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Effect of water regimes on seed quality parameters of rice (*Oryza sativa* L.) grown under aerobic and wetland conditions

H. P. Ranjitha[1*] , R. Paramesh[1] , H. E. Shashidhar[2] , N. Amruta[1] and S. P. Kiran

[1]Department of Seed Science and Technology,University of Agricultural Sciences, GKVK, Bengaluru-560065 (Karnataka), INDIA

[2]Department of Plant Biotechnology, University of Agricultural Sciences, GKVK, Bengaluru-560065 (Karnataka), INDIA

[*]Corresponding author. Email**:** ranjuranjitha91@gmail.com

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Abstract: A field experiment was conducted to know the effect of water regimes on seed quality parameters of rice and the was conducted by using factorial randomized complete block design, with two genotypes (BI-33 and Jaya) and two planting methods (Aerobic and Wetland). The resultants seeds were taken to conduct laboratory experiments pertaining to seed quality attributes and the studies revealed that the BI-33 under aerobic condition had shown a significantly higher seed quality with respect to germination (99%), mean seedling length (26.75cm), seedling dry weight (10.42 mg), SVI-I (2648) and SVI-II (1032) , highest total dehydrogenase activity (0.53 OD @ 480nm), highest amylase activity (14.67 %), highest total soluble protein content (7.15%) and recorded less EC (70.95 μSm-1/ppm). The experimental results revealed that both the genotypes and method of planting contribute for seed quality of the genotypes which were grown under different water regimes. The genotype grown under aerobic condition was better in seed quality parameters compared to wetland condition.

Keywords: Aerobic rice, Genotypes, Germination seed quality, Water regimes

INTRODUCTION

Rice is the most important and extensively grown staple food crop, accounting for 43% of the total food grain in the country. In Karnataka, rice is grown in an area of 12.78 lakh ha with the total production of 50.13 lakh tones and average productivity is 4126 kg ha-1 (Anonymous, 2013). Water is one of the precious natural resource of the world. According to the United Nations Organizations (UNO), water crisis is the major threat for mankind in the 21st century. From the total available water 75% used for rice cultivation. The rice production in India is strongly influenced by the amount and distribution of rainfall. Inadequate rainfall, lack of water harvesting measures and misuse of water for Agriculture have brought down the per capita availability of water by 40-60% in many Asian countries including India. The high requirement of water for rice cultivation is because rice is generally grown under lowland condition. Water will become a scarce commodity now and hence water saving techniques can offer distinct trade-offs for mitigating methane emission. To overcome this situation, many scientists and farmers have switched on to direct seeding under un-puddle conditions, which is termed as aerobic cultivation of rice (Shashidhar *et al.* 2007). Direct seeding is becoming an attractive alternative to transplanting of rice in order to save precious water. It is a production system in which especially developed aerobic rice varieties are grown in well-drained, non-puddled, and non-saturated soils, with appropriate management like any other field crops. So, the present study was taken with the objective of identifying physical and biochemical parameters influencing seed quality due to treatments imposed. Seed germination and early seedling growth are critical for determining the crop stand, density and final yield of the crop. There is a reduction in percent germination with increasing water stress. Increasing water stress reduced the levels of water and oxygen uptake rates after initial imbibitions and delayed the onset of germination and reduction in germination index . The quality parameters in five genotypes grown under two conditions (aerobic and SRI methods), the germination (96.7%), seedling length (20.6 cm), vigour index-I (1994), seedling dry weight (6.3 mg), vigour index-II (602) and total soluble protein (6.9%) registered significantly superior in aerobic method, while, hundred seed weight was more (2.10 g) in SRI method recorded slightly more soluble protein and total soluble sugars in seeds produced under aerobic condition (1.25 % and 1.14 %) than that of puddled condition (25.47% and 21.48%, respectively

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(Parashivamurthy *et al.* 2012. Among the tested genotypes, KRH-2 recorded significantly higher soluble protein and soluble sugars (1.35 % and 30 % under aerobic condition) while it was lowest in Jaya (0.97 % and 20 %) that grown under wetland condition (Ningaraju *et al*., 2015).

Since rice is the most water consuming crop, alternative strategies that require less water and produce stabilized production needs immediate attention. Aerobic rice is a new development in water saving technology, where rice is grown like any other upland cereal crop with supplementing irrigation. It is a system of growing high yielding rice in non-puddle and non-flooded aerobic soil. Since rice is the most water consuming crop, alternative strategies that require less water and produce stabilized production needs immediate attention. Aerobic rice is a new development in water saving technology, where rice is grown like any other upland cereal crop with supplementing irrigation. It is a system of growing high yielding rice in non-puddle and non-flooded aerobic soil. The present investigation was carried out to study the effect of water regimes on seed quality parameters of rice (*Oryza sativa* L.) grown under aerobic and wetland conditions.

MATERIALS AND METHODS

The seeds were sown in both aerobic and wetland conditions and harvested seeds were procured, cleaned and dried to bring down the moisture level (<13 %) and further used for laboratory experiments. Germination (%), Mean seedling length (cm), Mean seedling dry weight (mg) at final count, Seedling vigour Index I and II, Electrical conductivity (µSm-1/ppm), total soluble proteins (A_{595} nm), Total dehydrogenase activity (A_{480} nm), Amylase activity (A_{540} nm) were recorded as follows.

Seed germination (%): The germination test was conducted in the laboratory using Between Paper method as per ISTA(1985) . One hundred seeds of four replications were placed equidistantly on moist germination paper. The rolled towels were incubated in germination chamber and maintained at $25^0\pm 1^0$C with 90 percent relative humidity (RH). The first count and final count of germinated seedlings were taken on 5th and 14th day, respectively and the percentage of germination was expressed based on the normal seedlings.

Mean seedling length (cm): From the seeds kept for laboratory germination test, ten normal and healthy seedlings from each replication were selected randomly on the 14th day and seedling length (shoot and root) was measured in centimeters and mean shoot and root length were recorded separately and expressed in centimeters.

Mean seedling dry weight (mg): Ten seedlings selected for seedling length measurement were used for recording seedling dry weight. The seedlings were dried in a hot air oven maintained at 800+ 20C for 24 hours and cooled in a desiccator. The mean seedling dry weight was recorded and expressed in milligrams per seedling.

Seedling vigour index (SVI): The seedling vigour index (SVI) was determined based on mean seedling length and seedling dry weight (Abdul baki and Anderson 1973).

SVI-I = Mean seedling length (cm) × Germination (%) R

SVI-II = Mean seedling dry weigh(mg) × Germination (%)

Electrical conductivity (µSm-1/ppm): The electrical conductivity (EC) of seed leachate was determined as per the procedure outlined by . Twenty-five seeds were taken randomly from each treatment in four replications and soaked in 25 ml of double distilled water for 18 hours at 25 ±1O C. After incubation, the electrical conductivity of steeped water (seed leachate) was measured in digital conductivity meter (model D1909/DS-7007) and the EC was expressed in μSm^{-1}/ppm (ISTA 2012).

Total dehydrogenase activity (A_{480}nm): The total dehydrogenase activity of the seeds was estimated as per the method described by. Ten seeds of two replications selected randomly were preconditioned by imbibing for 24 hours in between two moist filter papers. The embryos were excised carefully and soaked in 0.5 percent Tetrazolium Chloride (TTC) solution in a test tube and incubated at $25^o\pm 1^o$C in dark for 18 hours. Then they were washed thoroughly with distilled water, the red colored formazan from stained embryos was extracted by soaking the stained embryos in 5ml of 2-methoxy ethanol for 6-8 hours in an airtight container. The extract was decanted and the color intensity was measured with the help of Spectrophotometer (model Mini spec-17) at 480 nm. The total dehydrogenase activity (TDH) was expressed in terms of OD values (ISTA 2012).

RESULTS AND DISCUSSION

Germination (%): Significant variations were observed for the germination (%) due to conditions and genotypes. Among the methods of planting, germination was highest (95.35 %) in aerobic and it was lowest in wetland condition (91.06 %). Among genotypes, BI 33 (97.75 %) recorded highest and lowest germination (%) was recorded in Jaya (88.66 %). The interaction between G × C found to differ significantly. BI-33 (99.00 %) recorded higher germination per cent under aerobic condition followed by BI-33 (96.50%) grown under wetland condition and Jaya (91.70 %) grown under aerobic condition while it was lowest in Jaya (85.60 %) grown under wetland condition (Table 1). It may be due to the genotype character and water use efficiency, and the nutrient uptake was more in case of aerobic genotype (BI-33) compared to wetland condition this will leads to increase in the storage food and it may be utilized during germination and plant development stages . Parashivamurthy *et al.* (2012) noted the quality parameters in five genotypes grown under two conditions (aerobic and SRI methods), the germination (96.7%) was superior in aerobic condition . Similar to our present study, they concluded that the variety cultivated under aerobic condition was better performer

Table 1. Influence of genotypes and methods of planting on germination, mean seedling length, mean seedling dry weight and seedling vigour-I. Mean values are of ten replicates.

Treatments	Germination (%)	Mean seedling length(cm)	Mean seedling dry weight(mg)	SVI-I	SVI-II
Genotypes					
G_1 (BI-33)	97.75	26.35	10.32	2576	1009
G_2 (JAYA)	88.66	24.33	10.03	2156	889
F test	*	*	*	*	*
S.Em±	1.011	1.078	0.1278	0.968	2.299
CD (P < 0.05)	3.235	3.449	0.408	3.0965	7.453
Methods of planting					
C_1 (AEROBIC)	95.35	25.64	10.27	2445	979
C_2 (WETLAND)	91.06	25.07	10.08	2283	918
F test	*	*	*	*	*
S.Em±	1.011	1.078	0.1278	0.967	2.299
CD (P < 0.05)	3.235	3.449	0.408	3.096	7.453
Genotypes x Methods of planting (GXC)					
G_1C_1	99.00	26.75	10.42	2648	1032
G_2C_1	91.70	24.55	10.12	2251	928
G_1C_2	96.50	25.95	10.22	2504	986
G_2C_2	85.62	23.93	9.95	2049	852
Mean	93.20	25.33	10.18	2361	949
F test	*	*	*	*	*
S.Em±	0.476	0.508	0.060	0.456	1.098
CD (P < 0.05)	1.525	1.626	0.192	1.459	3.513
CV (P < 0.05)	1.023	4.012	1.183	3.844	2.332

Table 2. Influence of genotypes and methods of planting on electrical conductivity (µs/ppm) and total dehydrogenase activity (TDH) at 480 nm.

Treatments	Electrical conductivity (µs/ppm)	TDH @ 480 nm	Total soluble seed protein (%)	Amylase activity @ 540 nm
Genotypes				
G_1 (BI-33)	62.82	0.43	6.48	14.60
G_2 (JAYA)	81.25	0.24	5.93	12.43
F test	*	*	*	*
S.E m±	4.360	0.021	0.123	0.40
CD (P < 0.05)	13.948	0.069	0.3816	1.25
Methods of planting				
C_1 (AEROBIC)	70.95	0.39	6.81	14.67
C_2 (WETLAND)	79.12	0.27	5.60	12.36
F test	*	*	*	*
S.E m±	4.360	0.021	0.123	0.40
CD (P < 0.05)	13.948	0.069	0.3816	1.25
Genotypes x Methods of planting (GXC)				
G_1C_1	65.15	0.53	7.15	15.97
G_2C_1	76.75	0.26	6.48	13.37
G_1C_2	72.50	0.33	5.83	13.22
G_2C_2	85.75	0.21	5.38	11.50
Mean	75.03	0.33	6.20	13.51
F test	*	*	*	*
S.E m±	2.055	0.010	0.17	0.57
CD (P < 0.05)	6.575	0.032	0.53	1.78
CV (P < 0.05)	5.478	6.050	5.64	8.54

than the wetland condition.

Mean seedling length: The mean seedling length differed significantly between genotypes and growing conditions. The mean seedling length was highest in aerobic (25.64cm) than wetland (25.07cm) condition. The genotype BI-33 (26.35 cm) recorded higher mean seedling length over Jaya (24.33 cm) (Table 1). BI-33 (26.75 cm) recorded higher mean seedling length under aerobic condition followed by BI-33 (25.95 cm) grown under wetland condition and Jaya (24.55 cm) grown under aerobic condition while it was lowest in Jaya (23.93 cm) grown under wetland condition. This may be due to high-density seeds having more amount of stored food hence it will contribute to produce taller seedlings , and seeds having higher density results in obtaining higher mean seedling dry weight.

Mean seedling dry weight: The mean seedling dry weight (10.27mg) was more in aerobic condition (10.08 mg) than wetland condition. The genotype BI-33 (10.32 mg) recorded higher mean seedling dry weight compared to Jaya (10.03). The interaction between G x C was significant.BI-33 (10.42 mg) recorded higher mean seedling length under aerobic condition followed byBI-33 (10.22 mg) grown under wetland condition and it was least in Jaya (10.12 mg) grown under aerobic condition followed by Jaya (9.95 mg) grown under wetland condition. This may be due to high-density seeds produce taller seedlings in paddy (Mortlock *et al.*, 1985) and seeds having higher density results in obtaining higher mean seedling dry weight (table 1).

Seedling vigour index – I and II: Significant differences were observed between genotypes, environment and their interaction. Seedling vigour-I was higher in aerobic (2445) than puddle (2283).Among the genotypes, BI 33 (2576) had higher seedling vigour index and the least was found in Jaya (2156). The interaction between G × C was significant.BI-33 (2648) recorded higher mean seedling length under aerobic condition followed byBI-33 (2504) grown under wetland condition and it was least in Jaya (2251) grown under aerobic condition followed by Jaya (2049) grown under wetland condition. Seedling vigour-II was higher in aerobic (979) than the wetland (918) condition. Among the genotypes, BI 33 (1009) had higher seedling vigour index and the least was found in Jaya (889). The interaction between G x C was significant.BI-33 (1032) recorded higher mean seedling length under aerobic condition followed byBI-33 (986) grown under wetland condition and it was least in Jaya (928) grown under aerobic condition followed by Jaya (852) grown under wetland condition. This is due to higher seed density, higher mean seedling length and dry weight and nutrient mobilization by the aerobic soil to the seeds grown under this soil.

Electrical conductivity (µSm-1/ppm): Electrical conductivity of the seed leachate was greatly influenced by the method of cultivation. Aerobic condition recorded significantly lower electrical conductivity (70.95 µSm-1/ppm) compared to the wetland (79.12 µSm-1/ppm). Among the interaction higher electrical conductivity was recorded in Jay (85.75dSm-1) grown under wetland condition, followed by Jaya (76.75dSm-1) under aerobic condition followed by BI-33 (72.50 dSm^{-1}) under wetland condition and it was least in BI-33 (65.15dSm^{-1}) under aerobic condition(Table 2). However, BI-33 recorded less (65.25 µs/ppm) amount of electrical conductivity under both the condition. This could indicate duel adaptability of BI-33 and less number of leachetes due to increased amount reactive oxygen species and more number of living cells and ion exchange is in dual acceptable condition between plant and soil in case of aerobically developed genotype .Similar research were found by Radha *et al* 2004 and Parashivamurthy *et al.* 2012. Similarly Radha in 2004 conducted the experiment and the results revealed that the aerobically growned varieties showed less electrical conductivity (83 dSm^{-1}) compared to puddled condition (113 dSm^{-1}).

Total dehydrogenase activity (TDH): Genotypes and methods of planting differed significantly for total dehydrogenase activity. It was higher in aerobic (0.39) than the wetland (0.27) condition. BI 33 recorded higher TDH (0.43) over Jaya (0.24). Among the interaction higher total dehydrogenase activity was recorded in BI-33 (0.53) grown under aerobic condition, followed by BI-33 (0.33) under wetland condition, followed by Jaya (0.26) under aerobic condition and it was least in Jaya (0.21) under wetland condition. Radha *et al.* (2004) recorded the TDH activity and results were revealed higher amylase activity in rice cultivars under aerobic method of production (0.29) than in the puddle cultivation (0.23). It may be due to high vigour seeds having more number of active and living cells which present in the seeds of aerobically growned genotypes and these will contribute to good germination and growth. (Table 2).

Amylase activity: The amylase activity revealed significant difference among the genotypes and methods of planting. Genotypes performed better in aerobic condition (14.67) than wetland (12.36). Higher amylase activity was noticed for BI 33 (14.60) and it was lowest. In Jaya (12.43). Amylase activity was higher in aerobic condition compared to wetland condition. If the amylase activity is reduced it results in delayed germination this is also one of the reasons that aerobically produced seeds had higher germination percent. Radha (2005) also reported that higher amylase activity indicated the mobilization of reserved food materials and make available for the root and shoot growth hence the cultivars showing higher amylase activity resulted in higher germination rate and faster seedling growth at an early stage (Table 2). Radha (2004) reputed that higher amylase activity in rice cultivars under aerobic method of production (1.33%) than in the puddle cultivation (1.25%).

Total soluble seed protein (TSP): Significant variation was observed among genotypes and methods of planting with respect to total soluble seed protein percentage. TSP was higher in aerobic (6.81 %) compared to the wetland (5.60 %).Among the genotypes, BI-33 (6.48 %) had the highest total soluble protein while, Jaya (5.93 %) had lower TSP. Among the interaction higher total soluble seed protein was recorded in BI-33 (7.15 %) grown under aerobic condition, followed by Jaya (6.48 %) under aerobic condition, followed by BI-33 (5.83 %) under wetland condition, and it was least in Jaya

(5.38 %) under wetland condition. That might be due to enhanced translocation of assimilates under stress in rice (Table 2). Radha *et al* 2004 conducted the experiment and the results revealed that among the tested genotypes, KRH-2 recorded significantly higher soluble protein 1.35 % under aerobic condition, while it was lowest in Jaya (0.97 % that grown under puddle condition.

Conclusion

The study revealed that the genotypes grown under aerobic condition had better seed quality parameters compared to the genotypes grown under wetland condition and this will help to the farmers where the irrigation is the major constraints and this study also helps to the breeders and seed technologists to select better seeds with good quality and may be suggested for higher seed quality parameters along with overall betterment of paddy.the results similar with the research of Radha *et al* 2004 Pashivamurthy *et al.* 2012.

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