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Original Research Article

Evaluation of Aromatic Short Grain Rices (*Oryza sativa* L.) Under Direct Seeding for Yield and Yield Components

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ABSTRACT

Aromatic rices constitute a small but an important sub-group of rice which are rated best in quality and fetch much higher price than high quality non-aromatic rice in international market. The present study aimed at evaluation of two hundred thirty seven aromatic short grain rices for yield and yield components under direct seeded condition. Detailed characterization for pest and disease was taken up under controlled conditions. Wide range of variability was recorded for all the components. The genotypes Seetabhog, Shukla Phool, Maguraphulla, RAU 3043, Barang, Dubraj (Raipur), Kali Muchhi, Munibhog, Krushnabhog and Champaran Basmati 2 were identified to be promising for yield under direct seeding. Ganjeikalli, Nagri Dubraj and Kalikati were found to be promising for pest and disease and pest resistance. This diverse aromatic short grain germplasm provides the raw material both for crop breeding to enhance productivity. Direct seeding of rice can be a potential option for better water use and high tolerance to water deficit condition and less cost of production.

Introduction

Rice (*Oryza sativa* L. 2n=24) belongs to the family, Graminae and sub family Oryzoidea and is one of the very few crop species endowed with rich genetic diversity which account over 100,000 landraces and improved cultivars. Genetic diversity is one of the most important factors with respect to crop improvement efforts. It plays a crucial role in progress and success of modern agriculture. Ever since the very beginning of agriculture (more than 10000 years ago) during the process of domestication and cultivation of crop plants, a wealth of genetic diversity has been utilized and partly preserved. Characterization and quantification of genetic diversity has long been a major goal in evolutionary biology. It is estimated that not even 15 % of the potential diversity has been utilized. Thousands of valuable allelic variations of traits of economic significance remain unutilized in nearly all crop plants. Though rice has become one of the most researched crops with wealth of scientific literature on all its aspects and endowed with rich diversity of landraces, the emphasis laid on the study of the valuable landraces is still meagre. Aromatic rices constitute a small but an important sub-group of rice. These are rated best in quality and fetch much higher price than high quality non-aromatic rice in international market thus making an important commercial commodity. It is more preferred by the consumers all over the world because of its scent and palatability. India has a wealth of specialty rices, the prominent among them are the aromatic rices including both basmati and the short grain indigenous types (local land race type) which have become part of our heritage and are considered as national treasure. In addition to long grain rices, the other short and medium scented rices are grown in India for centuries and the ancient texts and treatises have abundant references to the enormous scented rice diversity. Almost every state in India has its own collection of non-basmati short and medium grain aromatic rices. Many of these aromatic short grain rices cultivation is limited to small areas in specific locations mainly in Uttar Pradesh, Bihar, Orissa, West Bengal, Assam, Chhattisgarh, Madhya Pradesh, Maharashtra and also in other states. Farmers still seem to grow these cultivars mainly for domestic consumption despite being aware of their poor productivity and limited markets. These are generally consumed locally and are widely used for making kheer (sweet rice) for religions and festive occasions. These aromatic rices constitute an important source of genetic variation for utilization in breeding of high yielding aromatic rice varieties and hybrids. They are also adapted to local conditions in areas where in non-basmati grown areas and have very strong aroma under the prevailing warmer climate during grain maturity period. But, unfortunately, these valuable gifts of nature have somehow not got the necessary attention of rice scientists and traders, including exporters, to the extent that Basmati has commanded. As a result in the last several years many valuable aromatic rice varieties have either disappeared or are in the process of disappearing which needs to be addressed to conserve, characterize as well as utilize these valuable genetic resources in various rice breeding programmes. Further, very little information is available on the genetic diversity of indigenous short grained aromatic rice. Most of the information we have so far are about common varieties and our knowledge on aromatic rices is still at its nascent stage in spite of their outstanding quality like aroma and taste. Therefore, it is highly necessary not only to conserve the landrace genotypes but also to investigate the gene-pool of aromatic rice for breeding purposes of high yielding varieties in the country (Rabbani *et al.,* 2008). Aromatic short grain genotypes were mostly landraces with long growth duration, photoperiod sensitive, with low yield with susceptibility to lodging. As there was not much organized breeding work undertaken on the small and medium grain scented rices, concerted research efforts are needed to harness their potential to ensure better quality seeds and improved yields.

In addition, rice is the greatest consumer of water among all crops and consumes about 80% of the total irrigated fresh water resources in Asia. Water and soil are the prime natural resources that must be managed efficiently and effectively for sustainable agriculture and crop productivity. The global water scarcity analysis has revealed that up to two-third of world population will be affected by water scarcity over the next several decades (Wallace and Gregory, 2002). By 2025, 15 out of 75 million hectare of Asia's flood-irrigated rice crop will experience water shortage (Tuong and Bouman 2003). Decreasing water availability for agriculture threatens the productivity of irrigated rice ecosystem. Alternatives to the conventional flooded rice cultivation need to be developed world wide to reduce water consumption and produce more rice with less water (Belder *et al.*, 2004; Bouman, 2007; Bouman *et al.*, 2007). Many farmers are shifting from transplanting to direct sowing (Erguiza *et al.*, 1990). Conventional crop establishment practice in rice involves manual transplanting of rice in puddled soil developed through excessive tillage which in turn is a high energy consumption activity. Rice transplanting is a time consuming, labour intensive and arduous operation which is about 25 % of the total labour requirement for the crop production. Moreover, increasing energy prices, limited water and labour availability for transplanting necessitates farmers as well as researchers to develop alternate production systems for rice. Genetic improvement is one of the most efficient approaches to develop rice cultivars suited to conservation agriculture based technologies. Almost no varietal selection and breeding efforts have been made for developing rice cultivars amenable to resource conservation technologies suitable for alternate tillage and establishment methods, especially in unpuddled or reduced/zero-tillage soil conditions with direct seeding (Dry-DSR) in Asia (Fukai, 2002; Lafitte *et al.*, 2002, Weerakoon *et al.*, 2011). Rice grown in irrigated environments has been well adapted to contribute to high and stable yields. The varieties developed for conventional tillage system do not necessarily have the same performance and specific genotypes are recommended for no-till system (Yang and Baker, 1991). Therefore, some of the genotypes developed for irrigated rice ecosystem may perform well under direct seeding but may not necessarily have the same performance when subjected to conservation practices. For such cropping system, vigorous modern rice cultivars are increasingly required, which would not only facilitate rapid seedling establishment under a wide range of field conditions but also have increased competitive ability against weeds. Germplasm provides the base material for crop improvement. Understanding the nature and extent of the variation for yield and yield components would facilitate improvement by mobilizing the heritable variation through hybridization. The present study consisted of aromatic short grains rices which are very popular for their quality and yield but not evaluated for their performance for yield and yield components under direct seeded conditions in an attempt to identify elite lines with superior adaptation to direct seeded conservation agriculture technologies.

Materials and Methods

Field evaluation of Aromatic rices under direct seeding

The experimental material consisted of two hundred and thirty seven indigenous aromatic short grain land races collected from IGAU, Raipur, RAU Pusa, NDUAT, Faizabad and OUAT, Bhubaneswar are being maintained in working germplasm at Indian Institute of Rice Research (formerly DRR), Hyderabad. All the accessions were grown under dry direct seeded condition during wet season 2012 at Ramachandrapuram farm, ICRISAT campus in augmented blocks. The experimental field was dry ploughed and levelled properly. Dibbling of paddy seeds was done with a spacing of 20 cm between rows and within the row the approximate spacing of 15cm was maintained. Thinning of the plants after germination was taken up to maintain the required population and spacing. Application of pre-emergence herbicide pendimethalin 30 EC was applied during 4th to 8th day after sowing. The soil moisture was maintained to field capacity. Irrigations were scheduled accordingly to maintain the soil moisture to field capacity when the cracks were observed in the soil. The data on days to 50% flowering yield components and yield as well over all phenotypic performance of the genotypes was recorded. Detailed characterization for insect and pests and disease resistance also was done. For insect pests and diseases, Standard Evaluation System (SES) as recommended by IRRI, 1996 was followed. Among the 237 aromatic short grain rices screened under direct seeding, about 30 genotypes were failed either during crop emergence or establishment or consisted of incomplete field data. Hence these genotypes were deleted from final analysis. In total data for 207 aromatic rices were available under field evaluation of direct seeding. Further, these genotypes were also screened for disease and pest resistance through artificial inoculation in greenhouse conditions at IIRR. Since there are no appropriate checks for direct seeded conditions, replication of checks in each block was not done and all the genotypes were evaluated in blocks taking care of the soil heterogeneity and randomization. All the observations in field were recorded on five random representative plants and mean value was computed to record data on quantitative parameters (Table 1. The descriptive statistics of mean, standard deviation, variance and range were analysed using SAS 9.1 software.

Screening for insect pests and disease resistance

All the ASG genotypes were screened for major pests and diseases under field (Stem borer) as well as glass house condition (Brown plant hopper / White backed Planthopper, Gall midge, Leaf Blast (Blast nursery) and Bacterial Leaf Blight) as per the standard methodology. The score and symptoms of disease and pest reaction is presented in Table 2. To identify promising genotypes for stem borer in short grain aromatic rices, natural incidence of stem borer as per cent white ear damage under field conditions was recorded from 20 plants each during *Kharif* 2012. The mean white ear (WE) damage was converted to damage score on 0-9 scale (SES, 1996).

Results and Discussion

Performance of aromatic short grain rices

Estimates of mean, standard deviation and range for days to 50 % flowering, plant height (cm), panicle length (cm), productive tillers and yield (kg ha^{-1}) among the aromatic short grain rices were presented in the Table 3 and frequency distribution for pest and diseases among these genotypes is presented in Figure 1. Direct seeding of rice can be a potential option for faster, easier planting and reduced labour requirement. Direct seeding conditions followed by non-flooding of the field create an aerobic condition of soil. The characters suited for irrigated transplanting conditions might be different for dry aerobic conditions. The results indicated differential response of aromatic rices under direct seeded conditions. Based on the performance of aromatic rice genotypes under direct seeded conditions, early emergence and establishment coupled with high seedling vigour is the prime important character in the initial phases of crop establishment. In the present study as well differential response to early emergence and establishment was observed (data not presented). Some of the genotypes viz., RAU 3043, Dubraj, Shulka Phool etc., exhibited speedy emergence and establishment while, the genotypes like Kalajeevan, Bishnu Bhog, ASGPC-14, Sheetalkani, Koli Joha, Kapoor Chinni etc., exhibited very poor establishment of the crop under direct seeding. Further, the genotypes viz., Kalajira, Keasr, Heera Kani, Jalaka, Tenduphool etc, although germinated and established initially stage, they failed to survive till maturity and hence they are deleted from final analysis. In the present study, the plant height ranged from 77.6cm (IGSR-2-1-6) to 164.0 cm (Bhatagundi) with an average of 120.7 cm. Most of the genotypes were semi-tall to tall plant statured plant height (cm) is one of the important characteristic under direct seeding (Fukai, 2002).

Unlike the irrigated ecosystem where semi-dwarf stature is preferred, semi-tall stature is beneficial because in the initial stages of crop establishment, a heavy competition between weeds and rice exists (Garrity *et al.*, 1992; Jannink *et al.*, 2000; Zao *et al.*, 2006). Hence, in such a situation, semi-tall plant type with strong culm and robust root system is found to be more weed suppressive than a dwarf statured plant type which tends to remain stunted leading to poor performance.

Days to 50% flowering varied from 79 days (Kapoor Chini & Moongphali-B) to120 days (Magura & Lectimachi) with mean of 101 days. About nine genotypes recorded early heading (71-90 days to 50% flowering), 56 entries with medium heading (91-110 days to 50 % flowering and rest of the 142 entries were of late heading duration (111-130 days to 50% flowering). Under direct seeded conditions the duration of entries will be reduced at least by 7-10 days a seeds are directly dibbled and there is no transplantation shock recovery. Generally these aromatic short grain rices are land races and are late in duration. Even in the present study most of the genotypes are of late duration. However some of the genotypes exhibited <90 days to 50% flowering and up to 110 days. These genotypes can be utilized in the breeding programmes for developing lines with early and medium duration that can fit into the cropping systems.

With respect panicle length, large variation among the genotypes was observed. It ranged from 17.6 cm (Rajin 7) to 29.8 cm (Chini Kapoor) with an average of 23.9 cm Only 10 genotypes short panicle (16- 20 cm), 163 genotypes recorded medium panicles (21-25cm) and 34 genotypes recorded long panicles (>25cm). In addition to panicle length, wide diversity also existed for grain number, hull colour (data not furnished). Tiller number per hill is another important parameter under direct seeded conditions (Fischer *et al.*, 1997). In the present study, productive tillers per hill varied from 5 to 17 with a mean of 9 tillers per hill. Under aerobic conditions, there will not be any flooding in the field and so the suppression of unproductive tillers will not happen. Under transplanted conditions, tillering is delayed due to transplantation shock and the maximum tillering stage, the water level is maintained to suppress the unproductive tillering or delayed tillers which do not bear panicle. In direct seeding, excessive tillering at an early stage could result in reduced leaf biomass and photosynthesis at a later stage and eventually become one of the major reasons for lower yields. The genotypes with more productive tillers with an ability to suppress unproductive tillers after tillering phase is an important character required under direct seeding. In the present study, some of the genotypes are very robust in tillering ability which could able to produce more than 15 tillers and are highly productive.

Table.1 Measurement of agronomic and physiological characters

Character	Group
Time of heading (50% of plants with panicles)	Very early (<71 days) Early (71-90 days) Medium (91-110 days) Late (111-130 days) Very late (> 131 days)
Plant Height (cm)	Semidwarf (< 90 cm) Intermediate (90-125 cm) Tall (> 125 cm)
Panicle: Length of main axis (cm)	Very short (<16 cm) Short (16-20 cm) Medium (21-25 cm) Long (26-30 cm) Very long (>30 cm)
Panicle: Number plant^{-1} (Number of productive tillers)	Few (<11) Medium (11-20) Many (>20)

Table.2 Score and symptoms of the reaction to insect pests and diseases

Brown planthopper / Whitebacked planthopper (Glass house)		Stem borer (Field Screening)	
Damage Score	Reaction	Damage Score	Reaction
0	No damage	0	No damage
1	Very slight damage	1	1 - 5%
3	Lower leaf wilted with two green upper leaves	3	6 - 10%
5	Two lower leaves wilted with one green upper leaf	5	11 - 15%
7	All three leaves wilted but stem still green	7	16 - 25%
9	Plants dead	9	> 25%
Gall midge (Glass house)			
Percent plant damage	Reaction	% plant damage	Reaction
< 10%	Resistant	> 10%	Susceptible

Cont.,

Leaf Blast (Blast nursery)		Bacterial Leaf Blight (Glass house)	
Score	Symptoms	Score	Lesion area
0	No lesions	1	0 - 3%
1	Small brown specks of pin head size without sporulating centers	2	4 - 6%
2	Small round to slightly elongated, nercitic grey spots, about 1-2 mm in diameter with a distinct brown margin region and lesions were mostly found on the lower side	3	7 - 12%
3	Lesion type is the same as in scale 2, but significant number of lesions were on the upper side	4	13 - 25%
4	Typical sporulating blast lesions, 3 mm or longer, infecting less than 2% of the leaf area	5	26 - 50%
5	Typical sporulating blast lesions, infecting 2-10% of the leaf area	6	51 - 75%
6	Blast lesions infecting 11-25% of the leaf area	7	76 - 87%
7	Blast lesions infecting 26-50% of the leaf area	8	88 - 94%
8	Blast lesions infecting 51-75% of the leaf area	9	95 - 100%
9	More than 75% leaf area affected		

Table.3 Descriptive statistics of aromatic short grain rices under direct seeding for yield and yield components

Parameter	Days to 50% flowering	Plant Height (cm)	Panicle Length (cm)	Productive Tillers	Yield (Kg ha^{-1})
Min	79.0	77.6	17.6	5.0	107.1
Max	120.0	164.0	24.2	17.0	5107.1
Mean	101.5	120.7	23.9	8.8	2191.0
Std. error	0.5	1.2	0.4	0.1	76.3
Variance	46.6	298.2	29.1	4.3	1217568
Coeff. var	6.7	14.3	22.1	23.5	50.4
Stand. dev	6.8	17.3	5.4	2.1	1103.4
Median	102.0	123.2	24.2	8.0	2214.3
Skewness	-0.5	-0.3	10.5	1.1	0.2
Kurtosis	0.7	-0.7	136.4	1.8	-0.6
Geometric mean	101.2	119.4	24.0	8.6	1826.7

Table.4 Promising aromatic short grain rices resistant to more than one pest/disease

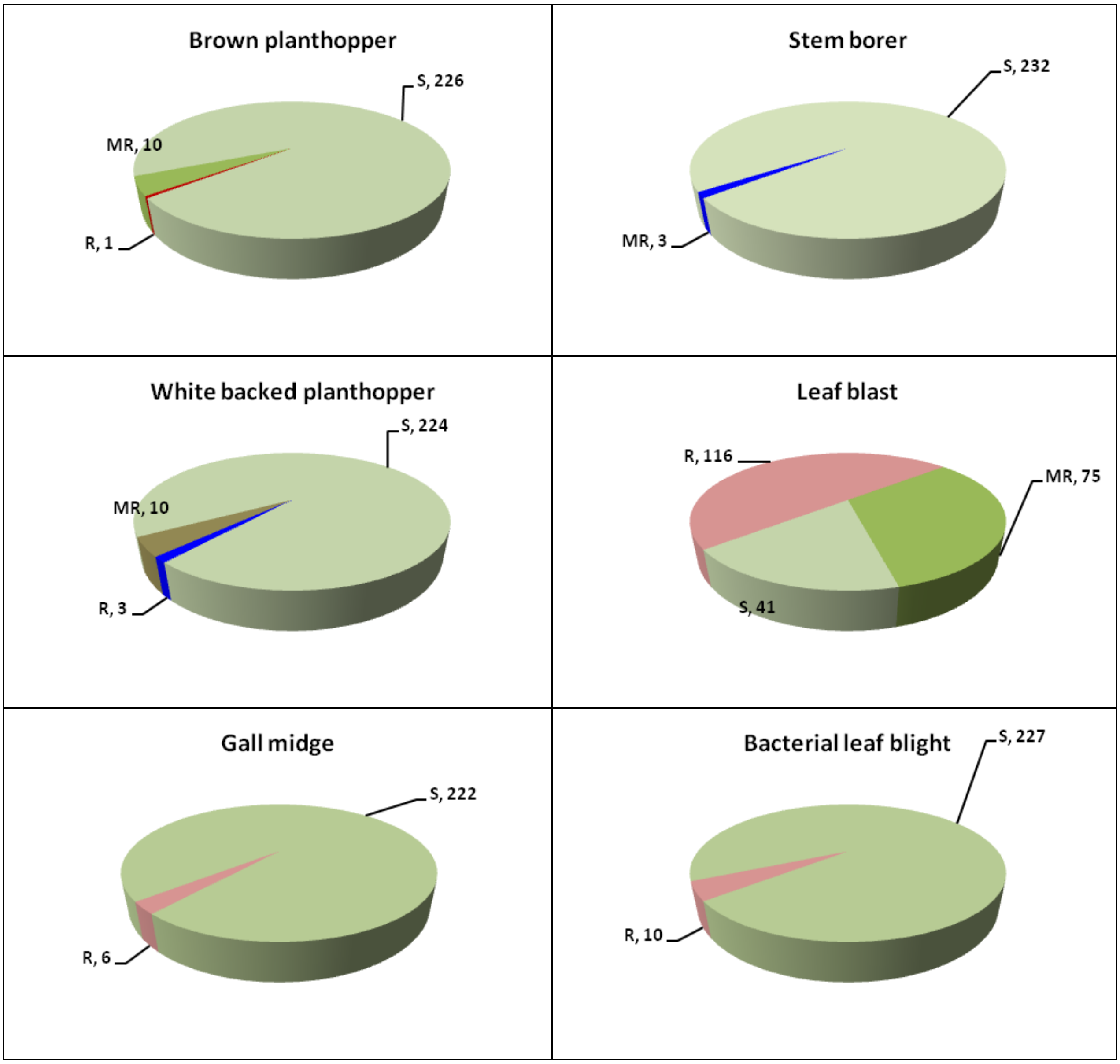
Name	Resistant to	Name	Resistant to
Basmati	BPH,GM4,BL	Dubraj (Raipur)	BPH, BL
Ganjeikalli	BPH,WBPH, BL	Kopusali joha	BPH, BL
Nagri Dubraj	BPH, WBPH, BLB	Kalakanhu	GM 4, BL
Kalikati	WBPH, BL, BLB	Kalajira	GM 4, BL
Karnal Local B	BPH,GM4,BL	Muhulakuchi	BLB, BL
Jiraphool	WBPH, BL	Chebdra Chhal	BLB, BL
Hankesh	WBPH, BL	Dhanprasad	BLB, BL
Neelabati	WBPH, BL	R 1462-243-100-7-1-1	BLB, BL
Barikunja	BPH, BL	Konbogi Joha	BLB, BL
Kataribhog	BPH, BL		

BPH: brown planthopper, WBPH: white backed planthopper, GM: gall midge, BLB: bacterial leaf blight, BL: blast

Table.5 Promising aromatic short grain rice genotypes under direct seeding condition

Genotype	Days to 50% flowering	Plant Height (cm)	Panicle Length (cm)	Productive Tillers	Yield (Kg ha^{-1})
Seetabhog	104	122.2	23.2	16	5107
Shukla Phool	91	123.6	24.6	16	4892
Maguraphulla	104	129	24.4	10	4785
RAU 3043	91	107.4	24.8	9	4750
Barang	92	128.6	27.6	8	4535
Dubraj (Raipur)	106	96.4	19	6	4357
Kali Muchhi	91	128.6	27.8	8	4178
Munibhog	105	109.2	21.6	8	4178
Krushnabhoga	89	97.4	25.2	8	4142
Champaran Basmati 2	104	118.6	25	7	4071
Chini Kapoor	93	148.6	29.8	12	3928
Manasi	90	94.4	24.4	8	3892
Chhatri Bhog	105	106.8	19.2	9	3892
Malaysia	109	103	22.2	10	3857
Rajin 12	106	109	19	9	3821
Dudaga	106	112.4	21.2	10	3785
Rajin 7	106	99.8	17.6	9	3785
Kanikabhog	107	127	24.6	8	3714
Tulsi Prasad	106	133.6	23.2	11	3607
Kalanamak (Birdpur)	105	109.2	21.8	12	3607

Fig.1 Frequency distribution for insect pests and diseases



With respect to yield under direct seeded conditions, it varied from 107 kg/ha (Kon Joha 1) to 5107 kg ha^{-1} (Seetabhog) with a mean yield of 2191kg ha^{-1}. Some of the genotypes totally failed to perform under direct seeded conditions while other genotypes survived till maturity. About 20 genotypes recorded mean yield between 3.5 kg ha $^{-1}$ to 5.0 kg ha^{-1} indicating that there is potential to realize better yields even under direct seeded conditions (Table 5). Based on evaluation of aromatic short grain rices under direct seeded conditions, large variation for the characters measured was observed and many of the genotypes could serve as potential donors for various traits of improvement (Belder *et al.*, 2004). However, low frequency of the entries moderately resistant / resistant to biotic stresses is recorded. These include 9 for brown plant hopper, 13 for white backed plant hopper, 7 for gall midge, 3 for stem borer, 36 for leaf blast and 8 for bacterial leaf blight (Table 4). Similarly top performing accessions were also identified and presented in Table 5. The information would be useful to breeders for use in the genetic improvement programmes on aromatic short grain rices in India.

Direct seeding of rice can be a potential option for faster and easier planting, reduced labour requirement and drudgery, early maturity, better water use and high tolerance to water deficit condition and less cost of production. Most of aromatic short grain cultivars are traditional rice varieties which have tall stature, low yield, photoperiod-sensitivity, susceptible to disease and pest and unresponsive to fertilizer. However, due to the pleasant and unique flavour and some other dominant grain quality characteristics, this is the important resource for breeding and improving the aromatic short grain rice cultivars for diverse demands of consumers in the world. The present study documented the genetic variability among these aromatic short grain rices which are very valuable genetic resources. This diverse aromatic short grain germplasm provides the raw material both for crop breeding to enhance productivity and for attempts to diversify the use of these rices, into a range of higher-value products that can help to lift the producers and their communities out of poverty. There is also a wide scope to create market for these speciality rices in other countries as well.

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