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Characterization of upland rice genotypes for drought tolerance and dormancy

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ABSTRACT

Fifteen rice cultivars were grown in rainfed upland and exposed to severe water stress (soil moisture 5.5 – 9.0%) for ten days to evaluate them for drought tolerance. The study revealed that the cultivars IET 18645 and IET 18460 could maintain their assimilatory surface area 130.2 and 135.1 $cm^2 plant^{-1}$, respectively even though their assimilatory units rolled to a maximum degree (leaf rolling score were 9 in both the cases) indicating their ability to escape drought through this mechanism. They were also able to maintain water potential in the leaf tissues to a desired extent. The cv. IET 18460 produced satisfactory grain yield of 2.18 t ha^{-1}. However, cvs. IET 18645 and IET 18460 were at par with Bandana and all the three cvs. significantly registered higher grain yield compared to the check cv. Govind (1.13t ha^{-1}). IET 18645, IET17509 and IET18781 exhibited strong dormancy behavior. IET 18645 showed longest grain dormancy of 28 days. Hence, IET 18645 can be identified as a potential donor for both drought tolerant upland rice cultivar and also longest grain dormancy.

Key words: *upland rice, drought tolerance, seed dormancy, water potential*

Direct seeded upland rice often suffers from moisture stress during various growth phases (Anon.1993). Farmers growing upland rice during March to June (ahu) have to depend on rainfall and the crop suffers from water stress leading to yield loss. In rainfed upland, moisture stress would occur either at specific growth phases or intermittently during the crop period based on rainfall pattern of a given season. Furthermore, the harvesting period of ahu rice coincides with heavy and incessant rain. This situation very often results in sprouting of the grains in the panicles. This is one of the causes of low return. Seshu and Serrells (1985) stressed the importance of dormancy in production of rice. A dormancy as short as 20-30 days would be helpful in overcoming the problems encountered during pre and post harvest periods, thereby saving the grains (Haloi 1998). Therefore, studies were undertaken to identify moisture stress tolerant rice genotypes with desired degree of dormancy in rainfed upland condition particularly in ahu season for incorporation of desirable physiological traits in the breeding programme

MATERIALS AND METHODS

A field experiment was conducted at the Regional Agricultural Research Station, Titabar, Assam during *ahu* season 2006 under rainfed upland condition .The physical properties of the soil are clay % 37.1, silt % 28^{0}5, sand % 33.3, bulk density 1.46 g cc^{-1}, maximum water holding capacity % 33.4, 1/3 bar moisture content % 18.5, 1/5 bar moisture content % 6.6.

Fifteen upland rice cultivars were dry sown in the field on 20th March, 2006 in random block design with 3 replications. Each plot had 6 rows, 3.5m long and spaced 20cm apart. Well decomposed FYM at 5 t ha^{-1} was applied during the final land preparation and mixed uniformly with the soil besides, fertilizers N, P_2O_5 and K_2O at 40,20,20 kg ha^{-1}, respectively. The soil moisture content in the root zone was estimated through TDR moisture meter (Model Trime-FM) at 15 cm soil depth. The parameters viz. leaf rolling score, leaf area $plant^{-1}$, root length, root volume, relative leaf water content (RLWC) and leaf water potential were recorded during the stress period. The scoring for leaf rolling was done following standard evaluation system (SES) for rice (IRRI-1980). Leaf area per plant was recorded by a leaf area meter (Systronics, Model No.211). Roots were carefully excavated from the soil and washed with running tap water to remove all dirt and organic matter for measurement of root length and root volume. Root length was measured from soil surface to tip of the longest root and root volume was measured by water displacement method. Fully expanded leaves were excised and RLWC was determined by the method outlined by Matin *et al* (1989). Water potential was determined in a plant water status console (Soil Moisture Equipment Corporation, Santabarbara, USA).

One hundred filled grains of each cultivar, soon after harvest were placed on moist blotting paper in covered petriplates (10cm in diameter) in three sets and these were kept at 50^{0}C in incubator to assess the intensity of dormancy. Number of seeds germinated were counted and recorded at 3 days interval upto 10days. The germination count less than 50%, between 50-60% and more than 60% were considered as strongly dormant (SD), moderately dormant (MD) and weakly dormant (WD) respectively. Germination test on second set of seeds was conducted at 7, 14, 21, 28 and 35 days after harvest to observe 80% germination, indicating breaking up of dormancy (Padmaja Rao 1994). Therefore, the period upto retention of 80% germination was considered as the desired viable period..

RESULTS AND DISCUSSION

A total of 390 mm rainfall was recorded during the whole crop season (sowing to physiological maturity) which was the lowest in comparison to the amount of rainfall for the same period of the previous ten years (average 553mm). The soil moisture content varied from 5.5 to 35.4% from sowing to flowering stage. Severe moisture stress occurred between 15th to 25th May, 2006 during which soil moisture percentage dropped from 9% to 5.5%. There was significant differences among the cultivars in their plant height. The cultivar IET 17898 recorded maximum plant height (99cm), whereas IET 18643 (75cm) and Govind (73cm) recorded minimum plant height. The cultivars viz. IET 18640(86cm) and IET 18645(83cm) had intermediate or semi-dwarf height (Table 1). Rao (2000) emphasized that non-lodging sturdy culms with intermediate or

Table 1. Characterization of upland rice cultivars for their drought tolerance parameters

Cultivars	Leaf rolling score	Leaf Area plant^{-1} (cm^2) at tillering stage	Plant height (cm) at flowering stage	Root length (cm) at tillering stage	Root volume hill^{-1} (cm^3) at tillering stage	Root shoot ratio	RLWC (%)at tillering stage	Leaf water potential (Kpa) at tillering stage	Days to maturity	Grain yield (t ha^{-1})
IET18645	9	130.2	83	19.2	3.0	0.32	64.2	2175	120	1.95
IET18640	9	135.1	86	20.2	3.6	0.35	65.9	2085	124	2.18
IET18643	7	132.0	75	17.8	2.8	0.30	59.9	2210	124	1.65
IET18244	5	122.8	95	14.6	1.9	0.22	50.0	1985	134	0.90
IET17509	7	131.5	94	16.6	2.2	0.23	67.9	2150	130	1.50
IET18221	5	137.7	80	17.0	1.8	0.19	70.9	2125	120	1.13
IET18238	5	129.4	82	13.5	1.2	0.17	78.3	1815	132	0.98
IET17898	7	130.3	99	16.2	2.9	0.19	63.3	2020	127	1.33
IET18783	3	113.1	89	12.6	1.5	0.18	43.2	1610	139	0.85
IET18620	3	110.7	92	13.0	1.7	0.17	39.6	1715	139	0.83
IET18796	3	120.8	82	15.2	2.2	0.25	76.7	1940	136	1.28
IET18781	3	127.8	90	13.9	1.8	0.18	49.7	1650	136	0.80
IET18797	3	124.1	85	14.5	2.0	0.26	64.4	1605	139	0.78
Bandana©	7	131.2	79	19.6	3.0	0.32	73.1	2220	120	1.73
Govind©	5	125.4	73	16.0	2.2	0.21	58.9	2175	130	1.13
CD (P=0.05)	-	3.24	2.82	1.25	0.22	0.03	4.33	59.3	2.01	0.46
CV(%)		10.81	16.25	18.50	18.52	15.52	21.00	21.32	10.02	15.25

RLWC - relative leaf water cntent

semi-dwarf height (80-90 cm) is one of the desirable traits for selection of upland rice varieties for yield. The leaf area showed significant differences among the cultivars. The cultivars IET 18645 and IET 18640 could maintain leaf surface area of 130.2 and 135.1cm^2 plant^{-1}, respectively even though their leaf rolled to a maximum degree (leaf rolling score were 9 in both the cases) indicating their ability to escape drought. Leaf rolling reduces the area of leaf exposed to the atmosphere and thus reduces transpiration (O,Toole and Cruz 1980). The same cultivars were able to maintain water potential in the leaf to a desired extent. Decrease in leaf water potential, compels leaves to begin rolling inward. However, the level of leaf water potential at which leaves begin to roll varies with cultivars. The cultivars IET 18640 (2085 Kpa), IET 18645 (2175 Kpa) and IET 18643 (2210 Kpa) registered higher leaf water potential during the stress period which signifies that they are ideal drought tolerant upland rice cultivars. A significant positive association (0.781*) was observed between leaf water potential and leaf rolling score (Table 2). Dingkuhn *et al* (1989) suggested that the leaves of drought resistant upland rices begin to roll even at a higher leaf water potential than those of low land rices. On the other hand, the cultivars. IET 18645 (64.2%) and IET 18640 (65.9%) maintained

Table 2. Simple correlation coefficients between different parameters and grain yield in rainfed upland rice

	Leaf rolling score	Leaf area plant^{-1}	Plant height	Root length	Root volume hill^{-1}	RLWC	Leaf water potential	Days to maturity	Grain yield
Leaf rolling score		0.687*	-0.086	0.870**	0.804**	0.372	0.781*	-0.830**	0.905**
Leaf area plant^{-1}			-0.272	0.730*	0.503	0.659	0.657	-0.810**	0.597
Plant height				-0.120	-0.114	-0.395	-0.382	0.381	-0.248
Root length					0.890**	0.481	0.821**	-0.884**	0.930**
Root volume hill^{-1}						0.261	0.644	-0.661*	0.889**
RLWC							0.466	-0.501	0.440
Leaf water potential								-0.854**	0.752*
Days to maturity									-0.780*

RLWC - relative leaf water cntent

Table 3. Characterization of upland rice cultivars for seed dormancy

Cultivars	Germination (%) at heat treatment	Germination (%) at days				
		7	14	21	28	35
IET18645	46 (SD)	0	8	35	68	100
IET18640	50 (MD)	5	10	62	100	
IET18643	62 (WD)	10	20	76	100	
IET18244	66 (WD)	12	85	100		
IET17509	13 (SD)	8	18	60	86	100
IET18221	90 (WD)	18	85	100		
IET18238	70 (WD)	35	90	100		
IET17898	78 (WD)	20	82	100		
IET18783	53 (MD)	12	40	90	100	
IET18620	58 (MD)	15	50	85	100	
IET18796	72 (WD)	5	25	100		
IET18781	38 (SD)	8	15	55	80	100
IET18797	63 (WD)	8	22	100		
Bandana	74 (WD)	5	40	90		
Govind	55 (MD)	5	30	75	100	

SD - Strongly Dormant, MD-Moderately Dormant, WD- Weakly Do`rmant comparatively higher RLWC under severe moisture stress at tillering stage when soil moisture percentage dropped to 6%. Relatively higher RLWC have also been reported in drought tolerant cultivars (Tyagi e*t al.,* 1999). The cultivars IET 18640 and IET 18645 recorded maximum root length and root volume during stress period which were at par with resistant check Bandana. The root to shoot ratio were significantly higher in these cultivars. Yoshida and Hasegawa (1982) asserted that the ratio of deep roots to shoot is a measure of a plant's ability to absorb water from soil layers of deep. They also reported that upland rices generally have deeper and thicker root system than lowland rice varieties (Table 2). Both root length and root volume had highly significant positive correlation (0.930** and 0.889**, respectively) with grain yield. These two varieties took less time (120 –124 days) for physiological maturity which were at par with Bandana. Multilocational trials revealed that short duration varieties with tolerance to drought suit the situation (Rao, 2000). Leaf rolling score also exhibited a highly significant negative correlation (-0.830**) with days to physiological maturity and thereby it signifies that these are the ideal drought tolerant cultivars (Table 2). IET 18640 produced satisfactory grain yield of 2.18 t ha^{-1}. However, the cvs. IET18645 (1.95 t ha^{-1}) and IET18643 (1.65 t ha^{-1}) were at par with Bandana (1.73 t ha^{-1}) and all the four cultivars registered significantly higher grain yield compared to the check Govind (1.13 t ha^{-1}) under water stress situation (Table 2) cultivars IET 18645, IET 17509 and IET18781 exhibited strong dormancy (Table 3). IET 18640, IET 18783, IET 18620 and the check Govind were moderately dormant, whereas all other cultivars including Bandana showed weak dormant characters. The cultivars IET 18244, IET 18221, IET 18238 and IET 17898 showed more than 80% germination in 7-14 days. IET 18640, IET 18643, IET 17509 and IET 18781 possessed the desired degree of dormancy upto 21 days. IET 18645 showed the longest grain dormancy of 28 days. The check cultivars Govind also to some extent exhibited the desired degree of dormancy upto 21 days.

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