACCTTAAACAA   [2615]

[                            2760      2770]
[                            .          .]
Papue               TTCAATTCAGTGCAGAGATC   [2704]
Lahi                TTCAATTCAGTGCAGAGATC   [2698]
Joha                TTCAATTCAGTGCAGAGATC   [2700]
Local Basmati       TTCAATTCAGTGCAGAGATC   [2690]
Sorpuma             TTCAATTCAGTGCAGAGATC   [2686]
Kawanglawang        TTCAATTCAGTGCAGAGATC   [2698]
Borjahinga          TTCAATTCAGTGCAGAGATC   [2693]
Til Bora            TTCAATTCAGTGCAGAGATC   [2698]
Hati Hali           TTCAATTCAGTGCAGAGATC   [2700]
Ranjit              TTCAATTCAGTGCAGAGATC   [2692]
Kakiberoin          TTCAATTCAGTGCAGAGATC   [2690]
Aubalam             TTCAATTCAGTGCAGAGATC   [2691]
Balam               TTCAATTCAGTGCAGAGATC   [2692]
Borua Beroin        TTCAATTCAGTGCAGAGATC   [2700]
Lallatoi            TTCAATTCAGTGCAGAGATC   [2692]
IR8                 TTCAATTCAGTGCAGAGATC   [2691]
Arfa                TTCAATTCAGTGCAGAGATC   [2692]
Bahadur             TTCAATTCAGTGCAGAGATC   [2692]
Pankaj              TTCAATTCAGTGCAGAGATC   [2694]
Bashful             TTCAATTCAGTGCAGAGATC   [2683]
Moircha             TTCAATTCAGTGCAGAGATC   [2691]
Joya                TTCAATTCAGTGCAGAGATC   [2690]
Bas Beroin          TTCAATTCAGTGCAGAGATC   [2699]
Ranga Borah         TTCAATTCAGTGCAGAGATC   [2692]
Mulahail            TTCAATTCAGTGCAGAGATC   [2682]
Guaroi              TTCAATTCAGTGCAGAGATC   [2696]
Mimutim             TTCAATTCAGTGCAGAGATC   [2700]
Harinarayn          TTCAATTCAGTGCAGAGATC   [2699]
Bherapawa           TTCAATTCAGTGCAGAGATC   [2697]
O. rufipogon        TTCAATTCAGTGCAGAGATC   [2635]
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Appendix 2: Aligned nucleotide sequence data matrix of the *OsC1* gene

```
[                                  10         20         30         40         50]
[                                  .          .          .          .          .]
Papue              ATGGGGAGGAGAGCTTGCTGCGCAAAGGAAGGGATGAAGAGAGGGGCATG   [50]
Lahi               ATGGGGAGGAGAGCTTGCTGCGCAAAGGAAGGGATGAAGAGAGGGGCATG   [50]
Joha               ATGGGGAGGAGAGCTTGCTGCGCAAAGGAAGGGATGAAGAGAGGGGCATG   [50]
Local Basmati      ATGGGGAGGAGAGCTTGCTGCGCAAAGGAAGGGATGAAGAGAGGGGCATG   [50]
Sorpuma            ATGGGGAGGAGAGCTTGCTGCGCAAAGGAAGGGATGAAGAGAGGGGCATG   [50]
Kawanglawang        ATGGGGAGGAGAGCTTGCTGCGCAAAGGAAGGGATGAAGAGAGGGGCATG   [50]
Borjahinga         ATGGGGAGGAGAGCTTGCTGCGCAAAGGAAGGGATGAAGAGAGGGGCATG   [50]
Til Bora           ATGGGGAGGAGAGCTTGCTGCGCAAAGGAAGGGATGAAGAGAGGGGCATG   [50]
Hati_Hali          ATGGGGAGGAGAGCTTGCTGCGCAAAGGAAGGGATGAAGAGAGGGGCATG   [50]
Ranjit             ATGGGGAGGAGAGCTTGCTGCGCAAAGGAAGGGATGAAGAGAGGGGCATG   [50]
Kakiberoin         ATGGGGAGGAGAGCTTGCTGCGCAAAGGAAGGGATGAAGAGAGGGGCATG   [50]
Aubalam            ATGGGGAGGAGAGCTTGCTGCGCAAAGGAAGGGATGAAGAGAGGGGCATG   [50]
Balam              ATGGGGAGGAGAGCTTGCTGCGCAAAGGAAGGGATGAAGAGAGGGGCATG   [50]
Borua Beroin       ATGGGGAGGAGAGCTTGCTGCGCAAAGGAAGGGATGAAGAGAGGGGCATG   [50]
Lallatoi           ATGGGGAGGAGAGCTTGCTGCGCAAAGGAAGGGATGAAGAGAGGGGCATG   [50]
IR8                ATGGGGAGGAGAGCTTGCTGCGCAAAGGAAGGGATGAAGAGAGGGGCATG   [50]
Arfa               ATGGGGAGGAGAGCTTGCTGCGCAAAGGAAGGGATGAAGAGAGGGGCATG   [50]
Bahadur            ATGGGGAGGAGAGCTTGCTGCGCAAAGGAAGGGATGAAGAGAGGGGCATG   [50]
Pankaj             ATGGGGAGGAGAGCTTGCTGCGCAAAGGAAGGGATGAAGAGAGGGGCATG   [50]
Bashful            ATGGGGAGGAGAGCTTGCTGCGCAAAGGAAGGGATGAAGAGAGGGGCATG   [50]
Moircha            ATGGGGAGGAGAGCTTGCTGCGCAAAGGAAGGGATGAAGAGAGGGGCATG   [50]
Joya               ATGGGGAGGAGAGCTTGCTGCGCAAAGGAAGGGATGAAGAGAGGGGCATG   [50]
Basberoin          ATGGGGAGGAGAGCTTGCTGCGCAAAGGAAGGGATGAAGAGAGGGGCATG   [50]
Ranga Borah        ATGGGGAGGAGAGCTTGCTGCGCAAAGGAAGGGATGAAGAGAGGGGCATG   [50]
Mulahail           ATGGGGAGGAGAGCTTGCTGCGCAAAGGAAGGGATGAAGAGAGGGGCATG   [50]
Guaroi             ATGGGGAGGAGAGCTTGCTGCGCAAAGGAAGGGATGAAGAGAGGGGCATG   [50]
Mimutim            ATGGGGAGGAGAGCTTGCTGCGCAAAGGAAGGGATGAAGAGAGGGGCATG   [50]
Harinarayan        ATGGGGAGGAGAGCTTGCTGCGCAAAGGAAGGGATGAAGAGAGGGGCATG   [50]
Bherapawa          ATGGGGAGGAGAGCTTGCTGCGCAAAGGAAGGGATGAAGAGAGGGGCATG   [50]
O. rufipogon       ATGGGGAGGAGAGCTTGCTGCGCAAAGGAAGGGATGAAGAGAGGGGCATG   [50]

[                                  60         70         80         90         100]
[                                  .          .          .          .          .]
Papue              GACGAGCAAGGAGGACGACGTGCTTGCCTCCTACATCAAGTCCCATGGCG   [100]
Lahi               GACGAGCAAGGAGGACGACGTGCTTGCCTCCTACATCAAGTCCCATGGCG   [100]
Joha               GACGAGCAAGGAGGACGACGTGCTTGCCTCCTACATCAAGTCCCATGGCG   [100]
Local Basmati      GACGAGCAAGGAGGACGACGTGCTTGCCTCCTACATCAAGTCCCATGGCG   [100]
Sorpuma            GACGAGCAAGGAGGACGACGTGCTTGCCTCCTACATCAAGTCCCATGGCG   [100]
Kawanglawang       GACGAGCAAGGAGGACGACGTGCTTGCCTCCTACATCAAGTCCCATGGCG   [100]
Borjahinga         GACGAGCAAGGAGGACGACGTGCTTGCCTCCTACATCAAGTCCCATGGCG   [100]
Til  Bora          GACGAGCAAGGAGGACGACGTGCTTGCCTCCTACATCAAGTCCCATGGCG   [100]
Hati Hali          GACGAGCAAGGAGGACGACGTGCTTGCCTCCTACATCAAGTCCCATGGCG   [100]
Ranjit             GACGAGCAAGGAGGACGACGTGCTTGCCTCCTACATCAAGTCCCATGGCG   [100]
Kakiberoin         GACGAGCAAGGAGGACGACGTGCTTGCCTCCTACATCAAGTCCCATGGCG   [100]
Aubalam            GACGAGCAAGGAGGACGACGTGCTTGCCTCCTACATCAAGTCCCATGGCG   [100]
Balam              GACGAGCAAGGAGGACGACGTGCTTGCCTCCTACATCAAGTCCCATGGCG   [100]
Borua Beroin       GACGAGCAAGGAGGACGACGTGCTTGCCTCCTACATCAAGTCCCATGGCG   [100]
Lallatoi           GACGAGCAAGGAGGACGACGTGCTTGCCTCCTACATCAAGTCCCATGGCG   [100]
IR8                GACGAGCAAGGAGGACGACGTGCTTGCCTCCTACATCAAGTCCCATGGCG   [100]
Arfa               GACGAGCAAGGAGGACGACGTGCTTGCCTCCTACATCAAGTCCCATGGCG   [100]
Bahadur            GACGAGCAAGGAGGACGACGTGCTTGCCTCCTACATCAAGTCCCATGGCG   [100]
Pankaj             GACGAGCAAGGAGGACGACGTGCTTGCCTCCTACATCAAGTCCCATGGCG   [100]
Bashful            GACGAGCAAGGAGGACGACGTGCTTGCCTCCTACATCAAGTCCCATGGCG   [100]
Moircha            GACGAGCAAGGAGGACGACGTGCTTGCCTCCTACATCAAGTCCCATGGCG   [100]
Joya               GACGAGCAAGGAGGACGACGTGCTTGCCTCCTACATCAAGTCCCATGGCG   [100]
Basberoin          GACGAGCAAGGAGGACGACGTGCTTGCCTCCTACATCAAGTCCCATGGCG   [100]
Ranga Borah        GACGAGCAAGGAGGACGACGTGCTTGCCTCCTACATCAAGTCCCATGGCG   [100]
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Mulahail          GACGAGCAAGGAGGACGACGTGCTTGCCTCCTACATCAAGTCCCATGGCG   [100]
Guaroi            GACGAGCAAGGAGGACGACGTGCTTGCCTCCTACATCAAGTCCCATGGCG   [100]
Mimutim           GACGAGCAACGAGGACGACGTGCTTGCCTCCTACATCAAGTCCCATGGCG   [100]
Harinarayan       GACGAGCAAGGAGGACGACGTGCTTGCCTCCTACATCAAGTCCCATGGCG   [100]
Bherapawa         GACGAGCAAGGAGGACGACGTGCTTGCCTCCTACATCAAGTCCCATGGCG   [100]
O. rufipogon      GACGAGCAAGGAGGACGACGTGCTTGCCTCCTACATCAAGTCCCATGGCG   [100]

[                          110       120       130       140       150]
[                            .         .         .         .         .]
Papue             AAGGCAAGTGGCGCGAGGTCCCCCAACGAGCTGGTGAGCTAGCTATTACC   [150]
Lahi              AAGGCAAGTGGCGCGAGGTCCCCCAACGAGCTGGTGAGCTAGCTATTACC   [150]
Joha              AAGGCAAGTGGCGCGAGGTCCCCCAACGAGCTGGTGAGCTAGCTATTACC   [150]
Local Basmati     AAGGCAAGTGGCGCGAGGTCCCCCAACGAGCTGGTGAGCTAGCTATTACC   [150]
Sorpuma           AAGGCAAGTGGCGCGAGGTCCCCCAACGAGCTGGTGAGCTAGCTATTACC   [150]
Kawanglawang      AAGGCAAGTGGCGCGAGGTCCCCCAACGAGCTGGTGAGCTAGCTATTACC   [150]
Borjahinga        AAGGCAAGTGGCGCGAGGTCCCCCAACGAGCTGGTGAGCTAGCTATTACC   [150]
Til Bora          AAGGCAAGTGGCGCGAGGTCCCCCAACGAGCTGGTGAGCTAGCTATTACC   [150]
Hati Hali         AAGGCAAGTGGCGCGAGGTCCCCCAACGAGCTGGTGAGCTAGCTATTACC   [150]
Ranjit            AAGGCAAGTGGCGCGAGGTCCCCCAACGAGCTGGTGAGCTAGCTATTACC   [150]
Kakiberoin        AAGGCAAGTGGCGCGAGGTCCCCCAACGAGCTGGTGAGCTAGCTATTACC   [150]
Aubalam           AAGGCAAGTGGCGCGAGGTCCCCCAACGAGCTGGTGAGCTAGCTATTACC   [150]
Balam             AAGGCAAGTGGCGCGAGGTCCCCCAACGAGCTGGTGAGCTAGCTATTACC   [150]
Borua Beroin      AAGGCAAGTGGCGCGAGGTCCCCCAACGAGCTGGTGAGCTAGCTATTACC   [150]
Lallatoi          AAGGCAAGTGGCGCGAGGTCCCCCAACGAGCTGGTGAGCTAGCTATTACC   [150]
IR8               AAGGCAAGTGGCGCGAGGTCCCCCAACGAGCTGGTGAGCTAGCTATTACC   [150]
Arfa              AAGGCAAGTGGCGCGAGGTCCCCCAACGAGCTGGTGAGCTAGCTATTACC   [150]
Bahadur           AAGGCAAGTGGCGCGAGGTCCCCCAACGAGCTGGTGAGCTAGCTATTACC   [150]
Pankaj            AAGGCAAGTGGCGCGAGGTCCCCCAACGAGCTGGTGAGCTAGCTATTACC   [150]
Bashful           AAGGCAAGTGGCGCGAGGTCCGCCAACGAGCTGGTGAGCTAGCTATTACC   [150]
Moircha           AAGGCAAGTGGCGCGAGGTCCCCCAACGAGCTGGTGAGCTAGCTATTACC   [150]
Joya              AAGGCAAGTGGCGCGAGGTCCCCCAACGAGCTGGTGAGCTAGCTATTACC   [150]
Basberoin         AAGGCAAGTGGCGCGAGGTCCCCCAACGAGCTGGTGAGCTAGCTATTACC   [150]
Ranga_Borah       AAGGCAAGTGGCGCGAGGTCCCCCAACGAGCTGGTGAGCTAGCTATTACC   [150]
Mulahail          AAGGCAAGTGGCGCGAGGTCCCCCAACGAGCTGGTGAGCTAGCTATTACC   [150]
Guaroi            AAGGCAAGTGGCGCGAGGTCCCCCAACGAGCTGGTGAGCTAGCTATTACC   [150]
Mimutim           AAGGCAAGTGGCGCGAGGTCCCCCAACGAGCTGGTGAGCTAGCTATTACC   [150]
Harinarayan       AAGGCAAGTGGCGCGAGGTCCCCCAACGAGCTGGTGAGCTAGCTATTACC   [150]
Bherapawa         AAGGCAAGTGGCGCGAGGTCCCCCAACGAGCTGGTGAGCTAGCTATTACC   [150]
O. rufipogon      AAGGCAAGTGGCGCGAGGTCCCCCAACGAGCTGGTGAGCTAGCTATTACC   [150]

[                          160       170       180       190       200]
[                            .         .         .         .         .]
Papue             TAATCGATCGATGGTCATCGATCATGAGATGATGATGATGAGATTTGTAC   [200]
Lahi              TAATCGATCGATGGTCATCGATCATGAGATGATGATGATGAGATTTGTAC   [200]
Joha              TAATCGATCGATGGTCATCGATCATGAGATGATGATGATGAGATTTGTAC   [200]
Local Basmati     TAATCGATCGATGGTCATCGATCATGAGATGATGATGATGAGATTTGTAC   [200]
Sorpuma           TAATCGATCGATGGTCATCGATCATGAGATGATGATGATGAGATTTGTAC   [200]
Kawanglawang      TAATCGATCGATGGTCATCGATCATGAGATGATGATGATGAGATTTGTAC   [200]
Borjahinga        TAATCGATCGATGGTCATCGATCATGAGATGATGATGATGAGATTTGTAC   [200]
Til Bora          TAATCGATCGATGGTCATCGATCATGAGATGATGATGATGAGATTTGTAC   [200]
Hati Hali         TAATCGATCGATGGTCATCGATCATGAGATGATGATGATGAGATTTGTAC   [200]
Ranjit            TAATCGATCGATGGTCATCGATCATGAGATGATGATGATGAGATTTGTAC   [200]
Kakiberoin        TAATCGATCGATGGTCATCGATCATGAGATGATGATGATGAGATTTGTAC   [200]
Aubalam           TAATCGATCGATGGTCATCGATCATGAGATGATGATGATGAGATTTGTAC   [200]
Balam             TAATCGATCGATGGTCATCGATCATGAGATGATGATGATGAGATTTGTAC   [200]
Borua Beroin      TAATCGATCGATGGTCATCGATCATGAGATGATGATGATGAGATTTGTAC   [200]
Lallatoi          TAATCGATCGATGGTCATCGATCATGAGATGATGATGATGAGATTTGTAC   [200]
IR8               TAATCGATCGATGGTCATCGATCATGAGATGATGATGATGAGATTTGTAC   [200]
Arfa              TAATCGATCGATGGTCATCGATCATGAGATGATGATGATGAGATTTGTAC   [200]
Bahadur           TAATCGATCGATGGTCATCGATCATGAGATGATGATGATGAGATTTGTAC   [200]
Pankaj            TAATCGATCGATGGTCATCGATCATGAGATGATGATGATGAGATTTGTAC   [200]
Bashful           TAATCGATCGATGGTCATCGATCATGAGATGATGATGATGAGATTTGTAC   [200]
Moircha           TAATCGATCGATGGTCATCGATCATGAGATGATGATGATGAGATTTGTAC   [200]
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Joya            TAATCGATCGATGGTCATCGATCATGAGATGATGATGATGAGATTTGTAC   [200]
Basberoin       TAATCGATCGATGGTCATCGATCATGAGATGATGATGATGAGATTTGTAC   [200]
Ranga Borah     TAATCGATCGATGGTCATCGATCATGAGATGATGATGATGAGATTTGTAC   [200]
Mulahail        TAATCGATCGATGGTCATCGATCATGAGATGATGATGATGAGATTTGTAC   [200]
Guaroi          TAATCGATCGATGGTCATCGATCATGAGATGATGATGATGAGATTTGTAC   [200]
Mimutim         TAATCGATCGATGGTCATCGATCATGAGATGATGATGATGAGATTTGTAC   [200]
Harinarayan     TAATCGATCGATGGTCATCGATCATGAGATGATGATGATGAGATTTGTAC   [200]
Bherapawa       TAATCGATCGATGGTCATCGATCATGAGATGATGATGATGAGATTTGTAC   [200]
O. rufipogon    TAATCGATCGATGGTCATCGATCATGAGATGATGATGATGAGATTTGTAC   [200]

[                        210       220       230       240       250]
[                          .         .         .         .         .]
Papue           TTAATTGTGATCTGTATGGATGCTGTTGTTGATCAAGTTCTTGCGATCGA   [250]
Lahi            TTAATTGTGATCTGTATGGATGCTGTTGTTGATCAAGTTCTTGCGATCGA   [250]
Joha            TTAATTGTGATCTGTATGGATGCTGTTGTTGATCAAGTTCTTGCGATCGA   [250]
Local Basmati   TTAATTGTGATCTGTATGGATGCTGTTGTTGATCAAGTTCTTGCGATCGA   [250]
Sorpuma         TTAATTGTGATCTGTATGGATGCTGTTGTTGATCAAGTTCTTGCGATCGA   [250]
Kawanglawang    TTAATTGTGATCTGTATGGATGCTGTTGTTGATCAAGTTCTTGCGATCGA   [250]
Borjahinga      TTAATTGTGATCTGTATGGATGCTGTTGTTGATCAAGTTCTTGCGATCGA   [250]
Til Bora        TTAATTGTGATCTGTATGGATGCTGTTGTTGATCAAGTTCTTGCGATCGA   [250]
Hati Hali       TTAATTGTGATCTGTATGGATGCTGTTGTTGATCAAGTTCTTGCGATCGA   [250]
Ranjit          TTAATTGTGATCTGTATGGATGCTGTTGTTGATCAAGTTCTTGCGATCGA   [250]
Kakiberoin      TTAATTGTGATCTGTATGGATGCTGTTGTTGATCAAGTTCTTGCGATCGA   [250]
Aubalam         TTAATTGTGATCTGTATGGATGCTGTTGTTGATCAAGTTCTTGCGATCGA   [250]
Balam           TTAATTGTGATCTGTATGGATGCTGTTGTTGATCAAGTTCTTGCGATCGA   [250]
Borua Beroin    TTAATTGTGATCTGTATGGATGCTGTTGTTGATCAAGTTCTTGCGATCGA   [250]
Lallatoi        TTAATTGTGATCTGTATGGATGCTGTTGTTGATCAAGTTCTTGCGATCGA   [250]
IR8             TTAATTGTGATCTGTATGGATGCTGTTGTTGATCAAGTTCTTGCGATCGA   [250]
Arfa            TTAATTGTGATCTGTATGGATGCTGTTGTTGATCAAGTTCTTGCGATCGA   [250]
Bahadur         TTAATTGTGATCTGTATGGATGCTGTTGTTGATCAAGTTCTTGCGATCGA   [250]
Pankaj          TTAATTGTGATCTGTATGGATGCTGTTGTTGATCAAGTTCTTGCGATCGA   [250]
Bashful         TTAATTGTGATCTGTATGGATGCTGTTGTTGATCAAGTTCTTGCGATCGA   [250]
Moircha         TTAATTGTGATCTGTATGGATGCTGTTGTTGATCAAGTTCTTGCGATCGA   [250]
Joya            TTAATTGTGATCTGTATGGATGCTGTTGTTGATCAAGTTCTTGCGATCGA   [250]
Basberoin       TTAATTGTGATCTGTATGGATGCTGTTGTTGATCAAGTTCTTGCGATCGA   [250]
Ranga Borah     TTAATTGTGATCTGTATGGATGCTGTTGTTGATCAAGTTCTTGCGATCGA   [250]
Mulahail        TTAATTGTGATCTGTATGGATGCTGTTGTTGATCAAGTTCTTGCGATCGA   [250]
Guaroi          TTAATTGTGATCTGTATGGATGCTGTTGTTGATCAAGTTCTTGCGATCGA   [250]
Mimutim         TTAATTGTGATCTGTATGGATGCTGTTGTTGATCAAGTTCTTGCGATCGA   [250]
Harinarayan     TTAATTGTGATCTGTATGGATGCTGTTGTTGATCAAGTTCTTGCGATCGA   [250]
Bherapawa       TTAATTGTGATCTGTATGGATGCTGTTGTTGATCAAGTTCTTGCGATCGA   [250]
O. rufipogon    TTAATTGTGATCTGTATGGATGCTGTTGTTGATCAAGTTCTTGCGATCGA   [250]

[                        260       270       280       290       300]
[                          .         .         .         .         .]
Papue           TCGATCTGAATTTTCAGGTTTGAGGCGGTGCGGCAAGAGCTGCAGGCTCC   [300]
Lahi            TCGATCTGAATTTTCAGGTTTGAGGCGGTGCGGCAAGAGCTGCAGGCTCC   [300]
Joha            TCGATCTGAATTTTCAGGTTTGAGGCGGTGCGGCAAGAGCTGCAGGCTCC   [300]
Local Basmati   TCGATCTGAATTTTCAGGTTTGAGGCGGTGCGGCAAGAGCTGCAGGCTCC   [300]
Sorpuma         TCGATCTGAATTTTCAGGTTTGAGGCGGTGCGGCAAGAGCTGCAGGCTCC   [300]
Kawanglawang    TCGATCTGAATTTTCAGGTTTGAGGCGGTGCGGCAAGAGCTGCAGGCTCC   [300]
Borjahinga      TCGATCTGAATTTTCAGGTTTGAGGCGGTGCGGCAAGAGCTGCAGGCTCC   [300]
Til Bora        TCGATCTGAATTTTCAGGTTTGAGGCGGTGCGGCAAGAGCTGCAGGCTCC   [300]
Hati Hali       TCGATCTGAATTTTCAGGTTTGAGGCGGTGCGGCAAGAGCTGCAGGCTCC   [300]
Ranjit          TCGATCTGAATTTTCAGGTTTGAGGCGGTGCGGCAAGAGCTGCAGGCTCC   [300]
Kakiberoin      TCGATCTGAATTTTCAGGTTTGAGGCGGTGCGGCAAGAGCTGCAGGCTCC   [300]
Aubalam         TCGATCTGAATTTTCAGGTTTGAGGCGGTGCGGCAAGAGCTGCAGGCTCC   [300]
Balam           TCGATCTGAATTTTCAGGTTTGAGGCGGTGCGGCAAGAGCTGCAGGCTCC   [300]
Borua Beroin    TCGATCTGAATTTTCAGGTTTGAGGCGGTGCGGCAAGAGCTGCAGGCTCC   [300]
Lallatoi        TCGATCTGAATTTTCAGGTTTGAGGCGGTGCGGCAAGAGCTGCAGGCTCC   [300]
IR8             TCGATCTGAATTTTCAGGTTTGAGGCGGTGCGGCAAGAGCTGCAGGCTCC   [300]
Arfa            TCGATCTGAATTTTCAGGTTTGAGGCGGTGCGGCAAGAGCTGCAGGCTCC   [300]
Bahadur         TCGATCTGAATTTTCAGGTTTGAGGCGGTGCGGCAAGAGCTGCAGGCTCC   [300]
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Pankaj TCGATCTGAATTTTCAGGTTTGAGGCGGTGCGGCAAGAGCTGCAGGCTCC [300]
Bashful TCGATCTGAATTTTCAGGTTTGAGGCGGTGCGGCAAGAGCTGCAGGCTCC [300]
Moircha TCGATCTGAATTTTCAGGTTTGAGGCGGTGCGGCAAGAGCTGCAGGCTCC [300]
Joya TCGATCTGAATTTTCAGGTTTGAGGCGGTGCGGCAAGAGCTGCAGGCTCC [300]
Basberoin TCGATCTGAATTTTCAGGTTTGAGGCGGTGCGGCAAGAGCTGCAGGCTCC [300]
Ranga Borah TCGATCTGAATTTTCAGGTTTGAGGCGGTGCGGCAAGAGCTGCAGGCTCC [300]
Mulahail TCGATCTGAATTTTCAGGTTTGAGGCGGTGCGGCAAGAGCTGCAGGCTCC [300]
Guaroi TCGATCTGAATTTTCAGGTTTGAGGCGGTGCGGCAAGAGCTGCAGGCTCC [300]
Mimutim TCGATCTGAATTTTCAGGTTTGAGGCGGTGCGGCAAGAGCTGCAGGCTCC [300]
Harinarayan TCGATCTGAATTTTCAGGTTTGAGGCGGTGCGGCAAGAGCTGCAGGCTCC [300]
Bherapawa TCGATCTGAATTTTCAGGTTTGAGGCGGTGCGGCAAGAGCTGCAGGCTCC [300]
O. rufipogon TCGATCTGAATTTTCAGGTTTGAGGCGGTGCGGCAAGAGCTGCAGGCTCC [300]

[310 320 330 340 350]
[. . . . .]
Papue GGTGGCTCAACTATCTCCGGCCTAACATCAAGCGCGGCAACATCGACGAC [350]
Lahi GGTGGCTCAACTATCTCCGGCCTAACATCAAGCGCGGCAACATCGACGAC [350]
Joha GGTGGCTCAACTATCTCCGGCCTAACATCAAGCGCGGCAACATCGACGAC [350]
Local Basmati GGTGGCTCAACTATCTCCGGCCTAACATCAAGCGCGGCAACATCGACGAC [350]
Sorpuma GGTGGCTCAACTATCTCCGGCCTAACATCAAGCGCGGCAACATCGACGAC [350]
Kawanglawang GGTGGCTCAACTATCTCCGGCCTAACATCAAGCGCGGCAACATCGACGAC [350]
Borjahinga GGTGGCTCAACTATCTCCGGCCTAACATCAAGCGCGGCAACATCGACGAC [350]
Til Bora GGTGGCTCAACTATCTCCGGCCTAACATCAAGCGCGGCAACATCGACGAC [350]
Hati Hali GGTGGCTCAACTATCTCCGGCCTAACATCAAGCGCGGCAACATCGACGAC [350]
Ranjit GGTGGCTCAACTATCTCCGGCCTAACATCAAGCGCGGCAACATCGACGAC [350]
Kakiberoin GGTGGCTCAACTATCTCCGGCCTAACATCAAGCGCGGCAACATCGACGAC [350]
Aubalam GGTGGCTCAACTATCTCCGGCCTAACATCAAGCGCGGCAACATCGACGAC [350]
Balam GGTGGCTCAACTATCTCCGGCCTAACATCAAGCGCGGCAACATCGACGAC [350]
Borua Beroin GGTGGCTCAACTATCTCCGGCCTAACATCAAGCGCGGCAACATCGACGAC [350]
Lallatoi GGTGGCTCAACTATCTCCGGCCTAACATCAAGCGCGGCAACATCGACGAC [350]
IR8 GGTGGCTCAACTATCTCCGGCCTAACATCAAGCGCGGCAACATCGACGAC [350]
Arfa GGTGGCTCAACTATCTCCGGCCTAACATCAAGCGCGGCAACATCGACGAC [350]
Bahadur GGTGGCTCAACTATCTCCGGCCTAACATCAAGCGCGGCAACATCGACGAC [350]
Pankaj GGTGGCTCAACTATCTCCGGCCTAACATCAAGCGCGGCAACATCGACGAC [350]
Bashful GGTGGCTCAACTATCTCCGGCCTAACATCAAGCGCGGCAACATCGACGAC [350]
Moircha GGTGGCTCAACTATCTCCGGCCTAACATCAAGCGCGGCAACATCGACGAC [350]
Joya GGTGGCTCAACTATCTCCGGCCTAACATCAAGCGCGGCAACATCGACGAC [350]
Basberoin GGTGGCTCAACTATCTCCGGCCTAACATCAAGCGCGGCAACATCGACGAC [350]
Ranga_Borah GGTGGCTCAACTATCTCCGGCCTAACATCAAGCGCGGCAACATCGACGAC [350]
Mulahail GGTGGCTCAACTATCTCCGGCCTAACATCAAGCGCGGCAACATCGACGAC [350]
Guaroi GGTGGCTCAACTATCTCCGGCCTAACATCAAGCGCGGCAACATCGACGAC [350]
Mimutim GGTGGCTCAACTATCTCCGGCCTAACATCAAGCGCGGCAACATCGACGAC [350]
Harinarayan GGTGGCTCAACTATCTCCGGCCTAACATCAAGCGCGGCAACATCGACGAC [350]
Bherapawa GGTGGCTCAACTATCTCCGGCCTAACATCAAGCGCGGCAACATCGACGAC [350]
O. rufipogon GGTGGCTCAACTATCTCCGGCCTAACATCAAGCGCGGCAACATCGACGAC [350]

[360 370 380 390 400]
[. . . . .]
Papue GACGAGGAGGAGCTCATCGTCAGGCTCCACACCCTCCTCGGCAACAGGTA [400]
Lahi GACGAGGAGGAGCTCATCGTCAGGCTCCACACCCTCCTCGGCAACAGGTA [400]
Joha GACGAGGAGGAGCTCATCGTCAGGCTCCACACCCTCCTCGGCAACAGGTA [400]
Local Basmati GACGAGGAGGAGCTCATCGTCAGGCTCCACACCCTCCTCGGCAACAGGTA [400]
Sorpuma GACGAGGAGGAGCTCATCGTCAGGCTCCACACCCTCCTCGGCAACAGGTA [400]
Kawanglawang GACGAGGAGGAGCTCATCGTCAGGCTCCACACCCTCCTCGGCAACAGGTA [400]
Borjahinga GACGAGGAGGAGCTCATCGTCAGGCTCCACACCCTCCTCGGCAACAGGTA [400]
Til Bora GACGAGGAGGAGCTCATCGTCAGGCTCCACACCCTCCTCGGCAACAGGTA [400]
Hati Hali GACGAGGAGGAGCTCATCGTCAGGCTCCACACCCTCCTCGGCAACAGGTA [400]
Ranjit GACGAGGAGGAGCTCATCGTCAGGCTCCACACCCTCCTCGGCAACAGGTA [400]
Kakiberoin GACGAGGAGGAGCTCATCGTCAGGCTCCACACCCTCCTCGGCAACAGGTA [400]
Aubalam GACGAGGAGGAGCTCATCGTCAGGCTCCACACCCTCCTCGGCAACAGGTA [400]
Balam GACGAGGAGGAGCTCATCGTCAGGCTCCACACCCTCCTCGGCAACAGGTA [400]
Borua Beroin GACGAGGAGGAGCTCATCGTCAGGCTCCACACCCTCCTCGGCAACAGGTA [400]
Lallatoi GACGAGGAGGAGCTCATCGTCAGGCTCCACACCCTCCTCGGCAACAGGTA [400]

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IR8              GACGAGGAGGAGCTCATCGTCAGGCTCCACACCCTCCTCGGCAACAGGTA   [400]
Arfa             GACGAGGAGGAGCTCATCGTCAGGCTCCACACCCTCCTCGGCAACAGGTA   [400]
Bahadur          GACGAGGAGGAGCTCATCGTCAGGCTCCACACCCTCCTCGGCAACAGGTA   [400]
Pankaj           GACGAGGAGGAGCTCATCGTCAGGCTCCACACCCTCCTCGGCAACAGGTA   [400]
Bashful          GACGAGGAGGAGCTCATCGTCAGGCTCCACACCCTCCTCGGCAACAGGTA   [400]
Moircha          GACGAGGAGGAGCTCATCGTCAGGCTCCACACCCTCCTCGGCAACAGGTA   [400]
Joya             GACGAGGAGGAGCTCATCGTCAGGCTCCACACCCTCCTCGGCAACAGGTA   [400]
Basberoin        GACGAGGAGGAGCTCATCGTCAGGCTCCACACCCTCCTCGGCAACAGGTA   [400]
Ranga Borah      GACGAGGAGGAGCTCATCGTCAGGCTCCACACCCTCCTCGGCAACAGGTA   [400]
Mulahail         GACGAGGAGGAGCTCATCGTCAGGCTCCACACCCTCCTCGGCAACAGGTA   [400]
Guaroi           GACGAGGAGGAGCTCATCGTCAGGCTCCACACCCTCCTCGGCAACAGGTA   [400]
Mimutim          GACGAGGAGGAGCTCATCGTCAGGCTCCACACCCTCCTCGGCAACAGGTA   [400]
Harinarayan      GACGAGGAGGAGCTCATCGTCAGGCTCCACACCCTCCTCGGCAACAGGTA   [400]
Bherapawa        GACGAGGAGGAGCTCATCGTCAGGCTCCACACCCTCCTCGGCAACAGGTA   [400]
O. rufipogon     GACGAGGAGGAGCTCATCGTCAGGCTCCACACCCTCCTCGGCAACAGGTA   [400]

[                         410       420       430       440       450]
[                           .         .         .         .         .]
Papue            ATCTCATCACTTCATGATCACTCCGAGTTCCGTATCAATTTCGTTGAGTT   [450]
Lahi             ATCTCATCACTTCATGATCACTCCGAGTTCCGTATCAATTTCGTTGAGTT   [450]
Joha             ATCTCATCACTTCATGATCACTCCGAGTTCCGTATCAATTTCGTTGAGTT   [450]
Local Basmati    ATCTCATCACTTCATGATCACTCCGAGTTCCGTATCAATTTCGTTGAGTT   [450]
Sorpuma          ATCTCATCACTTCATGATCACTCCGAGTTCCGTATCAATTTCGTTGAGTT   [450]
Kawanglawang     ATCTCATCACTTCATGATCACTCCGAGCTCCGTATCAATTTCGTTGAGTT   [450]
Borjahinga       ATCTCATCACTTCATGATCACTCCGAGTTCCGTATCAATTTCGTTGAGTT   [450]
Til Bora         ATCTCATCACTTCATGATCACTCCGAGCTCCGTATCAATTTCGTTGAGTT   [450]
Hati Hali        ATCTCATCACTTCATGATCACTCCGAGTTCCGTATCAATTTCGTTGAGTT   [450]
Ranjit           ATCTCATCACTTCATGATCACTCCGAGTTCCGTATCAATTTCGTTGAGTT   [450]
Kakiberoin       ATCTCATCACTTCATGATCACTCCGAGTTCCGTATCAATTTCGTTGAGTT   [450]
Aubalam          ATCTCATCACTTCATGATCACTCCGAGTTCCGTATCAATTTCGTTGAGTT   [450]
Balam            ATCTCATCACTTCATGATCACTCCGAGCTCCGTATCAATTTCGTTGAGTT   [450]
Borua Beroin     ATCTCATCACTTCATGATCACTCCGAGTTCCGTATCAATTTCGTTGAGTT   [450]
Lallatoi         ATCTCATCACTTCATGATCACTCCGAGTTCCGTATCAATTTCGTTGAGTT   [450]
IR8              ATCTCATCACTTCATGATCACTCCGAGTTCCGTATCAATTTCGTTGAGTT   [450]
Arfa             ATCTCATCACTTCATGATCACTCCGAGTTCCGTATCAATTTCGTTGAGTT   [450]
Bahadur          ATCTCATCACTTCATGATCACTCCGAGTTCCGTATCAATTTCGTTGAGTT   [450]
Pankaj           ATCTCATCACTTCATGATCACTCCGAGTTCCGTATCAATTTCGTTGAGTT   [450]
Bashful          ATCTCATCACTTCATGATCACTCCGAGTTCCGTATCAATTTCGTTGAGTT   [450]
Moircha          ATCTCATCACTTCATGATCACTCCGAGTTCCGTATCAATTTCGTTGAGTT   [450]
Joya             ATCTCATCACTTCATGATCACTCCGAGTTCCGTATCAATTTCGTTGAGTT   [450]
Basberoin        ATCTCATCACTTCATGATCACTCCGAGTTCCGTATCAATTTCGTTGAGTT   [450]
Ranga Borah      ATCTCATCACTTCATGATCACTCCGAGTTCCGTATCAATTTCGTTGAGTT   [450]
Mulahail         ATCTCATCACTTCATGATCACTCCGAGTTCCGTATCAATTTCGTTGAGTT   [450]
Guaroi           ATCTCATCACTTCATGATCACTCCGAGTTCCGTATCAATTTCGTTGAGTT   [450]
Mimutim          ATCTCATCACTTCATGATCACTCCGAGTTCCGTATCAATTTCGTTGAGTT   [450]
Harinarayan      ATCTCATCACTTCATGATCACTCCGAGTTCCGTATCAATTTCGTTGAGTT   [450]
Bherapawa        ATCTCATCACTTCATGATCACTCCGAGTTCCGTATCAATTTCGTTGAGTT   [450]
O. rufipogon     ATCTCATCACTTCATGATCACTCCGAGCTCCGTATCAATTTCGTTGAGTT   [450]

[                         460       470       480       490       500]
[                           .         .         .         .         .]
Papue            CACAGCTTAAATTTGGAGCTATTTGGTACTGTCGGTGTGTGGATAGTGAT   [500]
Lahi             CACAGCTTAAATTTGGAGCTATTTGGTACTGTCGGTGTGTGGATAGTGAT   [500]
Joha             CACAGCTTAAATTTGGAGCTATTTGGTACTGTCGGTGTGTGGATAGTGAT   [500]
Local Basmati    CACAGCTTAAATTTGGAGCTATTTGGTACTGTCGGTGTGTGGATAGAGAT   [500]
Sorpuma          CACAGCTTAAATTTGGAGCTATTTGGTACTGTCGGTGTGTGGATAGTGAT   [500]
Kawanglawang     CACAGCTTAAATTTGGAGCTATTTGGTACTGTCGGTGTGTGGATAGTGAT   [500]
Borjahinga       CACAGCTTAAATTTGGAGCTATTTGGTACTGTCGGTGTGTGGATAGTGAT   [500]
Til Bora         CACAGCTTAAATTTGGAGCTATTTGGTACTGTCGGTGTGTGGATAGTGAT   [500]
Hati Hali        CACAGCTTAAATTTGGAGCTATTTGGTACTGTCGGTGTGTGGATAGAGAT   [500]
Ranjit           CACAGCTTAAATTTGGAGCTATTTGGTACTGTCGGTGTGTGGATAGTGAT   [500]
Kakiberoin       CACAGCTTAAATTTGGAGCTATTTGGTACTGTCGGTGTGTGGATAGAGAT   [500]
Aubalam          CACAGCTTAAATTTGGAGCTATTTGGTACTGTCGGTGTGTGGATAGTGAT   [500]
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Balam            CACAGCTTAAATTTGGAGCTATTTGGTACTGTCGGTGTGTGGATAGTGAT   [500]
Borua Beroin     CACAGCTTAAATTTGGAGCTATTTGGTACTGTCGGTGTGTGGATAGTGAT   [500]
Lallatoi         CACAGCTTAAATTTGGAGCTATTTGGTACTGTCGGTGTGTGGATAGAGAT   [500]
IR8              CACAGCTTAAATTTGGAGCTATTTGGTACTGTCGGTGTGTGGATAGAGAT   [500]
Arfa             CACAGCTTAAATTTGGAGCTATTTGGTACTGTCGGTGTGTGGATAGTGAT   [500]
Bahadur          CACAGCTTAAATTTGGAGCTATTTGGTACTGTCGGTGTGTGGATAGAGAT   [500]
Pankaj           CACAGCTTAAATTTGGAGCTATTTGGTACTGTCGGTGTGTGGATAGTGAT   [500]
Bashful          CACAGCTTAAATTTGGAGCTATTTGGTACTGTCGGTGTGTGGATAGTGAT   [500]
Moircha          CACAGCTTAAATTTGGAGCTATTTGGTACTGTCGGTGTGTGGATAGTGAT   [500]
Joya             CACAGCTTAAATTTGGAGCTATTTGGTACTGTCGGTGTGTGGATAGTGAT   [500]
Basberoin        CACAGCTTAAATTTGGAGCTATTTGGTACTGTCGGTGTGTGGATAGTGAT   [500]
Ranga Borah      CACAGCTTAAATTTGGAGCTATTTGGTACTGTCGGTGTGTGGATAGTGAT   [500]
Mulahail         CACAGCTTAAATTTGGAGCTATTTGGTACTGTCGGTGTGTGGATAGTGAT   [500]
Guaroi           CACAGCTTAAATTTGGAGCTATTTGGTACTGTCGGTGTGTGGATAGTGAT   [500]
Mimutim          CACAGCTTAAATTTGGAGCTATTTGGTACTGTCGGTGTGTGGATAGTGAT   [500]
Harinarayan      CACAGCTTAAATTTGGAGCTATTTGGTACTGTCGGTGTGTGGATAGTGAT   [500]
Bherapawa        CACAGCTTAAATTTGGAGCTATTTGGTACTGTCGGTGTGTGGATAGTGAT   [500]
O. rufipogon     CACAGCTTAAATTTGGAGCTATTTGGTACTGTCGGTGTGTGGATAGTGAT   [500]

[                         510       520       530       540       550]
[                           .         .         .         .         .]
Papue            ATACTTTTTTCTTTTCCTGGTTACGGCTTTTTAGGGTTGTAATATAAACT   [550]
Lahi             ATACTTTTTTCTTTTCCTGGTTACGGCTTTTTAGGGTTGTAATATAAACT   [550]
Joha             ATACTTTTTTCTTTTCCTGGTTACGGCTTTTTAGGGTTGTAATATAAACT   [550]
Local Basmati    ATACTTTTTTCTTTTCCTGGTTACGGCTTTTTAGGGTTGTAATATAAACT   [550]
Sorpuma          ATACTTTTTTCTTTTCCTGGTTACGGCTTTTTAGGGTTGTAATATAAACT   [550]
Kawanglawang     ATACTTTTTTCTTTTCCTGGTTACGGCTTTTTAGGGTTGTAATATAAACT   [550]
Borjahinga       ATACTTTTTTCTTTTCCTGGTTACGGCTTTTTAGGGTTGTAATATAAACT   [550]
Til Bora         ATACTTTTTTCTTTTCCTGGTTACGGCTTTTTAGGGTTGTAATATAAACT   [550]
Hati Hali        ATACTTTTTTCTTTTCCTGGTTACGGCTTTTTAGGGTTGTAATATAAACT   [550]
Ranjit           ATACTTTTTTCTTTTCCTGGTTACGGCTTTTTAGGGTTGTAATATAAACT   [550]
Kakiberoin       ATACTTTTTTCTTTTCCTGGTTACGGCTTTTTAGGGTTGTAATATAAACT   [550]
Aubalam          ATACTTTTTTCTTTTCCTGGTTACGGCTTTTTAGGGTTGTAATATAAACT   [550]
Balam            ATACTTTTTTCTTTTCCTGGTTACGGCTTTTTAGGGTTGTAATATAAACT   [550]
Borua Beroin     ATACTTTTTTCTTTTCCTGGTTACGGCTTTTTAGGGTTGTAATATAAACT   [550]
Lallatoi         ATACTTTTTTCTTTTCCTGGTTACGGCTTTTTAGGGTTGTAATATAAACT   [550]
IR8              ATACTTTTTTCTTTTCCTGGTTACGGCTTTTTAGGGTTGTAATATAAACT   [550]
Arfa             ATACTTTTTTCTTTTCCTGGTTACGGCTTTTTAGGGTTGTAATATAAACT   [550]
Bahadur          ATACTTTTTTCTTTTCCTGGTTACGGCTTTTTAGGGTTGTAATATAAACT   [550]
Pankaj           ATACTTTTTTCTTTTCCTGGTTACGGCTTTTTAGGGTTGTAATATAAACT   [550]
Bashful          ATACTTTTTTCTTTTCCTGGTTACGGCTTTTTAGGGTTGTAATATAAACT   [550]
Moircha          ATACTTTTTTCTTTTCCTGGTTACGGCTTTTTAGGGTTGTAATATAAACT   [550]
Joya             ATACTTTTTTCTTTTCCTGGTTACGGCTTTTTAGGGTTGTAATATAAACT   [550]
Basberoin        ATACTTTTTTCTTTTCCTGGTTACGGCTTTTTAGGGTTGTAATATAAACT   [550]
Ranga Borah      ATACTTTTTTCTTTTCCTGGTTACGGCTTTTTAGGGTTGTAATATAAACT   [550]
Mulahail         ATACTTTTTTCTTTTCCTGGTTACGGCTTTTTAGGGTTGTAATATAAACT   [550]
Guaroi           ATACTTTTTTCTTTTCCTGGTTACGGCTTTTTAGGGTTGTAATATAAACT   [550]
Mimutim          ATACTTTTTTCTTTTCCTGGTTACGGCTTTTTAGGGTTGTAATATAAACT   [550]
Harinarayan      ATACTTTTTTCTTTTCCTGGTTACGGCTTTTTAGGGTTGTAATATAAACT   [550]
Bherapawa        ATACTTTTTTCTTTTCCTGGTTACGGCTTTTTAGGGTTGTAATATAAACT   [550]
O. rufipogon     ATTCTTTTTTCTTTTCCTGGTTACGGTTTTCTAGGGTTGTAATATAAACT   [550]

[                         560       570       580       590       600]
[                           .         .         .         .         .]
Papue            TCGCAACTTCTTATACGAGTCATTCGAAAAAAATTTGAAGCTGGCTAACG   [600]
Lahi             TCGCAACTTCTTATACGAGTCATTCGAAAAAAATTTGAAGCTGGCTAACG   [600]
Joha             TCGCAACTTCTTATACGAGTCATTCGAAAAAAATTTGAAGCTGGCTAACG   [600]
Local Basmati    TCGCAACTTCTTATACGAGTCATTCGAAAAAAAATTGAAGCTGGCTAACG   [600]
Sorpuma          TCGCAACTTCTTATACGAGTCATTCGAAAAAAATTTGAAGCTGGCTAACG   [600]
Kawanglawang     TCACAACTTCTTATACGAGTCATTCGAAAAAAATTTGGAGCTGGCTAACG   [600]
Borjahinga       TCGCAACTTCTTATACGAGTCATTCGAAAAAAATTTGAAGCTGGCTAACG   [600]
Til Bora         TCACAACTTCTTATACGAGTCATTCGAAAAAAATTTGGAGCTGGCTAACG   [600]
Hati Hali        TCGCAACTTCTTATACGAGTCATTCGAAAAAAATTTGAAGCTGGCTAACG   [600]
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Ranjit            TCGCAACTTCTTATACGAGTCATTCGAAAAAAAAATTGAAGCTGGCTAACG   [600]
Kakiberoin        TCGCAACTTCTTATACGAGTCATTCGAAAAAAAATTTGAAGCTGGCTAACG   [600]
Aubalam           TCGCAACTTCTTATACGAGTCATTCGAAAAAAAATTTGAAGCTGGCTAACG   [600]
Balam             TCACAACTTCTTATACGAGTCATTCGAAAAAAAATTTGGAGCTGGCTAACG   [600]
Borua Beroin      TCGCAACTTCTTATACGAGTCATTCGAAAAAAAATTTGAAGCTGGCTAACG   [600]
Lallatoi          TCGCAACTTCTTATACGAGTCATTCGAAAAAAAATTTGAAGCTGGCTAACG   [600]
IR8               TCGCAACTTCTTATACGAGTCATTCGAAAAAAAATTTGAAGCTGGCTAACG   [600]
Arfa              TCGCAACTTCTTATACGAGTCATTCGAAAAAAAATTTGAAGCTGGCTAACG   [600]
Bahadur           TCGCAACTTCTTATACGAGTCATTCGAAAAAAAAATTGAAGCTGGCTAACG   [600]
Pankaj            TCGCAACTTCTTATACGAGTCATTCGAAAAAAAATTTGAAGCTGGCTAACG   [600]
Bashful           TCGCAACTTCTTATACGAGTCATTCGAAAAAAAATTTGAAGCTGGCTAACG   [600]
Moircha           TCGCAACTTCTTATACGAGTCATTCGAAAAAAAATTTGAAGCTGGCTAACG   [600]
Joya              TCGCAACTTCTTATACGAGTCATTCGAAAAAAAATTTGAAGCTGGCTAACG   [600]
Basberoin         TCGCAACTTCTTATACGAGTCATTCGAAAAAAAATTTGAAGCTGGCTAACG   [600]
Ranga Borah       TCGCAACTTCTTATACGAGTCATTCGAAAAAAAATTTGAAGCTGGCTAACG   [600]
Mulahail          TCGCAACTTCTTATACGAGTCATTCGAAAAAAAATTTGAAGCTGGCTAACG   [600]
Guaroi            TCGCAACTTCTTATACGAGTCATTCGAAAAAAAATTTGAAGCTGGCTAACG   [600]
Mimutim           TCGCAACTTCTTATACGAGTCATTCGAAAAAAAATTTGAAGCTGGCTAACG   [600]
Harinarayan       TCGCAACTTCTTATACGAGTCATTCGAAAAAAAATTTGAAGCTGGCTAACG   [600]
Bherapawa         TCGCAACTTCTTATACGAGTCATTCGAAAAAAAATTTGAAGCTGGCTAACG   [600]
O. rufipogon      TCGCAACTTCTTATACGAGTCATTCGAAAAAAAATTTGGAGCTGGCTAACG   [600]

[                           610       620       630       640       650]
[                             .         .         .         .         .]
Papue             CTAGACAATAATAAGCTGATTTAACTTCTGTTTTATTTTTATTTATTTTT   [650]
Lahi              CTAGACAATAATAAGCTGATTTAACTTCTGTTTTATTTTTATTTATTTTT   [650]
Joha              CTAGACAATAATAAGCTGATTTAACTTCTGTTTTATTTTTATTTATTTTT   [650]
Local_Basmati     CTAGACAATAATAAGCTGATTTAACTTCTGTTTTATTTTTATTTATTTTT   [650]
Sorpuma           CTAGACAATAATAAGCTGATTTAACTTCTGTTTTATTTTTATTTATTTTT   [650]
Kawanglawang      CTAGACAATAATAAGCTGATTTAACTTCTGTTTTATTTTTATTTATTTTT   [650]
Borjahinga        CTAGACAATAATAAGCTGATTTAACTTCTGTTTTATTTTTATTTATTTTT   [650]
Til Bora          CTAGACAATAATAAGCTGATTTAACTTCTGTTTTATTTTTATTTATTTTT   [650]
Hati_Hali         CTAGACAATAATAAGCTGATTTAACTTCTGTTTTATTTTTATTTATTTTT   [650]
Ranjit            CTAGACAATAATAAGCTGATTTAACTTCTGTTTTATTTTTATTTATTTTT   [650]
Kakiberoin        CTAGACAATAATAAGCTGATTTAACTTCTGTTTTATTTTTATTTATTTTT   [650]
Aubalam           CTAGACAATAATAAGCTGATTTAACTTCTGTTTTATTTTTATTTATTTTT   [650]
Balam             CTAGACAATAATAAGCTGATTTAACTTCTGTTTTATTTTTATTTATTTTT   [650]
Borua Beroin      CTAGACAATAATAAGCTGATTTAACTTCTGTTTTATTTTTATTTATTTTT   [650]
Lallatoi          CTAGACAATAATAAGCTGATTTAACTTCTGTTTTATTTTTATTTATTTTT   [650]
IR8               CTAGACAATAATAAGCTGATTTAACTTCTGTTTTATTTTTATTTATTTTT   [650]
Arfa              CTAGACAATAATAAGCTGATTTAACTTCTGTTTTATTTTTATTTATTTTT   [650]
Bahadur           CTAGACAATAATAAGCTGATTTAACTTCTGTTTTATTTTTATTTATTTTT   [650]
Pankaj            CTAGACAATAATAAGCTGATTTAACTTCTGTTTTATTTTTATTTATTTTT   [650]
Bashful           CTAGACAATAATAAGCTGATTTAACTTCTGTTTTATTTTTATTTATTTTT   [650]
Moircha           CTAGACAATAATAAGCTGATTTAACTTCTGTTTTATTTTTATTTATTTTT   [650]
Joya              CTAGACAATAATAAGCTGATTTAACTTCTGTTTTATTTTTATTTATTTTT   [650]
Basberoin         CTAGACAATAATAAGCTGATTTAACTTCTGTTTTATTTTTATTTATTTTT   [650]
Ranga Borah       CTAGACAATAATAAGCTGATTTAACTTCTGTTTTATTTTTATTTATTTTT   [650]
Mulahail          CTAGACAATAATAAGCTGATTTAACTTCTGTTTTATTTTTATTTATTTTT   [650]
Guaroi            CTAGACAATAATAAGCTGATTTAACTTCTGTTTTATTTTTATTTATTTTT   [650]
Mimutim           CTAGACAATAATAAGCTGATTTAACTTCTGTTTTATTTTTATTTATTTTT   [650]
Harinarayan       CTAGACAATAATAAGCTGATTTAACTTCTGTTTTATTTTTATTTATTTTT   [650]
Bherapawa         CTAGACAATAATAAGCTGATTTAACTTCTGTTTTATTTTTATTTATTTTT   [650]
O. rufipogon      CTAGACAATAATAAGCTGATTTAACTTCTGTTTTATTTTTATTTATTTTT   [650]

[                           660       670       680       690       700]
[                             .         .         .         .         .]
Papue             ATCTTTATCTTTTTTAACAAATTTGTAATTTGAGCTGTGAAATCATAGCT   [700]
Lahi              ATCTTTATCTTTTTTAACAAATTTGTAATTTGAGCTGTGAAATCATAGCT   [700]
Joha              ATCTTTATCTTTTTTAACAAATTTGTAATTTGAGCTGTGAAATCATAGCT   [700]
Local Basmati     ATCTTTATCTTTTTTAACAAATTTGTAATTTGAGCTGTGAAATCATAGCT   [700]
Sorpuma           ATCTTTATCTTTTTTAACAAATTTGTAATTTGAGCTGTGAAATCATAGCT   [700]
Kawanglawang      ATCTTTATCTTTTTTAACAAATTTGTAATTTGAGCTGTGAAATCATAGCT   [700]
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Borjahinga	ATCTTTATCTTTTTTAACAAATTTGTAATTTGAGCTGTGAAATCATAGCT	[700]
Til Bora	ATCTTTATCTTTTTTAACAAATTTGTAATTTGAGCTGTGAAATCATAGCT	[700]
Hati Hali	ATCTTTATCTTTTTAAACAAATTTGTAATTTGAGCTGTGAAATCATAGCT	[700]
Ranjit	ATCTTTATCTTTTTTAACAAATTTGTAATTTGAGCTGTGAAATCATAGCT	[700]
Kakiberoin	ATCTTTATCTTTTTTAACAAATTTGTAATTTGAGCTGTGAAATCATAGCT	[700]
Aubalam	ATCTTTATCTTTTTTAACAAATTTGTAATTTGAGCTGTGAAATCATAGCT	[700]
Balam	ATCTTTATCTTTTTTAACAAATTTGTAATTTGAGCTGTGAAATCATAGCT	[700]
Borua Beroin	ATCTTTATCTTTTTTAACAAATTTGTAATTTGAGCTGTGAAATCATAGCT	[700]
Lallatoi	ATCTTTATCTTTTTTAACAAATTTGTAATTTGAGCTGTGAAATCATAGCT	[700]
IR8	ATCTTTATCTTTTTTAACAAATTTGTAATTTGAGCTGTGAAATCATAGCT	[700]
Arfa	ATCTTTATCTTTTTTAACAAATTTGTAATTTGAGCTGTGAAATCATAGCT	[700]
Bahadur	ATCTTTATCTTTTTTAACAAATTTGTAATTTGAGCTGTGAAATCATAGCT	[700]
Pankaj	ATCTTTATCTTTTTTAACAAATTTGTAATTTGAGCTGTGAAATCATAGCT	[700]
Bashful	ATCTTTATCTTTTTTAACAAATTTGTAATTTGAGCTGTGAAATCATAGCT	[700]
Moircha	ATCTTTATCTTTTTTAACAAATTTGTAATTTGAGCTGTGAAATCATAGCT	[700]
Joya	ATCTTTATCTTTTTTAACAAATTTGTAATTTGAGCTGTGAAATCATAGCT	[700]
Basberoin	ATCTTTATCTTTTTTAACAAATTTGTAATTTGAGCTGTGAAATCATAGCT	[700]
Ranga Borah	ATCTTTATCTTTTTTAACAAATTTGTAATTTGAGCTGTGAAATCATAGCT	[700]
Mulahail	ATCTTTATCTTTTTTAACAAATTTGTAATTTGAGCTGTGAAATCATAGCT	[700]
Guaroi	ATCTTTATCTTTTTTAACAAATTTGTAATTTGAGCTGTGAAATCATAGCT	[700]
Mimutim	ATCTTTATCTTTTTTAACAAATTTGTAATTTGAGCTGTGAAATCATAGCT	[700]
Harinarayan	ATCTTTATCTTTTTTAACAAATTTGTAATTTGAGCTGTGAAATCATAGCT	[700]
Bherapawa	ATCTTTATCTTTTTTAACAAATTTGTAATTTGAGCTGTGAAATCATAGCT	[700]
O. rufipogon	ATCTTTATCTTTTTTAACAAATTTGTAATTTGAGCTGTGAAATCATAGCT	[700]

[	710 720 730 740 750]	
[	. . . . .]	
Papue	TACTGCCG-TTTTGATCGATCGTGTATATATGTTGTCAGGTGGTCTCTCA	[749]
Lahi	TACTGCCG-TTTTGATCGATCGTGTATATATGTTGTCAGGTGGTCTCTCA	[749]
Joha	TACTGCCG-TTTTGATCGATCGTGTATATATGTTGTCAGGTGGTCTCTCA	[749]
Local Basmati	TACTGCCGGTTTTGATCGATCGTGTATATATGTTGTCAGGTGGTCTCTCA	[750]
Sorpuma	TACTGCCG-TTTTGATCGATCGTGTATATATGTTGTCAGGTGGTCTCTCA	[749]
Kawanglawang	TACTGCCG-TTTTGATCGATCGTGTATATATGTTGTCAGGTGGTCTCTCA	[749]
Borjahinga	TACTGCCG-TTTTGATCGATCGTGTATATATGTTGTCAGGTGGTCTCTCA	[749]
Til Bora	TACTGCCG-TTTTGATCGATCGTGTATATATGTTGTCAGGTGGTCTCTCA	[749]
Hati Hali	TACTGCCG-TTTTGATCGATCGTGTATATATGTTGTCAGGTGGTCTCTCA	[749]
Ranjit	TACTGCCG-TTTTGATCGATCGTGTATATATGTTGTCAGGTGGTCTCTCA	[749]
Kakiberoin	TACTGCCG-TTTTGATCGATCGTGTATATATGTTGTCAGGTGGTCTCTCA	[749]
Aubalam	TACTGCCG-TTTTGATCGATCGTGTATATATGTTGTCAGGTGGTCTCTCA	[749]
Balam	TACTGCCG-TTTTGATCGATCGTGTATATATGTTGTCAGGTGGTCTCTCA	[749]
Borua Beroin	TACTGCCGTTTTTGATCGATCGTGTATATATGTTGTCAGGTGGTCTCTCA	[750]
Lallatoi	TACTGCCGTTTTTGATCGATCGTGTATATATGTTGTCAGGTGGTCTCTCA	[750]
IR8	TACTGCCGTTTTTGATCGATCGTGTATATATGTTGTCAGGTGGTCTCTCA	[750]
Arfa	TACTGCCG-TTTTGATCGATCGTGTATATATGTTGTCAGGTGGTCTCTCA	[749]
Bahadur	TACTGCCG-TTTTGATCGATCGTGTATATATGTTGTCAGGTGGTCTCTCA	[749]
Pankaj	TACTGCCG-TTTTGATCGATCGTGTATATATGTTGTCAGGTGGTCTCTCA	[749]
Bashful	TACTGCCG-TTTTGATCGATCGTGTATATATGTTGTCAGGTGGTCTCTCA	[749]
Moircha	TACTGCCG-TTTTGATCGATCGTGTATATATGTTGTCAGGTGGTCTCTCA	[749]
Joya	TACTGCCG-TTTTGATCGATCGTGTATATATGTTGTCAGGTGGTCTCTCA	[749]
Basberoin	TACTGCCG-TTTTGATCGATCGTGTATATATGTTGTCAGGTGGTCTCTCA	[749]
Ranga Borah	TACTGCCG-TTTTGATCGATCGTGTATATATGTTGTCAGGTGGTCTCTCA	[749]
Mulahail	TACTGCCG-TTTTGATCGATCGTGTATATATGTTGTCAGGTGGTCTCTCA	[749]
Guaroi	TACTGCCG-TTTTGATCGATCGTGTATATATGTTGTCAGGTGGTCTCTCA	[749]
Mimutim	TACTGCCG-TTTTGATCGATCGTGTATATATGTTGTCAGGTGGTCTCTCA	[749]
Harinarayan	TACTGCCG-TTTTGATCGATCGTGTATATATGTTGTCAGGTGGTCTCTCA	[749]
Bherapawa	TACTGCCG-TTTTGATCGATCGTGTATATATGTTGTCAGGTGGTCTCTCA	[749]
O. rufipogon	TACTGCCG-TTTTGATCGATCGTGTATATATGTTGTCAGGTGGTCTCTCA	[749]

[	760 770 780 790 800]	
[	. . . . .]	
Papue	TTGCAGGCAGGCTGCCGGGCCGAACAGACAATGAAATCAAGAACT-----	[794]
Lahi	TTGCAGGCAGGCTGCCGGGCCGAACAGACAATGAAATCAAGAACTACTGG	[799]
Joha	TTGCAGGCAGGCTGCCGGGCCGAACAGACAATGAAATCAAGAACTACTGG	[799]

Local Basmati	TTGCAGGCAGGCTGCCGGGCCGAACAGACAATGAAATCAAGAACT-----	[795]
Sorpuma	TTGCAGGCAGGCTGCCGGGCCGAACAGACAATGAAATCAAGAACT-----	[794]
Kawanglawang	TTGCAGGCAGGCTGCCGGGCCGAACAGACAATGAAATCAAGAACTACTGG	[799]
Borjahinga	TTGCAGGCAGGCTGCCGGGCCGAACAGACAATGAAATCAAGAACTACTGG	[799]
Til Bora	TTGCAGGCAGGCTGCCGGGCCGAACAGACAATGAAATCAAGAACTACTGG	[799]
Hati_Hali	TTGCAGGCAGGCTGCCGGGCCGAACAGACAATGAAATCAAGAACTACTGG	[799]
Ranjit	TTGCAGGCAGGCTGCCGGGCCGAACAGACAATGAAATCAAGAACT-----	[794]
Kakiberoin	TTGCAGGCAGGCTGCCGGGCCGAACAGACAATGAAATCAAGAACT-----	[794]
Aubalam	TTGCAGGCAGGCTGCCGGGCCGAACAGACAATGAAATCAAGAACT-----	[794]
Balam	TTGCAGGCAGGCTGCCGGGCCGAACAGACAATGAAATCAAGAACTACTGG	[799]
Borua Beroin	TTGCAGGCAGGCTGCCGGGCCGAACAGACAATGAAATCAAGAACTACTGG	[800]
Lallatoi	TTGCAGGCAGGCTGCCGGGCCGAACAGACAATGAAATCAAGAACT-----	[795]
IR8	TTGCAGGCAGGCTGCCGGGCCGAACAGACAATGAAATCAAGAACT-----	[795]
Arfa	TTGCAGGCAGGCTGCCGGGCCGAACAGACAATGAAATCAAGAACT-----	[794]
Bahadur	TTGCAGGCAGGCTGCCGGGCCGAACAGACAATGAAATCAAGAACT-----	[794]
Pankaj	TTGCAGGCAGGCTGCCGGGCCGAACAGACAATGAAATCAAGAACT-----	[794]
Bashful	TTGCAGGCAGGCTGCCGGGCCGAACAGACAATGAAATCAAGAACTACTGG	[799]
Moircha	TTGCAGGCAGGCTGCCGGGCCGAACAGACAATGAAATCAAGAACT-----	[794]
Joya	TTGCAGGCAGGCTGCCGGGCCGAACAGACAATGAAATCAAGAACT-----	[794]
Basberoin	TTGCAGGCAGGCTGCCGGGCCGAACAGACAATGAAATCAAGAACTACTGG	[799]
Ranga Borah	TTGCAGGCAGGCTGCCGGGCCGAACAGACAATGAAATCAAGAACT-----	[794]
Mulahail	TTGCAGGCAGGCTGCCGGGCCGAACAGACAATGAAATCAAGAACT-----	[794]
Guaroi	TTGCAGGCAGGCTGCCGGGCCGAACAGACAATGAAATCAAGAACT-----	[794]
Mimutim	TTGCAGGCAGGCTGCCGGGCCGAACAGACAATGAAATCAAGAACT-----	[794]
Harinarayan	TTGCAGGCAGGCTGCCGGGCCGAACAGACAATGAAATCAAGAACT-----	[794]
Bherapawa	TTGCAGGCAGGCTGCCGGGCCGAACAGACAATGAAATCAAGAACTACTGG	[799]
O. rufipogon	TTGCAGGCAGGCTGCCGGGCCGAACAGACAATGAAATCAAGAACTACTGG	[799]

[	810 820 830 840 850]	
[	. . . . .]	
Papue	-----CACGCTCAGCCGCAAGATCGGCACCGCCGCCACCGCCGCCGCCGG	[839]
Lahi	AACAGCACGCTCAGCCGCAAGATCGGCACCGCCGCCACCGCCGCCGCCGG	[849]
Joha	AACAGCACGCTCAGCCGCAAGATCGGCACCGCCGCCACCGCCGCCGCCGG	[849]
Local Basmati	-----CACGCTCAGCCGCAAGATCGGCACCGCCGCCACCGCCGCCGCCGG	[840]
Sorpuma	-----CACGCTCAGCCGCAAGATCGGCACCGCCGCCACCGCCGCCGCCGG	[839]
Kawanglawang	AACAGCACGCTCAGCCGCAAGATCGGCACCGCCGCCACCGCCGCTGCCGG	[849]
Borjahinga	AACAGCACGCTCAGCCGCAAGATCGGCACCGCCGCCACCGCCGCCGCCGG	[849]
Til Bora	AACAGCACGCTCAGCCGCAAGATCGGCACCGCCGCCACCGCCGCTGCCGG	[849]
Hati Hali	AACAGCACGCTCAGCCGCAAGATCGGCACCGCCGCCACCGCCGCCGCCGG	[849]
Ranjit	-----CACGCTCAGCCGCAAGATCGGCACCGCCGCCACCGCCGCCGCCGG	[839]
Kakiberoin	-----CACGCTCAGCCGCAAGATCGGCACCGCCGCCACCGCCGCCGCCGG	[839]
Aubalam	-----CACGCTCAGCCGCAAGATCGGCACCGCCGCCACCGCCGCCGCCGG	[839]
Balam	AACAGCACGCTCAGCCGCAAGATCGGCACCGCCGCCACCGCCGCTGCCGG	[849]
Borua Beroin	AACAGCACGCTCAGCCGCAAGATCGGCACCGCCGCCACCGCCGCCGCCGG	[850]
Lallatoi	-----CACGCTCAGCCGCAAGATCGGCACCGCCGCCACCGCCGCCGCCGG	[840]
IR8	-----CACGCTCAGCCGCAAGATCGGCACCGCCGCCACCGCCGCCGCCGG	[840]
Arfa	-----CACGCTCAGCCGCAAGATCGGCACCGCCGCCACCGCCGCCGCCGG	[839]
Bahadur	-----CACGCTCAGCCGCAAGATCGGCACCGCCGCCACCGCCGCCGCCGG	[839]
Pankaj	-----CACGCTCAGCCGCAAGATCGGCACCGCCGCCACCGCCGCCGCCGG	[839]
Bashful	AACAGCACGCTCAGCCGCAAGATCGGCACCGCCGCCACCGCCGCCGCCGG	[849]
Moircha	-----CACGCTCAGCCGCAAGATCGGCACCGCCGCCACCGCCGCCGCCGG	[839]
Joya	-----CACGCTCAGCCGCAAGATCGGCACCGCCGCCACCGCCGCCGCCGG	[839]
Basberoin	AACAGCACGCTCAGCCGCAAGATCGGCACCGCCGCCACCGCCGCCGCCGG	[849]
Ranga Borah	-----CACGCTCAGCCGCAAGATCGGCACCGCCGCCACCGCCGCCGCCGG	[839]
Mulahail	-----CACGCTCAGCCGCAAGATCGGCACCGCCGCCACCGCCGCCGCCGG	[839]
Guaroi	-----CACGCTCAGCCGCAAGATCGGCACCGCCGCCACCGCCGCCGCCGG	[839]
Mimutim	-----CACGCTCAGCCGCAAGATCGGCACCGCCGCCACCGCCGCCGCCGG	[839]
Harinarayan	-----CACGCTCAGCCGCAAGATCGGCACCGCCGCCACCGCCGCCGCCGG	[839]
Bherapawa	AACAGCACGCTCAGCCGCAAGATCGGCACCGCCGCCACCGCCGCCGCCGG	[849]
O. rufipogon	AACAGCACGCTCAGCCGCAAGATCGGCACCGCCGCCACCGCCGCTGCCGG	[849]

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[                                  860       870       880       890       900]
[                                    .         .         .         .         .]
Papue              CAGCCGCGGTGGCAGCACGCCGGACACCGCCAGAGCGACGGACGCGGCGT   [889]
Lahi               CAGCCGCGGTGGCAGCACGCCGGACACCGCCAGAGCGACGGACGCGGCGT   [899]
Joha               CAGCCGCGGTGGCAGCACGCCGGACACCGCCAGAGCGACGGACGCGGCGT   [899]
Local Basmati      CAGCCGCGGTGGCAGCACGCCGGACACCGCCAGAGCGACGGACGCGGCGT   [890]
Sorpuma            CAGCCGCGGTGGCAGCACGCCGGACACCGCCAGAGCGACGGACGCGGCGT   [889]
Kawanglawang       CAGCCGCGGTGGCAGCACGCCGGACACCGCCAGAGCGACGGACGCGGCGT   [899]
Borjahinga         CAGCCGCGGTGGCAGCACGCCGGACACCGCCAGAGCGACGGACGCGGCGT   [899]
Til Bora           CAGCCGCGGTGGCAGCACGCCGGACACCGCCAGAGCGACGGACGCGGCGT   [899]
Hati Hali          CAGCCGCGGTGGCAGCACGCCGGACACCGCCAGAGCGACGGACGCGGCGT   [899]
Ranjit             CAGCCGCGGTGGCAGCACGCCGGACACCGCCAGAGCGACGGACGCGGCGT   [889]
Kakiberoin         CAGCCGCGGTGGCAGCACGCCGGACACCGCCAGAGCGACGGACGCGGCGT   [889]
Aubalam            CAGCCGCGGTGGCAGCACGCCGGACACCGCCAGAGCGACGGACGCGGCGT   [889]
Balam              CAGCCGCGGTGGCAGCACGCCGGACACCGCCAGAGCGACGGACGCGGCGT   [899]
Borua Beroin       CAGCCGCGGTGGCAGCACGCCGGACACCGCCAGAGCGACGGACGCGGCGT   [900]
Lallatoi           CAGCCGCGGTGGCAGCACGCCGGACACCGCCAGAGCGACGGACGCGGCGT   [890]
IR8                CAGCCGCGGTGGCAGCACGCCGGACACCGCCAGAGCGACGGACGCGGCGT   [890]
Arfa               CAGCCGCGGTGGCAGCACGCCGGACACCGCCAGAGCGACGGACGCGGCGT   [889]
Bahadur            CAGCCGCGGTGGCAGCACGCCGGACACCGCCAGAGCGACGGACGCGGCGT   [889]
Pankaj             CAGCCGCGGTGGCAGCACGCCGGACACCGCCAGAGCGACGGACGCGGCGT   [889]
Bashful            CAGCCGCGGTGGCAGCACGCCGGACACCGCCAGAGCGACGGACGCGGCGT   [899]
Moircha            CAGCCGCGGTGGCAGCACGCCGGACACCGCCAGAGCGACGGACGCGGCGT   [889]
Joya               CAGCCGCGGTGGCAGCACGCCGGACACCGCCAGAGCGACGGACGCGGCGT   [889]
Basberoin          CAGCCGCGGTGGCAGCACGCCGGACACCGCCAGAGCGACGGACGCGGCGT   [899]
Ranga Borah        CAGCCGCGGTGGCAGCACGCCGGACACCGCCAGAGCGACGGACGCGGCGT   [889]
Mulahail           CAGCCGCGGTGGCAGCACGCCGGACACCGCCAGAGCGACGGACGCGGCGT   [889]
Guaroi             CAGCCGCGGTGGCAGCACGCCGGACACCGCCAGAGCGACGGACGCGGCGT   [889]
Mimutim            CAGCCGCGGTGGCAGCACGCCGGACACCGCCAGAGCGACGGACGCGGCGT   [889]
Harinarayan        CAGCCGCGGTGGCAGCACGCCGGACACCGCCAGAGCGACGGACGCGGCGT   [889]
Bherapawa          CAGCCGCGGTGGCAGCACGCCGGACACCGCCAGAGCGACGGACGCGGCGT   [899]
O. rufipogon       CAGCCGCGGTGGCAGCACGCCGGACACCGCCAGAGCGACGGACGCGGCGT   [899]

[                                  910       920       930       940       950]
[                                    .         .         .         .         .]
Papue              CGTCCAGCTCCGTCGTGCCGCCGGGCCAGCAGCAGCAGCCAGCCTCCCGC   [939]
Lahi               CGTCCAGCTCCGTCGTGCCGCCGGGCCAGCAGCAGCAGCCAGCCTCCCGC   [949]
Joha               CGTCCAGCTCCGTCGTGCCGCCGGGCCAGCAGCAGCAGCCAGCCTCCCGC   [949]
Local Basmati      CGTCCAGCTCCGTCGTGCCGCCGGGCCAGCAGCAGCAGCCAGCCTCCCGC   [940]
Sorpuma            CGTCCAGCTCCGTCGTGCCGCCGGGCCAGCAGCAGCAGCCAGCCTCCCGC   [939]
Kawanglawang       CGTCCAGCTCCGTCGTGCCGCCGGGCCAGCAGCAGCAGCCAGCCTCCCGC   [949]
Borjahinga         CGTCCAGCTCCGTCGTGCCGCCGGGCCAGCAGCAGCAGCCAGCCTCCCGC   [949]
Til Bora           CGTCCAGCTCCGTCGTGCCGCCGGGCCAGCAGCAGCAGCCAGCCTCCCGC   [949]
Hati Hali          CGTCCAGCTCCGTCGTGCCGCCGGGCCAGCAGCAGCAGCCAGCCTCCCGC   [949]
Ranjit             CGTCCAGCTCCGTCGTGCCGCCGGGCCAGCAGCAGCAGCCAGCCTCCCGC   [939]
Kakiberoin         CGTCCAGCTCCGTCGTGCCGCCGGGCCAGCAGCAGCAGCCAGCCTCCCGC   [939]
Aubalam            CGTCCAGCTCCGTCGTGCCGCCGGGCCAGCAGCAGCAGCCAGCCTCCCGC   [939]
Balam              CGTCCAGCTCCGTCGTGCCGCCGGGCCAGCAGCAGCAGCCAGCCTCCCGC   [949]
Borua Beroin       CGTCCAGCTCCGTCGTGCCGCCGGGCCAGCAGCAGCAGCCAGCCTCCCGC   [950]
Lallatoi           CGTCCAGCTCCGTCGTGCCGCCGGGCCAGCAGCAGCAGCCAGCCTCCCGC   [940]
IR8                CGTCCAGCTCCGTCGTGCCGCCGGGCCAGCAGCAGCAGCCAGCCTCCCGC   [940]
Arfa               CGTCCAGCTCCGTCGTGCCGCCGGGCCAGCAGCAGCAGCCAGCCTCCCGC   [939]
Bahadur            CGTCCAGCTCCGTCGTGCCGCCGGGCCAGCAGCAGCAGCCAGCCTCCCGC   [939]
Pankaj             CGTCCAGCTCCGTCGTGCCGCCGGGCCAGCAGCAGCAGCCAGCCTCCCGC   [939]
Bashful            CGTCCAGCTCCGTCGTGCCGCCGGGCCAGCAGCAGCAGCCAGCCTCCCGC   [949]
Moircha            CGTCCAGCTCCGTCGTGCCGCCGGGCCAGCAGCAGCAGCCAGCCTCCCGC   [939]
Joya               CGTCCAGCTCCGTCGTGCCGCCGGGCCAGCAGCAGCAGCCAGCCTCCCGC   [939]
Basberoin          CGTCCAGCTCCGTCGTGCCGCCGGGCCAGCAGCAGCAGCCAGCCTCCCGC   [949]
Ranga Borah        CGTCCAGCTCCGTCGTGCCGCCGGGCCAGCAGCAGCAGCCAGCCTCCCGC   [939]
Mulahail           CGTCCAGCTCCGTCGTGCCGCCGGGCCAGCAGCAGCAGCCAGCCTCCCGC   [939]
Guaroi             CGTCCAGCTCCGTCGTGCCGCCGGGCCAGCAGCAGCAGCCAGCCTCCCGC   [939]
Mimutim            CGTCCAGCTCCGTCGTGCCGCCGGGCCAGCAGCAGCAGCCAGCCTCCCGC   [939]
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Harinarayan      CGTCCAGCTCCGTCGTGCCGCCGGGCCAGCAGCAGCAGCCAGCCTCCCGC   [939]
Bherapawa        CGTCCAGCTCCGTCGTGCCGCCGGGCCAGCAGCAGCAGCCAGCCTCCCGC   [949]
O. rufipogon     CGTCCAGCTCCGTCGTGCCGCCGGGCCAGCAGCAGCAGCCAGCCTCCCGC   [949]

[                         960       970       980       990      1000]
[                           .         .         .         .         .]
Papue            GCCGACACCGACACAGCAACGGCAGCGGCGGCGGCGGCGGCGACGACGAC   [989]
Lahi             GCCGACACCGACACAGCAACGGCAGCGGCGGCGGCGGCGGCGACGACGAC   [999]
Joha             GCCGACACCGACACAGCAACGGCAGCGGCGGCGGCGGCGGCGACGACGAC   [999]
Local Basmati    GCCGACACCGACACAGCAACGGCAGCGGCGGCGGCGGCGGCGACGACGAC   [990]
Sorpuma          GCCGACACCGACACAGCAACGGCAGCGGCGGCGGCGGCGGCGACGACGAC   [989]
Kawanglawang     GCCGACACCGACACAGCAACGGCAGCGGCGGCGGCGGCGGCGACGACGAC   [999]
Borjahinga       GCCGACACCGACACAGCAACGGCAGCGGCGGCGGCGGCGGCGACGACGAC   [999]
Til Bora         GCCGACACCGACACAGCAACGGCAGCGGCGGCGGCGGCGGCGACGACGAC   [999]
Hati Hali        GCCGACACCGACACAGCAACGGCAGCGGCGGCGGCGGCGGCGACGACGAC   [999]
Ranjit           GCCGACACCGACACAGCAACGGCAGCGGCGGCGGCGGCGGCGACGACGAC   [989]
Kakiberoin       GCCGACACCGACACAGCAACGGCAGCGGCGGCGGCGGCGGCGACGACGAC   [989]
Aubalam          GCCGACACCGACACAGCAACGGCAGCGGCGGCGGCGGCGGCGACGACGAC   [989]
Balam            GCCGACACCGACACAGCAACGGCAGCGGCGGCGGCGGCGGCGACGACGAC   [999]
Borua Beroin     GCCGACACCGACACAGCAACGGCAGCGGCGGCGGCGGCGGCGACGACGAC   [1000]
Lallatoi         GCCGACACCGACACAGCAACGGCAGCGGCGGCGGCGGCGGCGACGACGAC   [990]
IR8              GCCGACACCGACACAGCAACGGCAGCGGCGGCGGCGGCGGCGACGACGAC   [990]
Arfa             GCCGACACCGACACAGCAACGGCAGCGGCGGCGGCGGCGGCGACGACGAC   [989]
Bahadur          GCCGACACCGACACAGCAACGGCAGCGGCGGCGGCGGCGGCGACGACGAC   [989]
Pankaj           GCCGACACCGACACAGCAACGGCAGCGGCGGCGGCGGCGGCGACGACGAC   [989]
Bashful          GCCGACACCGACACAGCAACGGCAGCGGCGGCGGCGGCGGCGACGACGAC   [999]
Moircha          GCCGACACCGACACAGCAACGGCAGCGGCGGCGGCGGCGGCGACGACGAC   [989]
Joya             GCCGACACCGACACAGCAACGGCAGCGGCGGCGGCGGCGGCGACGACGAC   [989]
Basberoin        GCCGACACCGACACAGCAACGGCAGCGGCGGCGGCGGCGGCGACGACGAC   [999]
Ranga Borah      GCCGACACCGACACAGCAACGGCAGCGGCGGCGGCGGCGGCGACGACGAC   [989]
Mulahail         GCCGACACCGACACAGCAACGGCAGCGGCGGCGGCGGCGGCGACGACGAC   [989]
Guaroi           GCCGACACCGACACAGCAACGGCAGCGGCGGCGGCGGCGGCGACGACGAC   [989]
Mimutim          GCCGACACCGACACAGCAACGGCAGCGGCGGCGGCGGCGGCGACGACGAC   [989]
Harinarayan      GCCGACACCGACACAGCAACGGCAGCGGCGGCGGCGGCGGCGACGACGAC   [989]
Bherapawa        GCCGACACCGACACAGCAACGGCAGCGGCGGCGGCGGCGGCGACGACGAC   [999]
O. rufipogon     GCCGACACCGACACAGCAATGGCAGCGGCGGCGGCGGCGGCGACGACGAC   [999]

[                        1010      1020      1030      1040      1050]
[                           .         .         .         .         .]
Papue            CACCGTGTGGGCGCCCAAGGCCGTGCGGTGCACGCGCGGGTTCTTCTTCC   [1039]
Lahi             CACCGTGTGGGCGCCCAAGGCCGTGCGGTGCACGCGCGGGTTCTTCTTCC   [1049]
Joha             CACCGTGTGGGCGCCCAAGGCCGTGCGGTGCACGCGCGGGTTCTTCTTCC   [1049]
Local Basmati    CACCGTGTGGGCGCCCAAGGCCGTGCGGTGCACGCGCGGGTTCTTCTTCC   [1040]
Sorpuma          CACCGTGTGGGCGCCCAAGGCCGTGCGGTGCACGCGCGGGTTCTTCTTCC   [1039]
Kawanglawang     CACCGTGTGGGCGCCCAAGGCCGTGCGGTGCACGCGCGGGTTCTTCTTCC   [1049]
Borjahinga       CACCGTGTGGGCGCCCAAGGCCGTGCGGTGCACGCGCGGGTTCTTCTTCC   [1049]
Til Bora         CACCGTGTGGGCGCCCAAGGCCGTGCGGTGCACGCGCGGGTTCTTCTTCC   [1049]
Hati Hali        CACCGTGTGGGCGCCCAAGGCCGTGCGGTGCACGCGCGGGTTCTTCTTCC   [1049]
Ranjit           CACCGTGTGGGCGCCCAAGGCCGTGCGGTGCACGCGCGGGTTCTTCTTCC   [1039]
Kakiberoin       CACCGTGTGGGCGCCCAAGGCCGTGCGGTGCACGCGCGGGTTCTTCTTCC   [1039]
Aubalam          CACCGTGTGGGCGCCCAAGGCCGTGCGGTGCACGCGCGGGTTCTTCTTCC   [1039]
Balam            CACCGTGTGGGCGCCCAAGGCCGTGCGGTGCACGCGCGGGTTCTTCTTCC   [1049]
Borua Beroin     CACCGTGTGGGCGCCCAAGGCCGTGCGGTGCACGCGCGGGTTCTTCTTCC   [1050]
Lallatoi         CACCGTGTGGGCGCCCAAGGCCGTGCGGTGCACGCGCGGGTTCTTCTTCC   [1040]
IR8              CACCGTGTGGGCGCCCAAGGCCGTGCGGTGCACGCGCGGGTTCTTCTTCC   [1040]
Arfa             CACCGTGTGGGCGCCCAAGGCCGTGCGGTGCACGCGCGGGTTCTTCTTCC   [1039]
Bahadur          CACCGTGTGGGCGCCCAAGGCCGTGCGGTGCACGCGCGGGTTCTTCTTCC   [1039]
Pankaj           CACCGTGTGGGCGCCCAAGGCCGTGCGGTGCACGCGCGGGTTCTTCTTCC   [1039]
Bashful          CACCGTGTGGGCGCCCAAGGCCGTGCGGTGCACGCGCGGGTTCTTCTTCC   [1049]
Moircha          CACCGTGTGGGCGCCCAAGGCCGTGCGGTGCACGCGCGGGTTCTTCTTCC   [1039]
Joya             CACCGTGTGGGCGCCCAAGGCCGTGCGGTGCACGCGCGGGTTCTTCTTCC   [1039]
Basberoin        CACCGTGTGGGCGCCCAAGGCCGTGCGGTGCACGCGCGGGTTCTTCTTCC   [1049]
Ranga Borah      CACCGTGTGGGCGCCCAAGGCCGTGCGGTGCACGCGCGGGTTCTTCTTCC   [1039]
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Mulahail CACCGTGTGGGCGCCCAAGGCCGTGCGGTGCACGCGCGGGTTCTTCTTCC [1039]
Guaroi CACCGTGTGGGCGCCCAAGGCCGTGCGGTGCACGCGCGGGTTCTTCTTCC [1039]
Mimutim CACCGTGTGGGCGCCCAAGGCCGTGCGGTGCACGCGCGGGTTCTTCTTCC [1039]
Harinarayan CACCGTGTGGGCGCCCAAGGCCGTGCGGTGCACGCGCGGGTTCTTCTTCC [1039]
Bherapawa CACCGTGTGGGCGCCCAAGGCCGTGCGGTGCACGCGCGGGTTCTTCTTCC [1049]
O. rufipogon CACCGTGTGGGCGCCCAAGGCCGTGCGGTGCACGCGCGGGTTCTTCTTCC [1049]

[1060 1070 1080 1090 1100]
[. . . . .]
Papue ACGACCGTGAAACGGCGCCGCTCGCCGCGGCGGCGCCGGCGCCGGCAGGG [1089]
Lahi ACGACCGTGAAACGGCGCCGCTCGCCGCGGCGGCGCCGGCGCCGGCAGGG [1099]
Joha ACGACCGTGAAACGGCGCCGCTCGCCGCGGCGGCGCCGGCGCCGGCAGGG [1099]
Local Basmati ACGACCGTGAAACGGCGCCGCTCGCCGCGGCGGCGCCGGCGCCGGCAGGG [1090]
Sorpuma ACGACCGTGAAACGGCGCCGCTCGCCGCGGCGGCGCCGGCGCCGGCAGGG [1089]
Kawanglawang ACGACCGTGAAACGGCGCCGCTCGCCGCGGCGGCGCCGGCGCCGGCAGGG [1099]
Borjahinga ACGACCGTGAAACGGCGCCGCTCGCCGCGGCGGCGCCGGCGCCGGCAGGG [1099]
Til Bora ACGACCGTGAAACGGCGCCGCTCGCCGCGGCGGCGCCGGCGCCGGCAGGG [1099]
Hati Hali ACGACCGTGAAACGGCGCCGCTCGCCGCGGCGGCGCCGGCGCCGGCAGGG [1099]
Ranjit ACGACCGTGAAACGGCGCCGCTCGCCGCGGCGGCGCCGGCGCCGGCAGGG [1089]
Kakiberoin ACGACCGTGAAACGGCGCCGCTCGCCGCGGCGGCGCCGGCGCCGGCAGGG [1089]
Aubalam ACGACCGTGAAACGGCGCCGCTCGCCGCGGCGGCGCCGGCGCCGGCAGGG [1089]
Balam ACGACCGTGAAACGGCGCCGCTCGCCGCGGCGGCGCCGGCGCCGGCAGGG [1099]
Borua Beroin ACGACCGTGAAACGGCGCCGCTCGCCGCGGCGGCGCCGGCGCCGGCAGGG [1100]
Lallatoi ACGACCGTGAAACGGCGCCGCTCGCCGCGGCGGCGCCGGCGCCGGCAGGG [1090]
IR8 ACGACCGTGAAACGGCGCCGCTCGCCGCGGCGGCGCCGGCGCCGGCAGGG [1090]
Arfa ACGACCGTGAAACGGCGCCGCTCGCCGCGGCGGCGCCGGCGCCGGCAGGG [1089]
Bahadur ACGACCGTGAAACGGCGCCGCTCGCCGCGGCGGCGCCGGCGCCGGCAGGG [1089]
Pankaj ACGACCGTGAAACGGCGCCGCTCGCCGCGGCGGCGCCGGCGCCGGCAGGG [1089]
Bashful ACGACCGTGAAACGGCGCCGCTCGCCGCGGCGGCGCCGGCGCCGGCAGGG [1099]
Moircha ACGACCGTGAAACGGCGCCGCTCGCCGCGGCGGCGCCGGCGCCGGCAGGG [1089]
Joya ACGACCGTGAAACGGCGCCGCTCGCCGCGGCGGCGCCGGCGCCGGCAGGG [1089]
Basberoin ACGACCGTGAAACGGCGCCGCTCGCCGCGGCGGCGCCGGCGCCGGCAGGG [1099]
Ranga Borah ACGACCGTGAAACGGCGCCGCTCGCCGCGGCGGCGCCGGCGCCGGCAGGG [1089]
Mulahail ACGACCGTGAAACGGCGCCGCTCGCCGCGGCGGCGCCGGCGCCGGCAGGG [1089]
Guaroi ACGACCGTGAAACGGCGCCGCTCGCCGCGGCGGCGCCGGCGCCGGCAGGG [1089]
Mimutim ACGACCGTGAAACGGCGCCGCTCGCCGCGGCGGCGCCGGCGCCGGCAGGG [1089]
Harinarayan ACGACCGTGAAACGGCGCCGCTCGCCGCGGCGGCGCCGGCGCCGGCAGGG [1089]
Bherapawa ACGACCGTGAAACGGCGCCGCTCGCCGCGGCGGCGCCGGCGCCGGCAGGG [1099]
O. rufipogon ACGACCGTGAAACGGCGCCGCTCGCCGCGGCGGCGCCGGCGCCGGCAGGG [1099]

[1110 1120 1130 1140 1150]
[. . . . .]
Papue GAATTAGGAGACGGCGATGACGTCGACTGCGACTACTACTGCAGCGGCAG [1139]
Lahi GAATTAGGAGACGGCGATGACGTCGACTGCGACTACTACTGCAGCGGCAG [1149]
Joha GAATTAGGAGACGGCGATGACGTCGACTGCGACTACTACTGCAGCGGCAG [1149]
Local Basmati GAATTAGGAGACGGCGATGACGTCGACTGCGACTACTACTGCAGCGGCAG [1140]
Sorpuma GAATTAGGAGACGGCGATGACGTCGACTGCGACTACTACTGCAGCGGCAG [1139]
Kawanglawang GAATTAGGAGACGGCGATGACGTCGACTGCGACTACTACTGCAGCGGCAG [1149]
Borjahinga GAATTAGGAGACGGCGATGACGTCGACTGCGACTACTACTGCAGCGGCAG [1149]
Til Bora GAATTAGGAGACGGCGATGACGTCGACTGCGACTACTACTGCAGCGGCAG [1149]
Hati Hali GAATTAGGAGACGGCGATGACGTCGACTGCGACTACTACTGCAGCGGCAG [1149]
Ranjit GAATTAGGAGACGGCGATGACGTCGACTGCGACTACTACTGCAGCGGCAG [1139]
Kakiberoin GAATTAGGAGACGGCGATGACGTCGACTGCGACTACTACTGCAGCGGCAG [1139]
Aubalam GAATTAGGAGACGGCGATGACGTCGACTGCGACTACTACTGCAGCGGCAG [1139]
Balam GAATTAGGAGACGGCGATGACGTCGACTGCGACTACTACTGCAGCGGCAG [1149]
Borua Beroin GAATTAGGAGACGGCGATGACGTCGACTGCGACTACTACTGCAGCGGCAG [1150]
Lallatoi GAATTAGGAGACGGCGATGACGTCGACTGCGACTACTACTGCAGCGGCAG [1140]
IR8 GAATTAGGAGACGGCGATGACGTCGACTGCGACTACTACTGCAGCGGCAG [1140]
Arfa GAATTAGGAGACGGCGATGACGTCGACTGCGACTACTACTGCAGCGGCAG [1139]
Bahadur GAATTAGGAGACGGCGATGACGTCGACTGCGACTACTACTGCAGCGGCAG [1139]
Pankaj GAATTAGGAGACGGCGATGACGTCGACTGCGACTACTACTGCAGCGGCAG [1139]
Bashful GAATTAGGAGACGGCGATGACGTCGACTGCGACTACTACTGCAGCGGCAG [1149]
Moircha GAATTAGGAGACGGCGATGACGTCGACTGCGACTACTACTGCAGCGGCAG [1139]

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Joya            GAATTAGGAGACGGCGATGACGTCGACTGCGACTACTACTGCAGCGGCAG   [1139]
Basberoin       GAATTAGGAGACGGCGATGACGTCGACTGCGACTACTACTGCAGCGGCAG   [1149]
Ranga Borah     GAATTAGGAGACGGCGATGACGTCGACTGCGACTACTACTGCAGCGGCAG   [1139]
Mulahail        GAATTAGGAGACGGCGATGACGTCGACTGCGACTACTACTGCAGCGGCAG   [1139]
Guaroi          GAATTAGGAGACGGCGATGACGTCGACTGCGACTACTACTGCAGCGGCAG   [1139]
Mimutim         GAATTAGGAGACGGCGATGACGTCGACTGCGACTACTACTGCAGCGGCAG   [1139]
Harinarayan     GAATTAGGAGACGGCGATGACGTCGACTGCGACTACTACTGCAGCGGCAG   [1139]
Bherapawa       GAATTAGGAGACGGCGATGACGTCGACTGCGACTACTACTGCAGCGGCAG   [1149]
O. rufipogon    GAATTAGGAGACGGCGATGACGTCGACTGCGACTACTACTGCAGCGGCAG   [1149]

[                        1160      1170      1180      1190      1200]
[                           .         .         .         .         .]
Papue           CAGCTCGGCGGCGACGACGACGTCGTCGAGCTCATTACC-GGCGGTCGTC   [1188]
Lahi            CAGCTCGGCGGCGACGACGACGTCGTCGAGCTCATTACC-GGCGGTCGTC   [1198]
Joha            CAGCTCGGCGGCGACGACGACGTCGTCGAGCTCATTACC-GGCGGTCGTC   [1198]
Local Basmati   CAGCTCGGCGGCGACGACGACGTCGTCGAGCTCATTACC-GGCGGTCGTC   [1189]
Sorpuma         CAGCTCGGCGGCGACGACGACGTCGTCGAGCTCATTACC-GGCGGTCGTC   [1188]
Kawanglawang    CAGCTCGGCGGCGACGACGACGTCGTCGAGCTCATTACC-GGTGGTCGTC   [1198]
Borjahinga      CAGCTCGGCGGCGACGACGACGTCGTCGAGCTCATTACC-GGCGGTCGTC   [1198]
Til  Bora       CAGCTCGGCGGCGACGACGACGTCGTCGAGCTCATTACC-GGTGGTCGTC   [1198]
Hati Hali       CAGCTCGGCGGCGACGACGACGTCGTCGAGCTCATTACC-GGCGGTCGTC   [1198]
Ranjit          CAGCTCGGCGGCGACGACGACGTCGTCGAGCTCATTACC-GGCGGTCGTC   [1188]
Kakiberoin      CAGCTCGGCGGCGACGACGACGTCGTCGAGCTCATTACC-GGCGGTCGTC   [1188]
Aubalam         CAGCTCGGCGGCGACGACGACGTCGTCGAGCTCATTACC-GGCGGTCGTC   [1188]
Balam           CAGCTCGGCGGCGACGACGACGTCGTCGAGCTCATTACC-GGTGGTCGTC   [1198]
Borua Beroin    CAGCTCGGCGGCGACGACGACGTCGTCGAGCTCATTACC-GGCGGTCGTC   [1199]
Lallatoi        CAGCTCGGCGGCGACGACGACGTCGTCGAGCTCATTACC-GGCGGTCGTC   [1189]
IR8             CAGCTCGGCGGCGACGACGACGTCGTCGAGCTCATTACC-GGCGGTCGTC   [1189]
Arfa            CAGCTCGGCGGCGACGACGACGTCGTCGAGCTCATTACC-GGCGGTCGTC   [1188]
Bahadur         CAGCTCGGCGGCGACGACGACGTCGTCGAGCTCATTACC-GGCGGTCGTC   [1188]
Pankaj          CAGCTCGGCGGCGACGACGACGTCGTCGAGCTCATTACCCGGCGGTCGTC   [1189]
Bashful         CAGCTCGGCGGCGACGACGACGTCGTCGAGCTCATTACC-GGCGGTCGTC   [1198]
Moircha         CAGCTCGGCGGCGACGACGACGTCGTCGAGCTCATTACC-GGCGGTCGTC   [1188]
Joya            CAGCTCGGCGGCGACGACGACGTCGTCGAGCTCATTACC-GGCGGTCGTC   [1188]
Basberoin       CAGCTCGGCGGCGACGACGACGTCGTCGAGCTCATTACC-GGCGGTCGTC   [1198]
Ranga Borah     CAGCTCGGCGGCGACGACGACGTCGTCGAGCTCATTACC-GGCGGTCGTC   [1188]
Mulahail        CAGCTCGGCGGCGACGACGACGTCGTCGAGCTCATTACC-GGCGGTCGTC   [1188]
Guaroi          CAGCTCGGCGGCGACGACGACGTCGTCGAGCTCATTACC-GGCGGTCGTC   [1188]
Mimutim         CAGCTCGGCGGCGACGACGACGTCGTCGAGCTCATTACC-GGCGGTCGTC   [1188]
Harinarayan     CAGCTCGGCGGCGACGACGACGTCGTCGAGCTCATTACC-GGCGGTCGTC   [1188]
Bherapawa       CAGCTCGGCGGCGACGACGACGTCGTCGAGCTCATTACC-GGCGGTCGTC   [1198]
O. rufipogon    CAGCTCGGCGGCGACGACGACGTCGTCGAGCTCATTACC-GGCGGTCGTC   [1198]

[                        1210      1220      1230      1240      1250]
[                           .         .         .         .         .]
Papue           GAGCCGTGCTTCTCCGCCGGCGACGACTGGATGGACGACGTGAGAGCCTT   [1238]
Lahi            GAGCCGTGCTTCTCCGCCGGCGACGACTGGATGGACGACGTGAGAGCCTT   [1248]
Joha            GAGCCGTGCTTCTCCGCCGGCGACGACTGGATGGACGACGTGAGAGCCTT   [1248]
Local Basmati   GAGCCGTGCTTCTCCGCCGGCGACGACTGGATGGACGACGTGAGAGCCTT   [1239]
Sorpuma         GAGCCGTGCTTCTCCGCCGGCGACGACTGGATGGACGACGTGAGAGCCTT   [1238]
Kawanglawang    GAGCCGTGCTTCTCCGCCGGCGACGACTGGATGGACGACGTGAGAGCCTT   [1248]
Borjahinga      GAGCCGTGCTTCTCCGCCGGCGACGACTGGATGGACGACGTGAGAGCCTT   [1248]
Til Bora        GAGCCGTGCTTCTCCGCCGGCGACGACTGGATGGACGACGTGAGAGCCTT   [1248]
Hati Hali       GAGCCGTGCTTCTCCGCCGGCGACGACTGGATGGACGACGTGAGAGCCTT   [1248]
Ranjit          GAGCCGTGCTTCTCCGCCGGCGACGACTGGATGGACGACGTGAGAGCCTT   [1238]
Kakiberoin      GAGCCGTGCTTCTCCGCCGGCGACGACTGGATGGACGACGTGAGAGCCTT   [1238]
Aubalam         GAGCCGTGCTTCTCCGCCGGCGACGACTGGATGGACGACGTGAGAGCCTT   [1238]
Balam           GAGCCGTGCTTCTCCGCCGGCGACGACTGGATGGACGACGTGAGAGCCTT   [1248]
Borua Beroin    GAGCCGTGCTTCTCCGCCGGCGACGACTGGATGGACGACGTGAGAGCCTT   [1249]
Lallatoi        GAGCCGTGCTTCTCCGCCGGCGACGACTGGATGGACGACGTGAGAGCCTT   [1239]
IR8             GAGCCGTGCTTCTCCGCCGGCGACGACTGGATGGACGACGTGAGAGCCTT   [1239]
Arfa            GAGCCGTGCTTCTCCGCCGGCGACGACTGGATGGACGACGTGAGAGCCTT   [1238]
Bahadur         GAGCCGTGCTTCTCCGCCGGCGACGACTGGATGGACGACGTGAGAGCCTT   [1238]
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Pankaj          GAGCCGTGCTTCTCCGCCGGCGACGACTGGATGGACGACGTGAGAGCCTT   [1239]
Bashful         GAGCCGTGCTTCTCCGCCGGCGACGACTGGATGGACGACGTGAGAGCCTT   [1248]
Moircha         GAGCCGTGCTTCTCCGCCGGCGACGACTGGATGGACGACGTGAGAGCCTT   [1238]
Joya            GAGCCGTGCTTCTCCGCCGGCGACGACTGGATGGACGACGTGAGAGCCTT   [1238]
Basberoin       GAGCCGTGCTTCTCCGCCGGCGACGACTGGATGGACGACGTGAGAGCCTT   [1248]
Ranga_Borah     GAGCCGTGCTTCTCCGCCGGCGACGACTGGATGGACGACGTGAGAGCCTT   [1238]
Mulahail        GAGCCGTGCTTCTCCGCCGGCGACGACTGGATGGACGACGTGAGAGCCTT   [1238]
Guaroi          GAGCCGTGCTTCTCCGCCGGCGACGACTGGATGGACGACGTGAGAGCCTT   [1238]
Mimutim         GAGCCGTGCTTCTCCGCCGGCGACGACTGGATGGACGACGTGAGAGCCTT   [1238]
Harinarayan     GAGCCGTGCTTCTCCGCCGGCGACGACTGGATGGACGACGTGAGAGCCTT   [1238]
Bherapawa       GAGCCGTGCTTCTCCGCCGGCGACGACTGGATGGACGACGTGAGAGCCTT   [1248]
O. rufipogon    GAGCCGTGCTTCTCCGCCGGCGACGACTGGATGGACGACGTGAGAGCCTT   [1248]

[                         1260      1270      1280      1290   ]
[                            .         .         .         .   ]
Papue           GGCGTCGTTTCTTGACACCGACGACGCCTGGAACTTGTGTGCGTGA   [1284]
Lahi            GGCGTCGTTTCTTGACACCGACGACGCCTGGAACTTGTGTGCGTGA   [1294]
Joha            GGCGTCGTTTCTTGACACCGACGACGCCTGGAACTTGTGTGCGTGA   [1294]
Local Basmati   GGCGTCGTTTCTTGACACCGACGACGCCTGGAACTTGTGTGCGTGA   [1285]
Sorpuma         GGCGTCGTTTCTTGACACCGACGACGCCTGGAACTTGTGTGCGTGA   [1284]
Kawanglawang    GGCGTCGTTTCTTGACACCGACGACGCCTGGAACTTGTGTGCGTGA   [1294]
Borjahinga      GGCGTCGTTTCTTGACACCGACGACGCCTGGAACTTGTGTGCGTGA   [1294]
Til Bora        GGCGTCGTTTCTTGACACCGACGACGCCTGGAACTTGTGTGCGTGA   [1294]
Hati_Hali       GGCGTCGTTTCTTGACACCGACGACGCCTGGAACTTGTGTGCGTGA   [1294]
Ranjit          GGCGTCGTTTCTTGACACCGACGACGCCTGGAACTTGTGTGCGTGA   [1284]
Kakiberoin      GGCGTCGTTTCTTGACACCGACGACGCCTGGAACTTGTGTGCGTGA   [1284]
Aubalam         GGCGTCGTTTCTTGACACCGACGACGCCTGGAACTTGTGTGCGTGA   [1284]
Balam           GGCGTCGTTTCTTGACACCGACGACGCCTGGAACTTGTGTGCGTGA   [1294]
Borua Beroin    GGCGTCGTTTCTTGACACCGACGACGCCTGGAACTTGTGTGCGTGA   [1295]
Lallatoi        GGCGTCGTTTCTTGACACCGACGACGCCTGGAACTTGTGTGCGTGA   [1285]
IR8             GGCGTCGTTTCTTGACACCGACGACGCCTGGAACTTGTGTGCGTGA   [1285]
Arfa            GGCGTCGTTTCTTGACACCGACGACGCCTGGAACTTGTGTGCGTGA   [1284]
Bahadur         GGCGTCGTTTCTTGACACCGACGACGCCTGGAACTTGTGTGCGTGA   [1284]
Pankaj          GGCGTCGTTTCTTGACACCGACGACGCCTGGAACTTGTGTGCGTGA   [1285]
Bashful         GGCGTCGTTTCTTGACACCGACGACGCCTGGAACTTGTGTGCGTGA   [1294]
Moircha         GGCGTCGTTTCTTGACACCGACGACGCCTGGAACTTGTGTGCGTGA   [1284]
Joya            GGCGTCGTTTCTTGACACCGACGACGCCTGGAACTTGTGTGCGTGA   [1284]
Basberoin       GGCGTCGTTTCTTGACACCGACGACGCCTGGAACTTGTGTGCGTGA   [1294]
Ranga Borah     GGCGTCGTTTCTTGACACCGACGACGCCTGGAACTTGTGTGCGTGA   [1284]
Mulahail        GGCGTCGTTTCTTGACACCGACGACGCCTGGAACTTGTGTGCGTGA   [1284]
Guaroi          GGCGTCGTTTCTTGACACCGACGACGCCTGGAACTTGTGTGCGTGA   [1284]
Mimutim         GGCGTCGTTTCTTGACACCGACGACGCCTGGAACTTGTGTGCGTGA   [1284]
Harinarayan     GGCGTCGTTTCTTGACACCGACGACGCCTGGAACTTGTGTGCGTGA   [1284]
Bherapawa       GGCGTCGTTTCTTGACACCGACGACGCCTGGAACTTGTGTGCGTGA   [1294]
O. rufipogon    GGCGTCGTTTCTTGACACCGACGACGCCTGGAACTTGTGTGCGTGA   [1294]
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