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Traditional land races of rice in Karnataka: Reservoirs of valuable traits

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Traditional land races are important reservoirs of valuable traits and need special attention for future conservation. More than 50% of rainfed rice in Karnataka is under traditional rice, thus sheltering a potential genetic diversity. Drought stress is the major limiting factor for rice production and yield stability under rainfed regions. Diversity was evident in our traditional variety collection, which was more so in Uttara Kannada district. It possesses valuable traits, viz. medicinal properties, nutrition, taste, aroma, tolerance to drought and submergence, and other special uses. Majority of traditional varieties in rainfed uplands tolerate moisture stress and possess strong root system under field conditions. Land races, Dodiga and Navalisali in early and medium maturity groups respectively, were found significantly superior for yield and productivity traits under varied moisture stress situations over three years. Hence these land races are identified as good donors for drought tolerance in future breeding programmes.

Keywords: Diversity, drought tolerance, land races, rice, speciality traits.

RICE is the staple food of 70% of the Indian population, being cultivated on an area of 42 m ha under varying agroclimatic conditions of the country. The versatility in climate, soil, topography and method of cultivation in Karnataka has made the state a source of diversity in rice. In spite of the introduction of many high-yielding modern rice varieties, some land races are still popular in the farmers' fields in sizable areas under rainfed drill-sown situations of Karnataka due to their unique qualities. Land races are highly adapted to the regions and also have special uses[1] and varying levels of resistance to biotic and abiotic stresses[2]. Some of the land races cultivated in the rainfed ecosystem are on the verge of extinction owing to their long duration, low yield potential and susceptibility to pests and diseases. However, traditional varieties are important reservoirs of valuable traits and need special attention for future conservation. Rice is grown over an area of 1.45 m ha in Karnataka and direct seeding is practised in about 15% of the area[3]. Here, around 44% of the total area is under irrigation, while the rest is under the regime of the monsoon. Drill sowing of rice under rainfed condition is being practised in the Western Ghats area of Karnataka, covering the districts of Belgaum, Dharwad, Haveri, Uttar Kannada and pockets of Bijapur and Bidar. More than 50% of this area is under traditional rice[4], thus sheltering a potential genetic diversity that needs to be explored and conserved.

Drought stress is the major limiting factor for rice production and yield stability under rainfed regions, affecting 19.0 m ha of upland and over 14.0 m ha of rainfed lowland rice[5]. Rice cultivation in the rainfed drill-sown situation in Karnataka faces high risk of moisture stress at maximum tillering and reproductive stages, which may lead to yield loss of 25–100%. Most of the high-yielding varieties (HYV) developed so far are not bred specifically for drought situations. In this context, the present investigation was carried out to collect land races of rainfed ecosystem of northern Karnataka and to evaluate them for drought tolerance, which is the present-day need of mankind in view of water crises.

The survey was conducted in all rice-growing districts of northern Karnataka. The contributing farmers were approached, and information on personal and location details was gathered. Details on each accession regarding their uses and special features were collected and documented along with seeds from the respective farmers.

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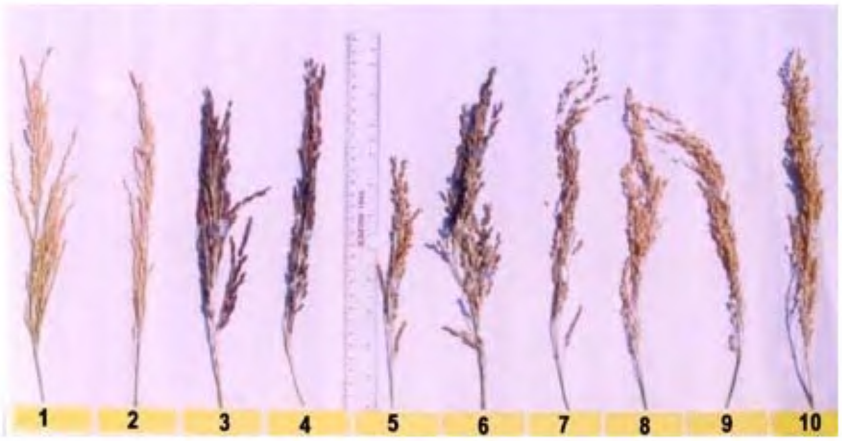

Figure 1. Panicle diversity among land races. 1, Mugad Sugandha; 2, Pusa Basmati; 3, Kagisali; 4, Karigajavile; 5, Yalakkisali; 6, Huggibhatta; 7, Beeraga; 8, Ambemohr; 9, Jeerigesanna and 10, Gandhasali.

Sixteen early and 18 medium-duration local varieties collected from the rainfed rice region were evaluated along with HYV checks under rainfed drill-sown conditions during *kharif* 2001–03, in target environment at the Agricultural Research Station, Mugad, Karnataka. The moisture stress was severe at vegetative (2001), reproductive (2002) and moderate stress at both stages (2003) in different growing seasons. This provided an opportunity to critically assess drought tolerance and productivity under moisture stress. The genotypes were grown by direct seeding in two rows of 4 m in randomized block design with two replications. Observations on days to 50% flowering, plant height, panicle length, panicle weight and per cent spikelet fertility were recorded. The leaf drying score was recorded according to the standard evaluation system developed by IRRI[6] during vegetative stage stress (2001). For observations on root traits, five random plants in each genotype were uprooted at 50 days after sowing during *kharif* 2003. The crop was exposed to 25 days of drought spell under field conditions before sampling. The experimental plot was soaked overnight and plants were uprooted along with soil clump to avoid root damage. Root length and root dry weight were recorded as average of five plants after gentle wash and complete drying. Year-wise and pooled analyses of productivity traits have been done using MSTATC software.

Collection of land races of rice and information on traditional knowledge gathered from the farmers revealed the enormous diversity in traditional varieties. The diversity in panicle size, shape and colour among land races is depicted in Figure 1. Uttar Kannada harboured maximum diversity of rice, which is evident by collection of the highest number of land races (52 out of 100 collected) from that location (Table 1). The region has traditional varieties with diversified uses, including few slender-grained aromatic rice varieties, which are preferred by local people to prepare sweet dishes. Thus farmers prefer growing land races due to their unique uses to cater to local needs. Earlier reports on documentation of few land races of Karnataka are available[7], which indicate that the cultivation of Dodiga, Hakkalasali and Antarsali prevailed a long time ago in Dharwad District. Researchers have already documented and improved a few land races, viz. Dodiga, Waner[8], Kagisali[9] and Antarsali[10]. However, there is a need for further exploration in this area as well as detailed studies on their special uses for further improvement.

Few land races collected are known to possess medicinal properties, viz. Chitiga, Honasu, Karikalavi, Karigajavile and Karibhatta (Table 2). Karikalavi and Karigajavile collected from Bidar and Belgaum districts respectively, are specially fed to lactating mothers and this is a routine practice in rural areas of these districts. Dambersali (Figure 2) and Nyareminda help to weed out plots due to their purple plants. Land races with purple-coloured base like Antarsali and Navalisali are also useful for this purpose. These varieties are grown in alternate years to facilitate rouging off-types, wild rices and help in easy identification of weed species, *Echinichloa*, which cannot be differentiated in the early stage of the crop[10]. Some of the traditional varieties collected are adapted to specific rice-growing situations like water submergence, flood and drought. Karibhatta and Neerguli are best suited for water submergence and flash flood-prone areas.

Majority of traditional varieties grown by farmers in the rainfed uplands are known to tolerate moisture stress and yield better even under adverse situations. During the survey, 16 different drought-tolerant land races were collected from upland ecosystem of Karnataka. Some of these drought-tolerant accessions, viz. Dodiga, Navalisali, Antarsali and Udarsali are also observed to have good early vigour and are tolerant to low fertility. As moisture stress is the major constraint in rainfed condition, land races were characterized in detail for drought tolerance at our research centre.

Table 1. Distribution of rice land races in northern Karnataka

District	Agro-ecological zone*	No. of land races collected	Land race
Bidar	1	5	Ratansagar, Bile kalavi, Parimala kalavi, Karikalavi, Mullukalavi
Bijapur	3	3	Kempunellu, Bilinellu, Sindagi local
Belgaum	9	14	Medumsali, Shankarpoonum, Jeersali, Somasali, Mascat, Mutalaga, Ambemori, Belgaum basmati, Kumud, Ambemohr, Karigajavile, Yalakkisali, Manila, Rajamani
Dharwad	8	19	Gopal Dodiga, Dambersali, Dodiga, Champakali, Navalisali, Nadantarsali, Chitaga mugad, Antarsali, Hakkalsali, Udarsali, Bolasali, Nizamshaith, Warisanna, Kayisali, Bangarkaddi, Doddabangarkaddi, Ginasali, Kagisali, Wanar
Haveri	8	7	Khaima, Raja khaima, Budda, Hanagal budda, Hakkal budda, Alur sanna, Mysore sanna
Uttara Kannada	9	52	Marnomi guddabhatta, Murukata bhatta, Zadagi, Padmarekha, Karkal dodiga, Dodda mullare, Chitaga, Konnur bhatta, Kannanur local, Gowrisanna, Shetagi, Karibhatta, Jedikuni, Doddabairanellu, Sampige, Halaga, Valya, Ratnachuda, Nereguli, Siddasala, Jiggoratiga, Karikantiga, Bilidadi moratiga, Holesalu chippiga, Sorata, Soratiga, Farm valya, Chipiga, Kareisadi, Honasu, Sannamullare, Honnekattu, Mabane, Bangar kovi, Zaddubhatta, Tirlu hegge, Case bhatta, Hegge, Neermuluga, Vasane sanna, Gandhasala, Beerga, Mysore mallige, Huggi bhatta, Dodda valya, Batukoli, Bili hegge, Nyare minda, Yedikuni, Adnen kelte, Mal bangarkaddi, Motte bangarkaddi

*Agro-ecological zones of Karnataka: 1, Northeastern transitional zone; 3, Northern dry zone; 8, Northern transitional zone, and 9, Hilly zone.

Table 2. Important traits observed in traditional varieties of rice in Karnataka

Special features*	Traditional variety
Drought tolerance	Gopal Dodiga, Dambersali, Dodiga, Champakali, Budda, Bile kalavi, Maranavami guddabatta, Murakata batta, Navalisali, Hakkalasali, Udarsali, Bolasali, Mascat, Hakkal budda, Doddi batta, Manila
Early vigour	Dodiga, Navalisali, Antarsali, Udarsali, Bangarkaddi
Tolerance to low fertility	Dodiga, Navalisali, Antarsali, Bolsali, Udarsali, Chitaga Mugad
Durable resistance to diseases and pests	Udarsali, Karigajavile, Antarsali
Good cooking quality	Ratansagar, Padmarekha, Rajkhaima, Mysore sanna, Gowri sanna, Shankar Poonam, Wari sanna, Sampige, Alur sanna, Bangar kaddi, Adnenkelte, Mala Bangarkaddi, Motte bangarkaddi
Good quality aromatic rice	Ambemohr, Kagisali, Beeraga, Kumud, Yalakkisali, Huggi bhatta, Karigajavile, Belgaum basmati
Nutritive and satiety value	Navalisali, Ginasali, Mysore mallige, Gandhasala, Karikalavi, Kempunellu, Honasu
Good quality popping/puffing	Ratnachuda, Nizamshait, Honnekattu
Good quality flaking	Udarsali, Valya, Sanna mullre, Dodda valya, Bilinellu
Medicinal properties	Chitaga, Honasu, Karibhatta, Karikalavi, Karigajavile
Submergence tolerance	Nereguli, Neermulga, Mutalaga
Weed identification	Nyreminda, Antarsali
Good for parboiling	Dodiga, Halaga, Honasu
Suitable for organic farming	Khaima, Jigguvaratiga, Antarsali

*Based on traditional knowledge gathered from farmers.

Mean grain yield levels during 2002 and 2003 were low in early as well as medium maturing varieties (Table 3). This was because of severe moisture stress at the reproductive stage during those years, indicating the sensitivity of this stage to drought stress[11]. Among early-maturing land races, Dodiga recorded significantly higher grain yield (5125 kg/ha) over the best check, Rasi (3125 kg/ha) under vegetative stress (2001). However, it was statistically on par with Rasi under reproductive stress (2002 and 2003). Another land race, Medumsali, although ranked second during 2001, failed to maintain its superiority under reproductive stress. Among medium-maturing land races, Navalisali was the best for grain yield and significantly superior over best check, MTU-1001 during all the three seasons. Bolasali ranked seventh under severe vegetative stress, whereas it ranked third and second during 2002 and 2003 respectively. This indicates the lesser sensitivity of Bolasali to reproductive stress. Khaima and Hakkalasai were found to be more sensitive to reproductive stress as they recorded much lower ranks during 2002 and 2003 compared to 2001.

The land race, Dodiga in the early group and Navalisali in the medium maturing group were found significantly superior to all other genotypes, including HYV checks for productivity over three years. Panicle weight and spikelet fertility were important productivity traits conferring

Table 3. Performance of early and medium duration land races under drought stress at different growth stages

Genotype	2001 (severe vegetative stress)	2002 (severe reproductive stress)	2003 (moderate stress at both stages)
Early maturing genotypes			
Dodiga	5125 a*	2500 a	3687 a
Waner-1	4583 abc	2438 ab	3187 abc
Medumsali	5125 a	2156 abc	2833 abc
Turumuri	3792 bcd	2375 ab	3312 abc
Bile Dodiag	4083 a–d	2344 ab	2979 abc
Rasi	3125 def	2375 ab	3417 ab
Gopal Dodiga	4083 a–d	1906 a–e	2750 abc
Champakali	3250 def	2250 abc	2937 abc
Dambersali	3958 a–d	1813 a–f	2667 a–d
Hanagal budda	3500 cde	2000 a–d	2625 a–d
Budda	4833 ab	1188 d–g	1271 fg
Amrut (HYV check)	2458 efg	1031 efg	1375 efg
Prasanna (HYV check)	1667 g	969 fg	1271 fg
Vandana (HYV check)	1500 g	719 g	854 g
Mean	3649	1862	2512
C.V. (%)	14.19	21.59	19.55
Medium maturing genotypes			
Navalisali	5958 a	2844 a	3583 a
Udursali	5666 ab	2484 ab	2458 bc
Bolasali	4291 cde	2406 bc	2937 ab
Antarsali	4833 bcd	2031 cd	2437 bcd
Khaima	5000 abc	1625 def	2042 c–g
Raja Khaima	3875 def	1969 d	2604 bc
Mysore sanna	4125 c–f	1938 d	2187 b–f
Hakkalasali	5000 abc	1469 ef	1583 e–i
Kannanur local	3458 cef	1813 de	2375 b–e
Betiga	3083 fgh	1875 de	2312 b–f
Konnur bhatta	4625 cd	1188 fgh	1271 g–j
Chitaga	2583 gh	1625 def	2104 c–f
MTU-1001 (HYV check)	4000 c–f	969 ghi	875 hij
Jaya (HYV check)	3917 def	875 hi	667 j
Avinash (HYV check)	3292 e–h	813 hi	521 j
Mean	4247	1728	1997
C.V. (%)	11.9	12.7	19.9

*Means in the columns followed by same letter are not significantly different at 0.05 probability.

Figure 2. View of purple land race, Dambersali.

higher yields in land races under drought conditions. Pronounced spikelet sterility due to impaired biochemical and physiological events due to moisture stress during reproductive stage was reported earlier[12]. Sterility in rice is because of dehydration in the root zone and hence deep, thick roots and moderate tillering are the preferred varietal characters for drought tolerance[13]. Accordingly, in the present study, land races with higher productivity and less spikelet sterility were found to have higher root length and root dry matter (Figure 3 *a* and *b*). Drought-tolerant genotypes were reported to possess long and thick roots, which provide drought avoidance[14] and are more common in traditional land races of upland rice[15]. These land races also showed superior drought score during 2001, indicating tolerance at the vegetative stage.

A delay in flowering occurs when rice experiences a water deficit before flowering[16]. The delay in heading is an expression of growth retardation during drying cycle and upon recovery, which is a strong indication of susceptibility to stress[17]. Accordingly, in the present study flowering was delayed in all genotypes during 2001, which

Table 4. Productivity and drought traits of early and medium maturing rice land races pooled over three seasons under drought conditions

Genotype	Grain yield (kg/ha)	Panicle length (cm)	Panicle weight (g)	Per cent spikelet fertility	Days to 50% flowering	Plant height (cm)	Drought score (2001)	Root length (cm) (2003)	Root dry weight (g) (2003)
Early maturing genotypes									
Dodiga	3771 a*	19.5 a–d	2.35 a	94.9 a	94.0 g	86.5 a	3	22.0	1.07
Waner-1	3403 ab	20.0 abc	1.86 b–e	92.1 ab	96.0 ef	82.0 ab	4	12.0	0.70
Medumsali	3371 ab	19.5 a–d	1.93 bcd	93.8 a	99.0 bc	87.0 a	4	13.0	0.63
Turumuri	3160 bc	17.5 d–g	2.04 abc	91.5 ab	99.0 bc	83.5 ab	3	22.0	0.34
Bile Dodiag	3135 bc	16.5 fgh	1.92 b–e	93.4 a	94.0 g	81.5 ab	3	15.0	0.29
Rasi (HYV check)	2972 bcd	16.0 fgh	1.63 c–f	90.5 ab	91.0 I	53.5 fg	4	11.0	0.71
Gopal Dodiga	2913 bcd	18.0 c–g	1.87 b–e	92.6 ab	92.5 h	76.0 a–d	2	11.5	0.97
Champakali	2812 b–e	20.5 ab	2.05 abc	87.5 a–d	94.0 g	84.5 ab	3	14.0	0.25
Dambersali	2812 b–e	19.5 a–d	1.80 b–e	94.1 a	92.0 hi	79.0 abc	3	9.5	0.26
Hanagal budda	2708 cde	19.5 a–d	1.95 a–d	91.8 ab	97.0 de	78.0 abc	4	14.0	0.43
Budda	2430 de	16.5 fgh	1.65 c–f	92.9 ab	99.5 bc	57.0 efg	3	11.5	0.35
Amrut (HYV check)	1621 g	17.0 efg	1.50 ef	92.3 ab	84.0 k	50.5 g	4	15.0	0.37
Prasanna (HYV check)	1302 gh	20.0 ab	1.55 def	80.4 cef	74.5 m	68.0 cde	4	9.5	0.19
Vandana (HYV check)	1024 h	18.5 c–g	1.30 f	83.3 b–f	79.5 l	53.0 fg	3	10.0	0.39
Mean	2521	18.0	1.80	90.4	93.3	71.2	–	13.5	0.50
C.V. (%)	17.6	4.79	11.5	15.7	0.62	7.47	–	–	–
Medium maturing genotypes									
Navalisali	4128 a	20.0 bcd	2.50 a	95.6 a	108.0 gh	85.5 a	3	14.5	1.78
Udursali	3536 b	22.0 ab	2.35 ab	95.0 a	113.0 b	87.0 a	3	15.0	1.23
Bolasali	3212 bc	23.5 a	2.30 abc	94.2 a	109.5 ef	90.0 a	4	12.5	0.98
Antarsali	3101 cd	19.0 b–f	2.10 bcd	95.3 a	108.5 fg	82.0 ab	3	13.0	1.23
Khaima	2889 cde	19.0 b–f	2.04 b–e	89.7 abc	105.5 I	74.5 abc	4	12.0	0.90
Raja Khaima	2816 c–f	19.0 b–f	1.96 cde	92.5 ab	105.0 I	78.0 ab	4	10.5	0.40
Mysore sanna	2750 d–g	20.5 abc	2.05 b–e	88.6 abc	104.5 ij	80.0 ab	5	10.0	0.46
Hakkalasali	2684 efg	18.5 c–f	2.15 a–d	87.4 a–d	112.5 bc	79.5 ab	3	12.5	1.62
Kannanur local	2549 fgh	18.5 c–f	1.95 cde	92.8 ab	108.0 gh	78.0 ab	4	16.0	0.70
Betiga	2424 ghi	19.5 b–e	2.31 abc	86.4 a–d	107.0 h	81.5 ab	3	9.0	0.51
Konnur bhatta	2361 hij	21.0 abc	1.90 de	90.5 ab	113.0 b	84.0 ab	5	12.5	0.53
Chitaga	2104 ijk	17.0 def	1.70 e	89.6 abc	107.5 gh	90.5 a	5	13.0	0.62
MTU-1001 (HYV check)	1948 jkl	16.0 f	2.25 a–d	85.7 b–e	110.0 e	45.5 e	4	7.0	0.32
Jaya (HYV check)	1819 jkl	18.0 c–f	1.98 b–e	85.0 b–e	119.5 a	46.5 e	4	10.5	1.65
Avinash (HYV check)	1542 klm	16.5 ef	2.02 b–e	78.9 def	111.5 cd	45.5 e	5	11.0	0.51
Mean	2333	19.4	2.10	88.4	109.2	72.7	–	11.9	0.9
C.V. (%)	14.7	7.49	10.5	14.3	0.53	11.20	–	–	–

*Means in the columns followed by same letter are not significantly different at 0.05 probability.
–, Data not available.

Table 5. Association of root traits with productivity traits under moisture stress

Trait	Correlation coefficient		
	Maturity group	Root length	Root dry weight
Grain yield	Early	0.51*	0.51*
	Medium	0.50*	0.23
Days to 50% flowering	Early	0.41	0.27
	Medium	0.04	0.48*
Plant height	Early	0.44	0.20
	Medium	0.57*	0.12
Panicle length	Early	–0.07	0.01
	Medium	0.38	0.21
Panicle weight	Early	0.70**	0.41
	Medium	0.01	0.46*

* and **: Significant at 0.05 and 0.01 probability respectively.

experienced severe stress at the vegetative stage. Flowering delay was more in high-yielding checks, like MTU-1001 (14 days) and Avinash (13 days), compared to drought-tolerant land races like Navalisali (8 days). Five early and 12 medium-duration land races were superior to best HYV checks in the respective maturity groups for productivity over 3 years under varied drought stress. In this study, Dodiga and Navalisali in early and medium maturity respectively, were significantly superior under moisture stress and were identified as good sources of drought-tolerant as well as productivity traits under stress.

Root length and root dry weight were positively and significantly associated with grain yield under stress in early-maturing land races. A similar trend was also observed in medium-maturing land races (Table 5). These root traits were also correlated positively with productivity traits like plant height and panicle weight in early-

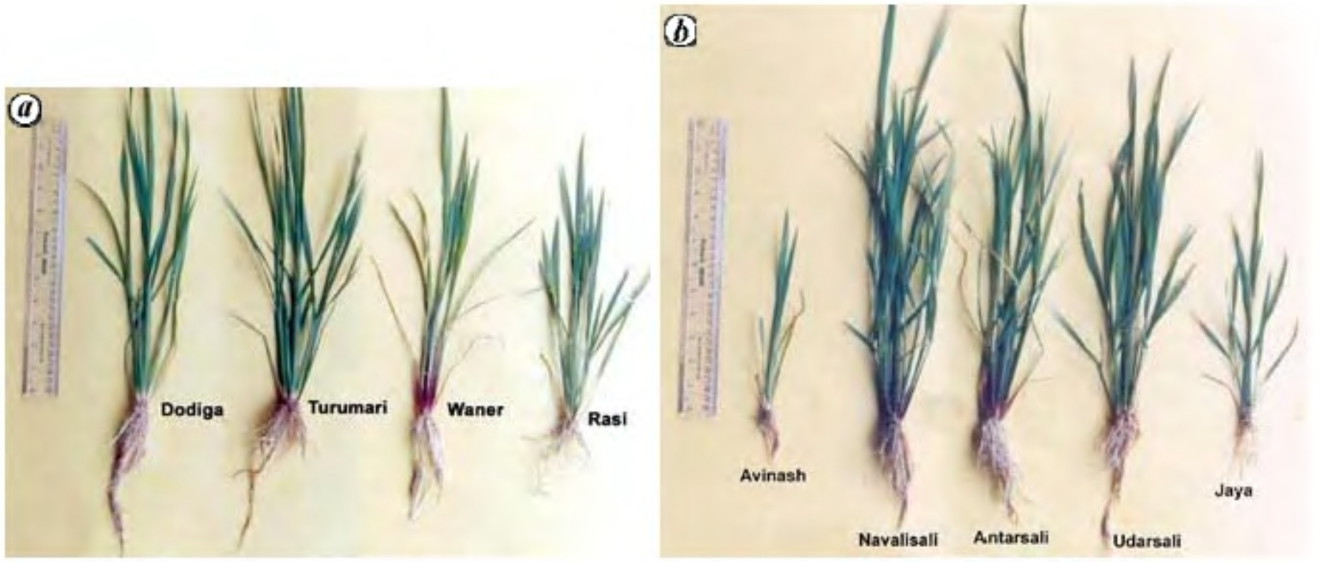

Figure 3. Root morphology of early duration (***a***) and medium duration (***b***) land races.

maturing land races. It was interesting to note that in medium-duration varieties panicle weight and root length were not correlated, while it was significantly positive between panicle weight and root dry weight. This indicates the importance of root dry weight in medium-maturing land races for better productivity under stress.

A total of 105 land races are conserved *ex situ* at the Agricultural Research Station, Mugad and are deposited in NBPGR, New Delhi. Careful purification and encouraging the farming community to grow traditional varieties could help in the *in situ* conservation of important land races that are presently being grown in sizable area. As the land races are specific to ecological niches with potential sources of valuable and rare genes, there is a great scope for transferring these genes among and across the species. In this regard work is in progress at our research station to transfer drought-tolerant traits to HYV from Dodiga and Navalisali as donors.

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