Association of Mesocotyl and Coleoptile Elongation with Seedling Vigor and Yield and its Components in Rice

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Abstract: The present study was carried out at laboratory, greenhouse and experimental farm of Rice Research and Training Center (RRTC), Sakha, Kafr El-Sheikh, Egypt during 2014 and 2015 season to investigate the differences in some seedling vigor, yield and its attributes and Nitrogen (N) status in milled grain which measured on eight rice varieties i.e. Giza 171, Giza 177, Giza 178, Sakha 101, Sakha 102, Sakha 103, Sakha 104 and Gaori. The results revealed that the short stature genotypes Sakha101 and Gaori (91.0 and 77.95cm) gave shortest Mesocotyl length and plant height. Where as, the tall plants of Giza171, Sakha 102 (126 and 106cm) had comparatively long mesocotyl. Also, the data indicated that tall plants tend to produce long coleoptile while semi-dwarf or short genotypes produced short ones. Sakha 101 and Giza 178 rice cultivars recorded the highest values of panicles m^{-2}, grains $panicle^{-1}$, grain yield t ha^{-1}, biomass production t ha^{-1} and harvest index. Nitrogen and protein content in milled grain was statistically higher in the genotype Gaori than other entries while the genotypes Sakha 101 and Sakha 103 uptake more nitrogen than the others. The results suggested that varieties of Giza177, Sakha102 and 104 are more tolerant to adverse conditions during seeding stage.

Keywords: Rice, seedling vigor, yield and its attributes, N status in milled grain.

1. INTRODUCTION

Rice is the staple food for nearly half of the world‘s population, most of whom live in developing countries. The crop occupies one-third of the world‘s total area planted to cereals and provides 35–60% of the calories consumed by 2.7 billion people [1]. Seedling vigor is a plant ability to emerge rapidly from soil or water [2]. Seed and seedling vigor is genetically controlled and modified by the environment and it is possible to incorporate this trait in high yielding varieties. Seed and seedling vigor in rice is associated with several quantitative characters [3]. Farmers in developing countries increasingly adopt direct seeding because of farm labor migration to non-farm jobs which lead to the labor shortage, and the consequent high wages for manual transplanting. Direct seeding eliminates labor demands for seedbed preparation, seedling care, pulling of seedlings, and transplanting shock [4]. The yield of rice under direct seeding is reported to be generally lower than transplanting. Reasons for this low yield include uneven distribution of seeds, poor seedling emergence and high competition of weeds. It is important for improving direct seeding to investigate the influence of contrasting crop management, like seed density and seedling establishment techniques associated with real time N management on the performance of different genotypes. Seedling vigor is difficult to measure in the field condition because of large environmental effects. Greenhouse and laboratory screening procedures have, therefore, been used to measure seedling vigor in rice. [5], used mesocotyl and coleoptile length to differentiation genotypes and indicated that the two traits could serve as indices of seedling vigor.

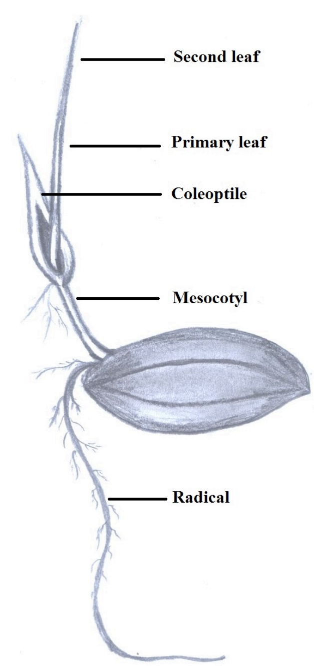

Figure 1: Young seedling of rice plant showing the mesocotyl and coleoptile.

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Being a major organ for nutrient uptake, the root plays an important role in the soil-plant system [6]. Its growth is directly related to the growth and biomass yield of shoots. Generally, plants have a characteristic of enhancing their efficiency of nutrient acquisition to overcome the stress from nutrient deficiency or root competition. Flexibility in biomass allocation, root morphology and root distribution pattern has been found to be an important adaptive mechanism to exquisite nutrients [6-9]. The objectives of the present study were to: (a) Determine the association traits with the seedling vigor among some rice genotypes, (b) Examine the relationship among mesocotyl / coleoptile elongation and some agronomic traits, yield and its components and N status in milled grain.

2. MATERIALS AND METHODS

This study was conducted at Rice Research and Training Center, Sakha, Kafr El-Sheikh, Egypt, during 2014 and 2015 seasons to study the traits related to seedling vigor, yield and its components and N status in milled grain. Eight rice varieties namely Giza 171, Giza 177, Giza 178, Sakha 101, Sakha 102, Sakha 103, Sakha 104 and Gaori were used for the study. The pedigree and origin of the rice varieties were presented in Table **1**.

Three experiments were carried out at laboratory, greenhouse and field condition.

2.1. Laboratory Test

A laboratory test was designed to determine the potential of the mesocotyl and coleoptile of the eight genotypes. The mesocotyl is the internode between the coleoptile node and the point of union of the root and the clum [10]. The mesocotyl (internode) only elongated in the dark, therefore, its length could be measured only when the seedling have been grown in the dark environment. The seeds of the eight genotypes were planted in Petri dish at 25^{o}C under incubation (under dark environment). After 10 days the length (mm) of mesocotyl and coleoptile were measured.

2.2. Greenhouse Evaluation

The greenhouse test was designed to determine the length of shoot and root for all rice genotypes at seedling stage. Fifty seeds per row were planted for each variety in a plastic tray which contains clay soil with 50% sand at the greenhouse to facilitate the measurement of root and shoot length. Water was added at regular intervals to maintain adequate soil moisture for seed germination. The length of seedling shoot and root were measured at 15, 21 and 28 days after sowing (DAS).

2.3. Field Experiment

A field experiment designed to measure morphological and yield and its components traits. The eight genotypes were transplanted in Randomize complete block design (RCBD) with four replication. The plot area was 20m^2 (4X5m). Plots received identical cultural treatments in terms of ploughing, cultivation, seed rate, N, P and K fertilizers, and disease control. Rice plants were transplanted at a spacing of 20cm × 20cm. nine physiological and agronomical traits were estimated, and yield and its components traits.

Table 1: Pedigree and Origin of the Tested Genotypes

Geno Type	Parentage	Origin
Giza 171	Nahda/Calady 40	Egypt
Giza 177	Giza 171/Yomjo No. 1//PiNo.4	Egypt
Giza 178	Giza 175/Milyang 49	Egypt
Sakha 101	Giza 176/Milyang 79	Egypt
Sakha 102	GZ 4098-7-1/Giza 177	Egypt
Sakha 103	Giza 177/Suweon 349	Egypt
Sakha 104	GZ 4096-8-1/GZ 4100-9-1	Egypt
Gaori	IR5591-1-1-1-1/ Taikeny7	Introduce

Table 2: Mesocotyl Length, Coleoptile Length and Plant Height of Eight Genotypes in 2014 and 2015 Season

Entry	Mesocotyl Length mm		Coleoptile Length mm		Plant Height cm	
	2014	2015	2014	2015	2014	2015
Giza 171	2.97	2.9	16.98	16.49	127.37	126.6
Giza 177	4.83	4.94	18.13	17.88	96.47	100.5
Giza 178	1.93	1.96	12.12	11.55	93.37	98.7
Sakha 101	0	0	10.16	9.89	90.05	95.47
Sakha 102	3.89	3.92	12.12	12.94	107.5	105.83
Sakha 103	1.13	0.95	19.07	18.83	95.3	99.27
Sakha 104	3.14	3.03	12.11	12.93	107.37	110.47
Gaori	1.83	1.92	19.09	19.27	70.63	85.27
LSD 0.05	0.22	0.21	1.14	1.78	6.62	8.46

2.4. Statistical Analysis

The mean data of eight entries for all the traits were subjected to analysis of variance according to the differences between means were tested using the LSD method [16].

3. RESULTS AND DISCUSSION

The eight rice genotypes differed significantly in their mesocotyl, coleoptile elongation and plant height (Table **2**). Giza 177 and Sakha 102 recorded the highest values of mesocotyl length (4.83 and 3.89mm in 2014, 4.94 and 3.92mm in 2015). While, the semi-

Table 3: Correlation Coefficient Among Selected Traits Measured on Eight Rice Entries

	Mesocotyl	Coleoptile	Shoot	Root	Height	FLA	Heading	Panicles	G/P	GY	Biomass	HI
Coleoptile	0.356	1										
Shoot	0.744**	0.570*	1									
Root	0.524*	0.162	0.341	1								
Height	0.156	-0.224	0.005	-0.289	1							
FLA	-0.201	-0.630*	-0.380	0.238	0.365	1						
Heading	-0.088	-0.504	-0.421	-0.132	0.808**	0.668**	1					
Panicles	-0.474	-0.754**	-0.656**	-0.128	0.433	0.842**	0.792**	1				
G/P	-0.279	-0.629*	-0.560*	0.099	0.410	0.818**	0.788**	0.867**	1			
GY	-0.309	-0.751**	-0.561*	-0.081	0.418	0.755**	0.762**	0.894**	0.877**	1		
Biomass	-0.179	-0.677**	-0.353	-0.340	0.759**	0.620*	0.835**	0.743**	0.686**	0.811**	1	
HI	-0.236	-0.295	-0.438	0.355	-0.320	0.399	0.155	0.470	0.573*	0.578*	0.001	1
Uptake	-0.493	-0.461	-0.676**	-0.091	0.100	0.545*	0.530*	0.669**	0.720**	0.758**	0.416	0.709**

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Mesocotyl: Mesocotyl length mm	Coleoptile: Coleoptile length mm	Shoot: Shoot length mm
Root: Root length mm	Height: Plant height cm	FLA: Flag leaf area cm^{-2}
Heading: Days to heading	Panicles: Panicles $plant^{-1}$	G/P: Grains $panicle^{-1}$
GY: Grain yield t ha^{-1}	Biomass: Biomass yield t ha^{-1}	HI: Harvest index
Uptake: N Uptake kg ha^{-1} by milled grain		

dwarf rice variety Sakha 101 had no mesocotyl. Concerning to coleoptile, the early maturing varieties Sakha 103, Giza 177 and Gaori exhibited the highest values of coleoptile. This indicated that the early maturing varieties had long coleoptile and mesocotyl, so these varieties emergence of soil surface earlier than others.

Regarding plant height, Giza 171 recorded the tallest genotypes compared with the other genotypes. Generally, the short stature genotype Sakha 101 (91cm) had a reduced mesocotyl length and plant height whereas the tall rice varieties Giza 171 and Sakha 102 (126.99 and 106.67cm) had longer mesocotyl. Furthermore, the correlation coefficients for mesocotyl, coleoptile *vs*. root and shoot length at different stages were significantly and highly significantly positive (Table **3**). These results indicated that the rice varieties which have long mesocotyl and coleoptile, shoot and root length had a highly seedling vigor. Turner *et al.* and Mgonja *et al.* [10, 11] reported that dwarf genotypes have shorter mesocotyl and total length as compared to standard genotypes. These data also showed that genotypes exhibit different potential for mesocotyl and coleoptile length can be selected by breeders in the subsequent development of semi-dwarf genotypes for drill-seeded rice.

Figure **2** illustrated that the shoot and root length mm of different rice entries at 15, 21 and 28 days after

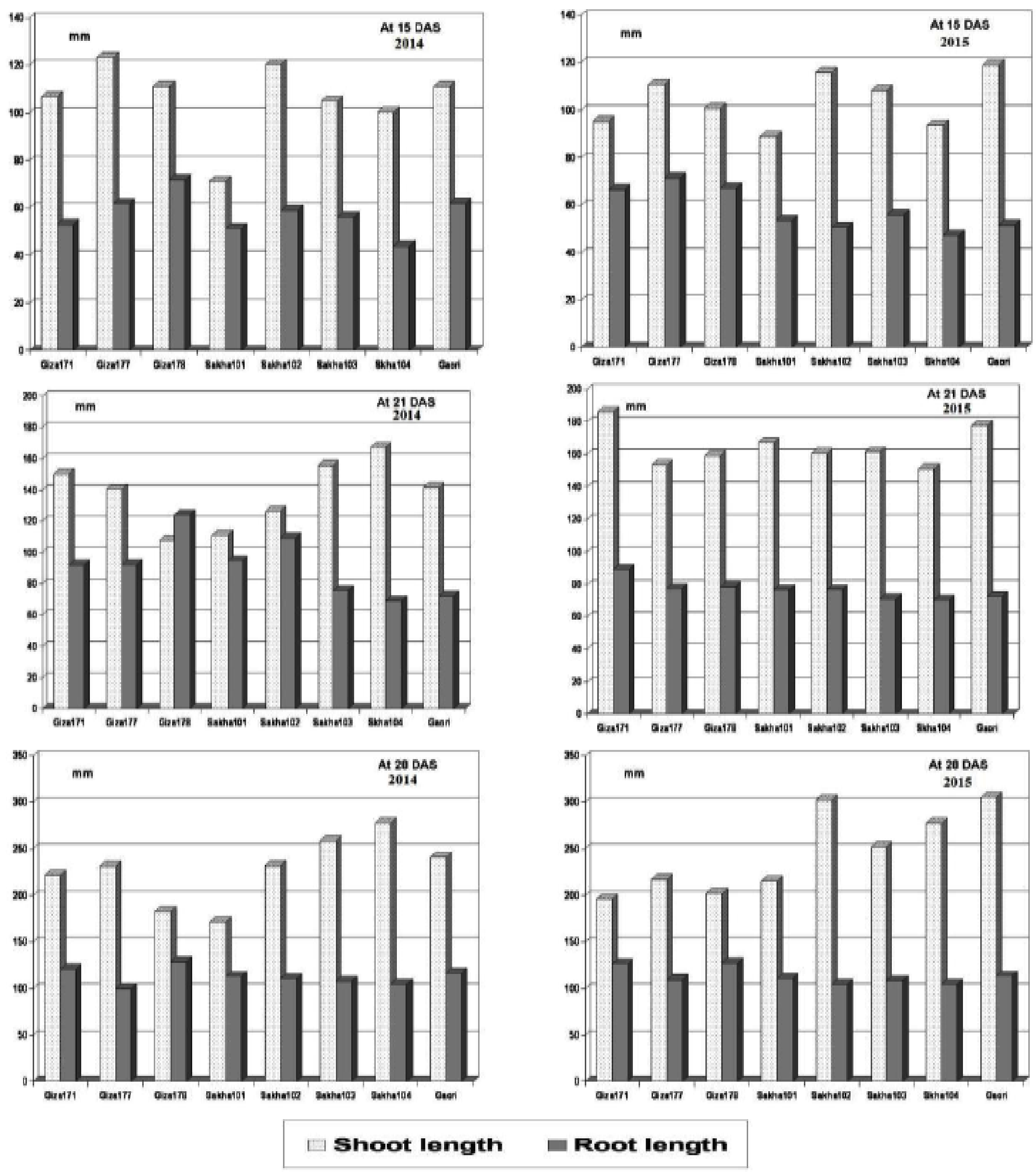

Figure 2: Shoot and root length mm of different rice entries at 15, 21 and 28 days after sowing (DAS) in 2014 and 2015 season.

Table 4: Flag Leaf Area, Chlorophyll Content and Days to Heading of Eight Genotypes in 2014 and 2015 Season

Entry	Flag Leaf Area cm^{-2}		Chlorophyll Content SPAD		Days to Heading	
	2014	2015	2014	2015	2014	2015
Giza 171	29.47	30	33.47	38.2	116.17	122.33
Giza 177	25.39	29.2	42.77	46.13	94.47	97.87
Giza 178	41.2	43.33	40.68	47.47	97.63	99.67
Sakha 101	32.93	32.6	43.17	48.03	101.37	105.22
Sakha 102	26.63	30.27	41.77	45.17	93.4	95.33
Sakha 103	28.43	30.97	42.2	45.97	92.53	95.3
Sakha 104	29.9	31.9	46.5	45.2	101.2	101.8
Gaori	14.5	21.37	41.39	45.47	66.87	71.87
LSD 0.05	1.49	1.51	0.73	0.81	4.46	5.71

sowing (DAS) in 2014 and 2015 season. Regarding shoot length in 2014, the early maturing rice varieties, Giza 177, Sakha 102 and Gaori recorded the highest values of shoot length at 21 days after sowing, these mainly due to genetic stature whereas, these varieties gave the highest values of total mesocotyl and coleoptile length to help these varieties emergence from the soil surface. While Sakha 101 gave the lowest values of shoot length this mainly due to shortest of mesocotyl and coleoptile. At 21 and 28 DAS, the rice varieties differ significantly in their shoot length. Sakha 104 and Sakha 103 exhibited the highest values of shoot length at 21 and 28 DAS. While Sakha 101 recorded the shortest one. While in 2015, Giza 177, Sakha 102 and Gaori exhibited the highest values of shoot length at 15 DAS on the other hand, Sakha 101 gave the lowest one. Giza 177 and Gaori showed the highest values of shoot length at 21 DAS. Regarding shoot length at 28 DAS, Gaori and Sakha 102 gave the tallest shoot. The differences among the rice genotypes in their shoot length mainly were due to the genetic background. Concerning to root length 2014, the rice genotypes differ significantly in their root length at 15, 21 and 28 DAS. Giza 178, Giza 177 and Gaori gave the highest values of root length at 15 DAS while, Sakha 101 recorded the lowest one. These mainly due to the genetic background among the rice varieties. Giza 178 gave the highest values of root length at 21 and 28 DAS. These mainly due to the genetic nature of variety because Giza 178 indica / japonica type, thus there is a hybrid vigor in the seedling stage. Concerning to root length in 2015 at 15, 21 and 28 DAS, the rice varieties Giza 171, Giza 178 and Giza 177 recorded the highest root length values.

Flag leaf area cm^{-2}, chlorophyll content and days to heading significantly differed among the rice genotypes (Table **4**). Giza 178 gave the highest values of flag leaf area on the other hand, Gaori gave the lowest one. Regarding the correlation coefficient between flag leaf area and yield and its components, there are positive significant and highly significant correlation between flag leaf area and each of panicles $hill^{-1}$, grain $panicle^{-1}$, grain yield t ha^{-1}, biomass yield t ha^{-1} and nitrogen uptake kg ha^{-1} (Table **3**). Regarding chlorophyll content, Sakha 101 and Sakha 104 gave the highest chlorophyll content while Giza 171 gave the lowest one. These mainly due to the genetic background. Concerning to days to heading, significant variability was found among the tested genotypes for days to heading. Gaori was earlier than the other rice varieties under this investigation. Karim *et al*. [12] and Jamal *et al*. [13] reported that variation for days to maturity was attributed by the genetic constituent rather than environment. There are a positive significant and highly significant correlation between days to heading and each of plant height, flag leaf area, panicles $hill^{-1}$, grains $panicle^{-1}$, grain yield t ha^{-1}, biomass yield t ha^{-1} and nitrogen uptake kg ha^{-1} (Table **3**). The results suggested that the genotypes that took more days to heading were likely to have more yield. Panicles $hill^{-1}$, grains $panicle^{-1}$ and 1000-grain weight (g) are presented in Table **5**. A great variability with high range was exhibited for a number of productive tillers $hill^{-1}$ and grain $panicle^{-1}$. Giza178 and Sakha101 exhibited the highest values of panicles $hill^{-1}$ and grain $panicle^{-1}$. On the other hand, Gaori recorded the lowest values of panicles $hill^{-1}$ and grain $panicle^{-1}$. Positive significant and a highly significant correlation was detected between each of panicles $hill^{-1}$ and grain $panicle^{-1}$ and

Table 5: Panicles Hill^{-1}, Grains Panicle^{-1} and 1000-Grain Weight of Eight Genotypes in 2014 and 2015 Season

Entry	Panicles Hill^{-1}		Grains Panicle^{-1}		1000-Grain Weight g	
	2014	2015	2014	2015	2014	2015
Giza 171	21.68	20.83	136.37	144.4	22.62	22.76
Giza 177	20.36	18.7	121.1	124.1	26.55	27.73
Giza 178	23.52	23.73	149.4	159.73	21.08	21.9
Sakha 101	24	23.87	151.17	148.3	26.97	27.1
Sakha 102	20.13	20	126.23	125.1	27.75	27.84
Sakha 103	20.35	21.17	148.3	126.83	23.4	24.43
Sakha 104	21.98	23.95	137.17	135.03	26.14	27
Gaori	15.87	16.85	91.77	70.11	22.32	22.03
LSD 0.05	1.65	1.45	11.4	8	0.51	0.4

Table 6: Grain Yield, Biomass Yield and Harvest Index of Eight Genotypes in 2014 and 2015 Season

Entry	Grain Yield t ha^{-1}		Biomass Yield t ha^{-1}		Harvest Index	
	2014	2015	2014	2015	2014	2015
Giza 171	6.97	7.73	24.21	25.83	0.288	0.299
Giza 177	8.35	7.9	19.93	21.5	0.419	0.368
Giza 178	8.89	9.94	22.6	22.83	0.393	0.435
Sakha 101	10.06	10.5	22.13	24.57	0.453	0.427
Sakha 102	8.67	7.87	22.6	25.8	0.383	0.305
Sakha 103	7.99	8.38	19.53	19.97	0.409	0.419
Sakha 104	9.83	9.81	29.5	27.37	0.333	0.358
Gaori	3.98	3.78	10.93	13.37	0.364	0.283
LSD 0.05	0.88	0.91	1.8	1.42	0.01	0.021

grain yield t ha^{-1}, biomass yield t ha^{-1}, harvest index and nitrogen uptake kg ha^{-1} (Table **3**). Sakha101 and Sakha 102 gave the heaviest 1000-grain weight while, Giza 178, Gaori and Giza 171 recorded the lightest 1000-grain weight, these differences among the studied genotypes mainly due to the differences in genetic nature of these varieties. Giza 178 and Sakha 101 recorded the highest grain yield t ha^{-1} and harvest index. This variation in the grains yield might be due to the correlation of grain yield ha^{-1} with various yield contributing characteristics like; flag leaf area, grains panicle^{-1}, number of grains panicle^{-1} and grain weight and correlation with these traits. Similarly [14], reported positive correlation among number of panicle plant^{-1}, panicle length, number of grains panicle^{-1} and 1000-grain weight and grain yield ha^{-1}.

Data in Table **7** showed significant variation among genotypes in the nitrogen and protein content in the milled grain, also in their ability to take up N. The highest concentration of nitrogen and protein were recorded by Gaori. This mainly due to the dilution effect thus Gaori produced the minimum grain yield. Nitrogen uptake by milled grain had significantly positive correlation with grain yield (Table **3**). These results suggested that the genotypes that uptake more nitrogen were likely to have a somewhat increase in grain yield. This mainly due to that rice genotypes should efficiently utilize the N taken up from the soil to produce grain [15].

CONCLUSION

The short stature genotypes Sakha 101 and Gaori gave shortest Mesocotyl length and plant height.

Table 7: Nitrogen Content % in Milled Grain, Protein Content % and Nitrogen Uptake kg ha^{-1} by Rice Grain of Eight Genotypes in 2014 and 2015 Season

Entry	N % in Milled Grain		Protein Content %		Nitrogen Uptake by Rice Grain kg ha^{-1}	
	2014	2015	2014	2015	2014	2015
Giza171	1.226	1.29	7.29	7.68	85.5	99.8
Giza177	1.029	1.243	6.12	7.39	86	98.3
Giza178	1.028	1.107	6.12	6.59	91.4	110
Sakha101	1.192	1.272	7.09	7.57	119.9	133.8
Sakha102	1.067	1.134	6.35	6.75	92.6	89.4
Sakha103	1.385	1.45	8.24	8.62	110.8	121.6
Sakha104	1.01	0.978	6.01	5.82	99.4	96
Gaori	1.843	1.847	10.97	10.96	73.4	69.7
LSD 0.05	0.039	0.074	1.24	1.44	8.6	10.8

Where as, the tall plants of Giza 171, Sakha 102 had comparatively long mesocotyl. The tall plants tend to produce long coleoptile while semi-dwarf or short genotypes produced short ones. The high yielding varieties i.e., Giza 177, Sakha 102 and Sakha 104 are more tolerant to adverse conditions during seedling stage. Our results recommended that these varieties have to evaluate under direct seeded rice method.

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