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Evaluation of Seed Yield and Quality under Different Planting Systems in Rice (*Oryza sativa*. L)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Out of different planting systems available in rice, various factors such as local conditions, water resources and labour availability decides the choice of planting. To study whether the large scale seed production can be taken under different popular planting systems without any compromise on seed quality is the need of the hour. The present experiment was conducted to understand the influence of different planting methods on seed yield and quality in rice. The experiment was carried out *Kharif,* 2022 with two rice varieties namely RNR 15048 and KNM 118. Each variety was sown

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separately in five different planting systems i.e., T_1-Transplanting (Control), T_2-Dry direct seeded rice, T_3-Direct wet seeded rice, T_4-Aerobic rice, T_5-Drum seeded rice with three replications in the factorial randomised block design. The maximum seed yield of 7.6 t/ha was in aerobic planting system and the influence of seed quality parameters in different planting methods like germination, seedling vigour index-I and II, physical purity, field emergence, accelerated ageing test showed that aerobic system of planting has shown good quality with germination value of 97%, seedling vigour index-I of 2357.04, seedling vigour index-II of 1339.51, physical purity of 99.04%, seed reserve utilization with efficiency of 15.15, field emergence of 93.5% and when subjected to accelerated ageing under required conditions till 5th day the aerobic rice has shown 96% of germination. Among all the planting systems, aerobic rice has shown superior performance representing it's role in the development of quality seed parameters.

Keywords: Rice; planting methods; varieties; seed quality; seed yield parameters.

1. INTRODUCTION

Rice is a staple food crop and widely consumed all over the world playing a vital role in ensuring food security across the globe [1]. The Oryza genus has its origin in the ancient landmass of Gondwanaland [2]. Over 90% of the rice in the world is grown and consumed in Asia and is an essential part of their culture, diet and economy [3,4]. To maintain global food security and meet the growing populations' need in the 21st century, rice production must be increased quantitatively and improved qualitatively [5]. Rice cultivation is generally practiced through transplanting as it ensures better control of weeds [6], uniform ripening with less lodging, However, manual transplanting is expensive, laborious and time-consuming and involves lot of drudgery [7,8]. Further the labour cost incurred in manual transplanting accounts for approximately 25% of the cultivation cost, taking about 300 to 350 man-hours per hectare. The industrialization [9] associated migration of labour has led to labour shortage in the rural areas with undue delay in transplanting, which showed a significant reduction in yield [10]. The increased cost of weeding and transplanting system is the primary reason for the increased cultivation cost under transplanted rice. To address the trouble of labour shortages, water scarcity [11] and drudgery among women workers, alternative planting methods of rice stand establishment such as direct dry seeded rice[12], direct wet-seeded rice, aerobic rice and drum-seeder rice are not only essential for the production of crops but also for the seed production.

Quality seed in respect of high genetic and physical purity, germination percentage, vigour and freedom from seed-borne diseases and insects [13] is essential for realizing the full potential of a variety [14]. As good quality seed is important in getting higher yields it is essential to identify the suitability of different cultivation systems on rice seed yield and seed quality. The present work aims at evaluating the seed quality under various cultivation systems for further adoption in quality seed production for supply of quality seed.

2. MATERIALS AND METHODS

This present experiment was taken up during *kharif* 2022, at Seed Science and Technology Department, Seed Research and Technology Centre, Rajendranagar geographically located at 17^0 19'31.55614"N latitude and 78^0 24'25.05198"E longitude and falls under Southern Telangana agro-climatic zone utilizing two varieties of rice namely RNR 15048 and KNM 118. Each variety was sown separately in five different types of planting systems i.e. T_1-Transplanting (Control), T2-Dry direct seeded rice, T_3-Direct wet seeded rice, T_4-Aerobic rice, T_5-Drum seeder rice and replicated thrice. Recommended package of practices were followed for raising a healthy crop. The following observations were recorded.

2.1 Germination Percent

The germination test was done as per ISTA [15] procedure with using 400 seeds. The test conditions of 95 ± 3 percent relative humidity and 25 ± 2°C temperature were maintained in the germination chamber and recorded on 14th day, the number of normal seedlings were counted and germination percentage.[16].

2.2 Seedling Vigour Index

The SVI I and II were calculated as procedure given by Abdul-Baki and Anderson [17].

Seedling vigour index-I = Germination (%) x Mean seedling length (cm)

Seedling vigour index-II = Germination (%) x Dry Matter Production (mg/seedling)

2.3 Accelerated Ageing Test

Seeds of two rice genotypes namely RNR 15048 and KNM 118 produced under different planting systems were subjected to accelerated ageing for 3,4 and 5 days at relative humidity of 100 percent and temperature of 40 ± 1°C by placing 25 grams of seeds with moisture content of 10-12% in accelerated ageing boxes. The germination percentage was noted down after the ageing period [18].

2.4 Seed Reserve Utilization Efficiency

For determination of seed reserve utilization efficiency, four replications comprising of 25 seeds in each replication and weight was taken at standard storage conditions (W1) and dried at 104°C for 24 hours and then they were reweighed (W2). Seed water content (WC) was calculated by using formula [(W1-W2)/W2]. WC, and the initial seed dry weight (ISDW; mg/seed) of each rice was recorded as [W1×(1-WC)/25]. After eight days of germination, the roots and shoots of seedlings were separated from the seeds. The seedlings dry weight (SLDW) and the remnant seed dry weight (RSDW; mg/seed) were noted down after oven drying at 104°C for 24 hours. The weight of the utilised (mobilized) seed reserve (WUSR) was calculated as (ISDW-RSDW). The Seed Reserve Utilization Efficiency (SRUE) was calculated as follows (SLDW / WUSR) [19].

3. RESULTS AND DISCUSSION

3.1 Seed Yield

The seed yield showed significant difference among the varieties and treatments. KNM 118 recorded a higher yield of 5.84 t/ha in comparison to RNR 15048. Among the planting methods also a significantly superior variation was observed with a maximum seed yield of 6.66 t/ha in aerobic system(T_4) and minimum of direct wet seeded rice (T_3) 2.97 t/ha. The V × T interaction is found to be significant with a of highest yield of 7.61 t/ha in KNM 118 cultivated under aerobic method, and while lowest in KNM 118 cultivated by wet direct seeded rice method (2.74 t/ha) (Table 1). A significantly higher straw and grain yield was observed in direct seeding by drum seeder over sprouted seeds in puddled soil (broadcasting) and normal transplanting method [20]. Maximum yield in aerobic method could be due to early establishment leading to greater performance of yield contributing characters. This could also due to early seedling vigour of these varieties with higher biomass accumulation.

3.2 Influence of Planting Methods on Seed Quality

3.2.1 Physical purity

Physical purity was significantly influenced among varieties and the highest physical purity percent was observed in RNR 15048 with 98.95%. Among the planting methods there was no significant difference but numerically superior performance was observed in aerobic rice with 99.04% and the minimum was observed in wet direct seeded rice with 98.76%. However no interaction effect (significant difference) was observed in all.

3.2.2 Germination percentage

The germination percentages in all the treatments were above Indian minimum seed certification standards. The average germination percent of both the varieties under different planting systems is 95 and 96 %. A significant variations in germination percent was recorded among the planting methods, however a significance was recorded among the interactions (Table 1). A maximum germination of 97% was recorded in aerobic method of cultivation (T_4). However wet direct seeded rice and Drum seeder rice was found to be on par for the best treatment. The present recordings are in accordance with findings of Ranjitha et al. [21] who observed highest germination (95.35 %) for seed obtained from aerobic condition and lowest (91.06 %) under wetland condition. Higher nutrient availability due to oxygen availability and associated better performance under aerobic conditions is leading to development of seeds with better germination and quality.

3.2.3 Seedling vigour index-I and II

It was revealed that a significant difference in SVI I was observed among the planting methods only. Where varieties showed no significant difference. The aerobic planting system has significantly influenced SVI I (2357.04) (Table 2) followed by the drum seeder method (2256.70) and lowest in direct wet seeded rice (2108.64). The V × T interaction was found non-significant, however RNR 15048 cultivated under aerobic system recorded highest SVI I (2374.62). A significant difference in SVI II was observed among the planting methods, while differences among varieties and V × T interaction was non-significant (Table 2). Among the planting methods, aerobic system of cultivation (T_4) reported highest SV II of 1339.51, while none of the planting systems were on par with aerobic method. A superior vigour index in aerobic method [21] and in SRI method [22] over conventional methods was noticed in earlier studies. This could be acknowledged due to higher nitrification of ammonia in the root zone because of prevailing oxic environment. The dry matter accumulation at reproductive stage is higher because of greater expansion of the rhizosphere volume leading to enhanced ammonium uptake [23] and N reserve from soil [24] in the aerobic system of cultivation. The poor performance under dry direct wet seeded rice could be due to the anaerobic conditions leading to late establishment and poor early growth.

3.2.4 Accelerated ageing

The seed subjected to accelerated ageing for 3 days didn't show any significant variation among the varieties, planting systems and V × T interaction, while a significant difference among the planting systems was recorded for seeds subjected to accelerated ageing for four and five days (Table 3). The aerobic method of cultivation recorded highest germination after subjecting to accelerated ageing for four and five days. The direct dry seeded rice showed on par performance with aerobic rice both at four and five days of accelerated ageing, while least performance was observed in transplanted rice. The ability of seedlings to germinate and produce healthy seedlings is mainly due to their resistance to deteriorative changes, which is revealed by accelerated ageing during germination [25].

3.2.5 Seed reserve utilization efficiency

Results of seed reserve utilization efficiency showed that among varieties, there was no significant variation noticed (Table 4). The effect of SRUE among different planting systems showed that there was superior significant variation noticed and maximum seed reserve utilization efficiency was noticed in aerobic system with value of 15.15 and the lowest was noticed in dry direct seeded rice with value of 13.52. Non significance was noticed among the interaction. None of the treatment was found to be on par with aerobic system (T_4). Superior performance under aerobic system is due to higher vigour and viability of these seeds.

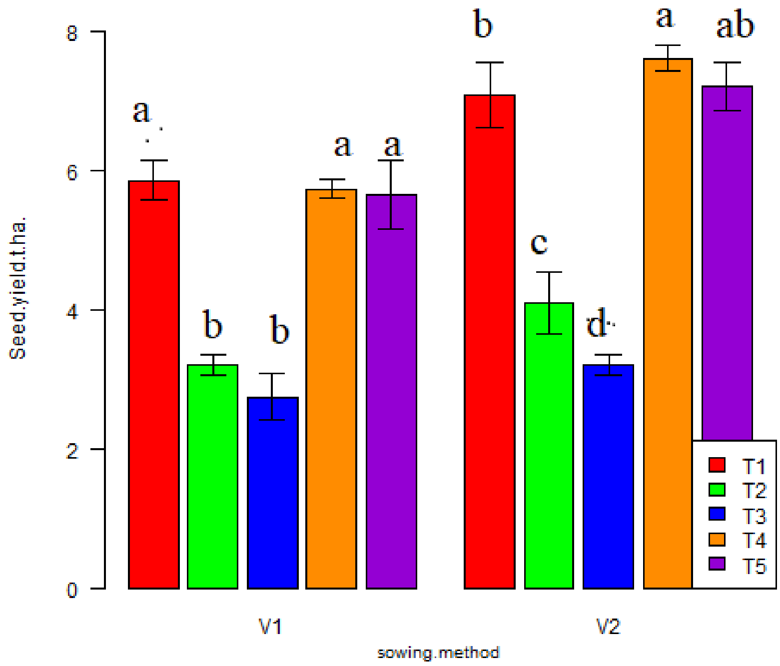

Fig. 1. Influence of varieties and different planting methods on seed yield

Table 1. Influence of varieties and different planting methods on physical purity and germination percentage of seed

Treatments		Physical purity (%)			Germination (%)		
		RNR15048	KNM 118	Mean	RNR 15048	KNM 118	Mean
T_1-(Control-Transplanting)		98.75	98.89	98.82	94	95	95^{c}
T_2-Direct dry seeded rice		99.02	98.90	98.96	95	95	95^{bc}
T_3-Direct wet seeded rice		98.91	98.61	98.76	96	96	96^{ab}
T_4-Aerobic rice		99.05	99.03	99.04	97	96	97^{a}
T_5-Drum seeder rice		99.01	99.03	99.02	97	95	96^{ab}
Mean		98.95	98.89	98.92	96	95	96
C.V(%)			0.13			1.10	
V	SEm (±)		0.06			0.24	
	CD@5%		0.19			NS	
T	SEm (±)		0.10			0.39	
	CD@5%		NS			1.17	
VxT	SEm (±)		0.14			0.55	
	CD@5%		NS			1.65	

**Values having the same letter were not significantly different from each other at the p < 0.05 level*

Table 2. Influence of varieties and different planting methods on Seedling Vigour Index

Treatments		Seedling vigour index-I			Seedling vigour index-II		
		RNR 15048	KNM 118	Mean	RNR 15048	KNM 118	Mean
T_1(Control-Transplanting)		2250.88	2131.04	2190.96^{b}	984.06	1062.45	1023.260^{b}
T_2-Direct dry seeded rice		2223.90	2224.61	2224.25^{ab}	1104.76	1049.10	1076.93^{b}
T_3-Direct wet seeded rice		2178.78	2038.50	2108.64^{b}	1191.83	1039.96	1115.90^{b}
T_4-Aerobic rice		2374.62	2339.46	2357.04^{a}	1401.86	1277.16	1339.51^{a}
T_5-Drum seeder rice		2273.63	2239.78	2256.70^{ab}	1129.06	999.73	1064.40^{b}
Mean		2260.36	2194.68	2227.52	1162.32	1085.68	1124
C.V(%)			4.12			11.15	
V	SEm (±)		31.01			31.52	
	CD@5%		NS			NS	
T	SEm (±)		49.03			49.84	
	CD@5%		145.67			148.07	
VxT	SEm (±)		69.34			70.48	
	CD@5%		NS			NS	

**Values having the same letter were not significantly different from each other at the p < 0.05 level*

Table 3. Influence of varieties and different planting methods on accelerated ageing of seed for 3, 4 and 5 days

Treatments		Accelerated ageing								
		3rd day			4th day			5th day		
		RNR 15048	KNM 118	Mean	RNR 15048	KNM 118	Mean	RNR 15048	KNM 118	Mean
T_1-(Control-Transplanting)		97	96	97	96	95	95[d]	94	93	94[b]
T_2- Direct dry seeded rice		97	97	97	97	97	97[ab]	95	95	95[ab]
T_3- Direct wet seeded rice		97	96	97	97	96	96[bc]	95	94	95[b]
T_4- Aerobic rice		98	98	98	97	97	97[a]	96	96	96[a]
T_5- Drum seeder rice		96	97	97	95	96	96[cd]	94	94	94[b]
Mean		97	97	97	96	96	96	95	94	95
C.V (%)			0.48			0.86			0.71	
V	SEm(±)		0.23			0.17			0.21	
	CD@5%		NS			NS			NS	
T	SEm(±)		0.36			0.27			0.33	
	CD@5%		NS			0.82			0.99	
VxT	SEm(±)		0.51			0.39			0.47	
	CD@5%		NS			NS			NS	

**Values having the same letter were not significantly different from each other at the p < 0.05 level*

Table 4. Influence of varieties and different planting methods on Seed Reserve. Utilization Efficiency and field emergence

Treatments		Seed reserve utilization efficiency			Field emergence (%)		
		V_1	V_2	Mean	V_1	V_2	Mean
T_1 -(Control-Transplanting)		13.96	13.47	13.72[b]	91.33	90.33	90.83[b]
T_2- Direct dry seeded rice		13.47	13.57	13.52[b]	89.66	90.33	90.00[b]
T_3- Direct wet seeded rice		13.82	13.94	13.88[b]	90.66	90.66	90.66[b]
T_4- Aerobic rice		15.73	14.94	15.15[a]	95.00	92.00	93.50[a]
T_5- Drum seeder rice		13.62	14.35	13.99[b]	90.00	90.00	90.00[b]
Mean		14.05	14.05	14.05	91.33	90.66	90.99
C.V(%)			4.34			1.62	
V	SEm (±)		0.19			0.33	
	CD@5%		NS			NS	
T	SEm (±)		0.30			0.52	
	CD@5%		0.89			1.58	
VxT	SEm (±)		0.42			0.74	
	CD@5%		NS			NS	

**Values having the same letter were not significantly different from each other at the p < 0.05 level*

3.2.6 Field emergence

There was no significant variation observed among varieties but the field emergence was significantly influenced by the different planting methods (Table 4). Among the treatments, maximum field emergence percent was recorded in aerobic system with 93.5% and the lowest field emergence was shown in dry direct seeded rice and drum seeded rice (90%). However, there was no significant deviation between interactions of varieties and method of planting.

V1 - RNR 15048 and V2- KNM 118, Values are means ± SE. T_1-Transplanting (Control), T2-Dry direct seeded rice, T_3-Direct wet seeded rice, T_4-Aerobic rice, T_5-Drum seeded rice. Values having the same letter were not significantly different from each other at the $p < 0.05$ level.

4. CONCLUSION

Aerobic method also known as aerobic rice cultivation is an alternative approach to traditional flooded rice cultivation that involves growing in non flooded conditions. And it is concluded that aerobic rice showed superior performance over other methods of planting in terms of higher yield and quality parameters like seed germination, Seedling vigour index I & II, Field emergence and accelerated ageing. Unlike traditional flooded rice fields, aerobic rice requires significantly very less amount of water, less weed menace and ultimately reduces manual labour without any reduction in seed quality. It also reduces incidence and severity of pests and diseases. The aerobic rice cultivation mainly conserves water unlike other planting methods. Hence seed production can be easily take up in larger areas for timely distribution of quality seed to the end users.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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