emergent
Life Sciences Research

Research Article

Response of seed reserve utilization and its associated traits in rice genotypes

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Received: 25 September 2022
Accepted: 15 December 2022
Online: 19 December 2022

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Emer Life Sci Res (2022) 8(2): 222-228

E-ISSN: 2395-6658
P-ISSN: 2395-664X

DOI: https://doi.org/10.31783/elsr.2022.82222228

Abstract

An experiment on seed reserve utilization using seven rice genotypes was conducted at the Department of Seed Science and Technology, PJTSAU, Rajendranagar, Hyderabad in Factorial Completely Randomised Design with three replications during the year 2021. Seed reserve utilization and its associated traits *viz*., the weight of utilized seed reserve (WUSR), seedling dry weight (SLDW), remnant seed dry weight (RSDW), seed reserve utilization efficiency (SRUE), and seed reserve depletion percentage (SRDP) varied significantly among the genotypes, days to emergence and their interaction. While initial seed dry weight (ISDW) showed significance among genotypes only. About, the interaction between genotypes and days to emergence, significantly high ISDW (23.93 mg/seed), RSDW (530 mg) and SRUE (29.8) and significantly low WUSR (2.10 mg/seed) and SRDP (8.97 %) were recorded in AUS 276 on 6th day, while significantly high WUSR and SLDW were recorded in Dular (11.76 mg/seed) and Moroberekan (206.33 mg) on 14th day, respectively. Significantly low ISDW (9.30 mg/seed) and SLDW (49.67 mg) on the 6th day, significantly low RSDW (78.33 mg) and SRUE (14.8), and significantly high SRDP (66.63 %) on the 14th day was recorded in RNR 15048. The results explain that WUSR, SLDW, and SRDP increased significantly from the 6th day to 14th day for all the genotypes indicating the depletion of seed reserves for the growth and development of seedlings, and among the characters studied, WUSR is the most important for conversion into seedling tissue than seed reserve utilization efficiency.

Keywords rice, remnant seed dry weight, seed reserve depletion, seed reserve utilization, seedling dry weight

Introduction

Germination is an important stage in the growth of a plant and the beginning of a new life that starts with the imbibition of water and ends with the emergence of a radicle, after which seedling growth begins [1]. Seedling growth starts with the emergence of the radicle and ends when the energy reserves are exhausted within the seed. Further, the seedling carries out photosynthesis for growth and development. The vigorous growth of seedlings is an essential feature for profitable and sustainable crop production. This indicates that germination and heterotrophic growth are assumed to be crucial steps for the establishment of seedlings [2-3]. The mobilization of seed reserves which include carbohydrates, proteins, and lipids from storage tissues or the endosperm, starts as soon as seeds imbibe water. This process supplies vital energy to support germination and seedling growth [4]. In most seeds, the majority of seed storage reserves do not play a major role in germination; they are required in the later stages for the supply of nutrients to the heterotrophic seedling growth [1]. The utilization of seed reserves is a complex quantitative trait that is influenced by the interactions between genetic and environmental factors. Vigorous seedlings grow and develop as a result of the mobilization of storage reserves and the efficiency of conversion of seed reserves into seedling tissue [5-6]. The majority of the grain in rice is made up of the starchy endosperm, and the primary biochemical process driving seedling growth is the amylolytic breakdown of stored starch [7]. The amylose and amylopectin in the starch are first hydrolyzed by α-amylase, and then the oligosaccharides that are released are further hydrolyzed until glucose and maltose are generated [1]. In the meantime, glucose and maltose are produced when β-amylase hydrolyzes starch polymers that were initially released by α-amylase. Eventually, glucose is mobilized to the scutellum where it is converted into sucrose, which is then mobilized to the plant's developing tissues, shoot, or root [8]. The faster breakdown of storage reserves helps in its faster mobilization leading to early and vigorous seedling growth capable of competing with the crop weeds [9]. The production of early and vigorous seedlings is an important feature of direct-seeded rice which will be the future of rice crops due to water deficiencies. This study is hence conducted to identify genotypes with better and faster reserve utilization and the attributes associated with seed reserve utilization.

Genotypic differences for seed reserve utilization and its associated traits were found to be significant in wheat [10] and rice [11]. This might be helpful to identify better genotypes with faster reserve utilization and emergence to have higher early seedling vigour.

Methodology

The experimental material consisted of seven rice genotypes *viz*., AUS 276, Dular, IR 64, N - 22, RNR 15048, Vandana, and Moroberekan which were collected from the Indian Institute of Rice Research, Hyderabad. The experiment was carried out during the year 2021 at the Department of Seed Science and Technology, Professor Jayashankar Telangana State Agricultural University, Rajendranagar using a Factorial Completely Randomized Design in three replications, with genotypes as the main factor and days to emergence as sub-factor. For the evaluation of seed reserve utilization, three replicates of 25 seeds each were weighed (W_1), dried at 104 °C for 24 h, and weighed again (W_2). [(W1-W2)/W2] was used to compute seed water content (WC). The initial seed dry weight (ISDW; mg per seed) of each seed was computed as [W1 (1-WC)/25] based on the corresponding WC. Following the germination of three replicates of 25 seeds each in Petri plates for eight days, seedlings were manually separated from the original seeds. After being dried in a hot air oven at 104 °C for 24 hours, the seedling dry weight (SLDW) and the remnant seed dry weight (RSDW; mg per seed) were measured. The weight of the used seed reserve (WUSR) was determined using the formula (ISDW - RSDW). The formula for calculating the seed reserve utilization efficiency (SRUE) was (SLDW / WUSR) and seed reserve depletion percentage (SRDP) was (WUSR/ISDW) ×100 [6].

Results and Discussion

The initial seed dry weight (ISDW) was found significant among genotypes but non-significant for days to emergence and the interaction between genotypes and days to emergence. Whereas, the weight of utilized seed reserve (WUSR), seedling dry weight (SLDW), remnant seed dry weight (RSDW), seed reserve utilization efficiency (SRUE), and seed reserve depletion percentage (SRDP) were significant among genotypes, days to emergence and the interaction between genotypes and days to emergence (Table 1). Similar results were observed by Cheng [5] and Soltani [6]. Among the genotypes, ISDW was significantly high in AUS 276 (23.56 mg/seed), which was on par with Moroberekan (23.29 mg/seed) and significantly low in RNR 15048 (9.44 mg/seed). The weight of utilized seed reserve was significantly high in Vandana (8.37 mg/seed) and significantly low in RNR

Table 1. Analysis of variance for seed reserve utilization and associated parameters for Genotypes and days to emergence

	ISDW	WUSR	SLDW	RSDW	SRUE	SRDP
Genotype (G)	363.91**	21.18**	6551.13**	164072.03**	32.76**	0.089**
Days to emergence (D)	0.68	146.51**	29142.06**	88868.37**	121.01**	0.443**
G X D	0.14	2.00**	644.72**	1270.58**	5.31**	0.003**

*P < 0.05; **P < 0.01

15048 (4.85 mg/seed) among the genotypes. It was maximum on the 14th day (9.94 mg/seed) and minimum on the 6th day (2.93 mg/seed) among the days of emergence. In the interaction between genotypes and days to emergence, the maximum utilized reserve was recorded in Dular (11.76 mg/seed) on the 14th day which was on par with Vandana (10.90 mg/seed) and Moroberekan (11.67mg/seed) on 14th day. The minimum utilized reserve was observed in AUS 276 (2.10 mg/seed) which was on par with all other genotypes except Vandana (4.10 mg/seed) on the 6th day (Table 2; Figure 1). Among the genotypes, SLDW was significantly high in Vandana (140.6 mg) and was on par with Moroberekan (134.80 mg) and significantly low in RNR 15048 (79 mg). Among the days to emergence, significantly low on the 6th day (63.52 mg) and significantly high on the 14th day (160.76 mg). Due to the interaction, significantly low SLDW was recorded in RNR 15048 (49.67 mg) which was on par with all other genotypes except Vandana (81.67 mg) on the 6th day. Significantly high SLDW was recorded in Moroberekan (206.33 mg) on the 14th day.

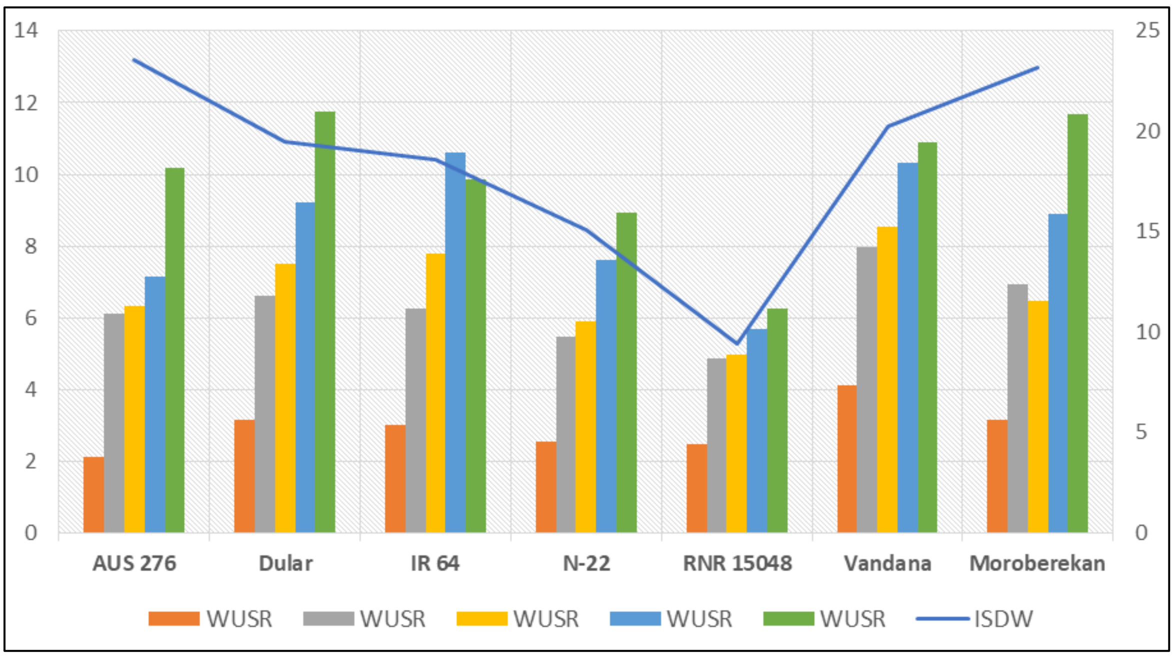

Figure 1. Relation between ISDW and their corresponding values of WUSR for rice genotypes at 6th, 8th, 10th, 12th and 14th day of emergence

Significantly high RSDW was recorded in AUS 276 (429.53 mg) and significantly low in RNR 15048 (114.73 mg) among the genotypes. It was maximum on the 6th day (385.29 mg) and minimum on the 14th day (213.14 mg) among days to emergence. Due to the interaction, a significantly high RSDW was recorded in AUS 276 (530 mg) on the 6th day and a significant low was observed in RNR

Table 2. Mean initial values of seed reserve utilization and its associated traits in rice genotypes

Days to emergence (D)													
		ISDW - Initial seed dry weight (mg/seed)						WUSR - Weight of utilized seed reserve (mg/seed)					
Genotypes (G)		6th day	8th day	10th day	12th day	14th day	Mean	6th day	8th day	10th day	12th day	14th day	Mean
AUS 276		23.30	23.93	23.31	23.73	23.53	**23.56**	2.10	6.12	6.34	7.16	10.18	**6.38**
Dular		19.22	19.90	19.44	19.42	19.35	**19.46**	3.16	6.61	7.49	9.20	11.76	**7.65**
IR 64		18.43	18.70	18.24	18.84	18.69	**18.58**	3.00	6.25	7.78	10.62	9.86	**7.50**
N-22		15.24	15.16	14.92	14.96	15.04	**15.06**	2.55	5.48	5.89	7.61	8.94	**6.10**
RNR 15048		9.50	9.55	9.30	9.44	9.38	**9.44**	2.46	4.86	4.97	5.70	6.25	**4.85**
Vandana		20.23	20.81	19.96	20.23	20.07	**20.26**	4.10	7.96	8.54	10.33	10.90	**8.37**
Moroberekan		22.48	23.45	23.46	23.37	23.19	**23.19**	3.15	6.93	6.48	8.88	11.67	**7.42**
Mean		**18.34**	**18.79**	**18.38**	**18.57**	**18.46**	**18.51**	**2.93**	**6.32**	**6.78**	**8.50**	**9.94**	**6.89**
C.V (%)		3.618						9.545					
G	**SEm (±)**	0.173						0.170					
	C.D (0.05)	0.488**						0.479					
D	**SEm (±)**	0.146						0.144					
	C.D (0.05)	0.412						0.405					
G x D	**SEm (±)**	0.387						0.308					
	C.D (0.05)	1.090						1.072					

Days to emergence (D)													
		SLDW - Seedling dry weight (mg)						RSDW - Remnant seed dry weight (mg)					
Genotypes (G)		6th day	8th day	10th day	12th day	14th day	Mean	6th day	8th day	10th day	12th day	14th day	Mean
AUS 276		61.33	115.33	124.33	136.33	174.33	**122.33**	530.00	445.33	424.33	414.33	333.67	**429.53**
Dular		60.33	107.00	124.67	150.33	183.00	**125.07**	401.33	332.33	298.67	255.33	189.67	**295.47**
IR 64		63.33	104.33	127.67	180.00	156.00	**126.27**	385.67	311.33	261.67	205.33	220.67	**276.93**
N-22		59.00	96.00	104.00	125.33	139.33	**104.73**	317.33	242.00	225.67	183.67	152.33	**224.20**
RNR 15048		49.67	80.67	82.33	90.00	92.33	**79.00**	176.00	117.33	108.33	93.67	78.33	**114.73**
Vandana		81.67	134.00	142.33	171.00	174.00	**140.60**	403.33	321.33	285.33	247.33	229.33	**297.33**
Moroberekan		69.33	122.00	122.33	154.00	206.33	**134.80**	483.33	413.00	424.33	362.33	288.00	**394.20**
Mean		**63.52**	**108.48**	**118.24**	**143.86**	**160.76**	**118.97**	**385.29**	**311.81**	**289.76**	**251.71**	**213.14**	**290.34**
C.V (%)		10.592						6.971					
G	**SEm (±)**	3.254						5.226					
	C.D (0.05)	9.178						14.739					

Continued

Table 2. Mean initial values of seed reserve utilization and its associated traits in rice genotypes (Continued)

D	SEm (±)	2.750						4.416					
	C.D (0.05)	7.756						12.457					
G x D	SEm (±)	7.276						11.685					
	C.D (0.05)	20.522						32.958					
Days to emergence (D)													
		SRUE - Seed reserve utilization efficiency						**SRDP - Seed reserve depletion percentage (%)**					
Genotypes (G)		6thday	8thday	10thday	12thday	14thday	**Mean**	6thday	8thday	10thday	12thday	14thday	**Mean**
AUS 276		29.80	18.84	19.62	19.12	17.24	**20.92**	8.97	25.57	27.18	30.22	43.24	**27.04**
Dular		18.75	16.24	16.68	16.36	15.60	**16.72**	16.42	33.17	38.55	47.52	60.78	**39.29**
IR 64		21.28	16.66	16.40	16.92	15.82	**17.42**	16.40	33.34	42.69	56.39	52.81	**40.32**
N-22		23.22	17.52	17.66	16.41	15.71	**18.11**	16.74	36.27	39.49	50.98	59.33	**40.56**
RNR 15048		20.21	16.64	16.60	15.73	14.80	**16.79**	25.90	50.86	53.56	60.12	66.63	**51.41**
Vandana		19.93	16.84	16.67	16.56	15.96	**17.19**	20.22	38.24	42.77	51.27	54.34	**41.37**
Moroberekan		22.00	17.61	18.91	17.35	17.58	**18.69**	13.97	29.55	27.66	38.00	50.27	**31.89**
Mean		**22.17**	**17.19**	**17.50**	**16.92**	**16.10**	**17.98**	**16.95**	**35.29**	**38.84**	**47.79**	**55.34**	**38.84**
C.V (%)		7.315						10.307					
G	**SEm (±)**	0.340						1.034					
	C.D (0.05)	0.958						2.916					
D	**SEm (±)**	0.287						0.874					
	C.D (0.05)	0.809						2.464					
G x D	**SEm (±)**	0.759						2.311					
	C.D (0.05)	2.142						6.520					

15048 (78.33 mg) on the 14th day which was on par RNR 15048 on the 12th (93.67 mg) and 10th day (108.33) (Table 2). Seed reserve utilization efficiency was observed to be significantly high in AUS 276 (20.92) and significantly low in Dular (16.72) which was on par with RNR 15048 (16.79), Vandana (17.19), and IR 64 (17.42) among the genotypes. Among the days to emergence, a significant high was recorded on the 6th day (22.17) and a significant low on the 14th day (16.10). Due to the interaction, significantly high utilization efficiency was observed in AUS 276 (29.8) on the 6th day and significantly low was observed in RNR 15048 (14.8) on the 14th day. The significantly low value was on par with Dular, IR 64, RNR 15048, and Vandana on the 8th, 10th, 12th, and 14th day each and par with N-22 on the 12th and 14th day. Significantly high SRDP was recorded in RNR 15048 (51.41 %) and significantly low was recorded in AUS 276 (27.04 %) among the genotypes. The depletion percentage was maximum on the 14th day (55.34 %) and minimum on the 6th day (16.95 %) among the days to emergence. Due to the interaction, significantly high depletion was recorded in RNR 15048 (66.63 %) on the 14th day which was on par with RNR 15048 (60.12 %) on the 12th day and Dular (60.78 %) on the 14th day whereas, significantly low was in AUS 276 (8.97 %) which was on par with Moroberekan (13.97 %) on 6th day (Table 2).

During the days of emergence, remnant seed dry weight and seed reserve utilization efficiency were higher on 6th day and decreased with an increase in days due to the utilization of seed reserves by the developing seedling. Whereas, utilized seed reserve per seed, seedling dry weight, and seed reserve depletion increased from 6th to 14th day and significantly high on 14th day. These parameters increased significantly from the 6th day to the 14th day for all the genotypes indicating the depletion of seed reserves for the growth and development of seedlings. Similar findings were reported by Cheng [5] which explains that seedling dry weight and weight of the utilized seed reserve were increased, while the seed reserve utilization efficiency decreased, during seed germination. The SDW and WUSR were affected by the seed weight but SRUE was least affected by the seed weight.

Among the interactions between genotype and days to emergence, AUS 276 has higher ISDW which provided more amounts of seed reserves to have higher utilization efficiency. Similar results were observed by Cheng [11]. Even though Vandana has lesser ISDW than AUS 276 it has a higher utilized seed reserve per seed which produced higher seedling dry weight but had lower utilization efficiency. This indicates that utilized seed reserve per seed (WUSR) plays an important role in the conversion of reserves into seedling tissue rather than seed reserve utilization efficiency or initial seed weight. Similar results were also reported by Shroyer and Cox [9] and Soltani [6]. They mentioned that the weight of mobilized seed reserve is an important component of seedling growth and efforts should be made for the improvement of mobilization of the seed reserves to increase the seedling growth under stress conditions. Among the interactions between genotype and days to emergence, RNR 15048 has significantly low ISDW, WUSR, and SRUE but it has a significantly high seed reserve depletion percentage. Thus, seeds with lower initial seed weight carrying lesser seed reserves tend to deplete their reserves faster to enable faster radicle emergence compared to other genotypes. Similar results were reported by Lafond and Backer [12].

Conclusion

In conclusion, as the days to emergence increased, the weight of utilized seed reserve, seedling dry weight, and depletion percentage increased irrespective of the genotypes, however, higher seed reserve utilization efficiency was observed on the 6th day itself. The rice genotypes with higher initial seed weight might have had higher seed reserve utilization efficiency, however, the weight of utilized seed reserve is most important for the conversion into seedling dry weight rather than seed weight. The genotypes with lower seed weight have higher seed reserve depletion percentages leading to faster radicle emergence.

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